# The Morality of Nuclear Power:

# An Ignatian Discernment

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# The Morality of Nuclear Power Generation: An Ignatian Discernment



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# INTRODUCTION

After a hiatus of several decades, a renewed interest in building nuclear reactors for generating electricity has developed in the United States and elsewhere. Proponents of nuclear power assert that this would reduce the use of fossil fuels and the consequent emission of carbon dioxide, which is a major contributor of greenhouse gas to climate change and global warming. Currently electric utilities using fossil fuels are the major contributor, and so various spokespersons for the nuclear industry, along with a few “environmentalists,” regard the reintroduction of nuclear fuels as a necessary component of the twenty-first century electricity-generating fuel mix. A consensus to reduce and de-emphasize fossil fuels in electricity generation is being solidified on regional, national and global levels. A refined energy strategy must both slow down (through conservation) and meet the rapidly increasing worldwide demand for electricity and minimize expanding coal, gas and oil fuel use for such electricity generation. Should nuclear power be part of that strategy?

**Goal**. The purpose of this paper is to propose a time-honored method of coming to a moral decision (Ignatian discernment). We will take this decision-making process step by step through *four phases* dealing with whether new nuclear power plants should be constructed to replace those older ones that are being phased out due to retirement. In the past we have used this process and it works. Our purpose is to persuade the reader as to the efficacy of this procedure both to increase their own understanding as concerned citizens and to give them a means of passing the method on to others who are part of the policy-making process.

**Methodology.** This discernment process is not new to these Special Issues, but has already been used as a guide for coming to personal decision-making in the June, 2007, addition under "Retreats," as well as in the 2006 contribution to this website called “Eco-Spirituality through the Seasons.” Each of the two authors of the paper at hand has worked on nuclear issues for over a quarter of a century and has produced books on the subject including *Critical Hour* found on this website. Our website Special Issues is meant to introduce subjects for immediate and careful consideration by a broader public throughout the world although special attention is given to the American scene. Since this website is not an interactive blog as such, immediate interaction with others is not what we intend, though your responses are always welcome. *Our interest is not to discuss but rather to furnish the process as a way for readers to interact with energy decision- and policy-makers.*

Nuclear activity is a natural phenomenon and obviously the morality does not deal with radioactivity within our Earth or the nuclear activity in the sun. Contrary to what nuclear proponents would hold, the natural activity does not per se justify the use of dangerous materials and processes when not necessary for the benefit of the inhabitants of this planet. Nuclear power may be similar to the Tree of the Knowledge of Good and Evil. It is not to be handled by those who think that humanity includes technical gods who are able to do anything that they deem possible. Prudence directs us to look more closely at our past actions (history of nuclear reactor activity), current actions with the health and safety risks associated (morality), immediate future actions (the necessity of continued nuclear power use), and long-term life of our planet (proliferation of nuclear weaponry through expanded use of nuclear power). This is not an emerging moral issue with a result in question, but rather an existing moral issue that needs dispassionate, thoughtful and prayerful discernment because so very much is at stake for our civilization. We take up the four aspects (history, morality, necessity, and proliferation) in sequential order.

**Limitations.** In order to complete a manageable treatment of this subject, we limit discussion to certain issues. First, we will not actually work through the moral issues related to nuclear weapons production, retention and use, which some others have discussed quite thoroughly (see Bibliography). From the beginning of the nuclear age the wartime and peacetime uses were highly intertied. While the production, retention and use of nuclear weapons have a long history in moral discussion, few connect nuclear weapons with nuclear power generation. Unfortunately, even today, nuclear weapons are being considered by the U.S. administration for use against certain specific targets in Iran -- and unnecessary risks that would precipitate misuse should be halted. This we hold as a moral imperative even without going into all the details.

Secondly, we will not attempt to evaluate all conceivable peacetime uses of the atom (see Appendix One). In many of the medical, industrial and research applications the use of nuclear reactor materials is not necessary, and alternative means of production or substitutes are available.

Thirdly, we refrain from discussing all possible forms of terrorist use of sites for terrorist attack, sabotage or blackmail or of nuclear materials being processed, used, stored or transported. Literature is available on this subject as well. See, for example, *The Four Faces of Nuclear Terrorism*. Of course, nuclear power plants and their materials lend themselves to being terrorist targets and that is one of the arguments presented here -- but terrorism is simply not the total complex picture, nor should we make it so here.

**Our hope**. Changes occur quite often through catastrophe but no one wants a nuclear power plant accident to contaminate and kill in order to precipitate change. Moral judgments can emerge through serious and prayerful reflection and move to reasonable policy and regulatory action. If questions of safety, necessity and proliferation dangers are sufficiently answered, then we are confident a sound energy strategy and policy will be forthcoming.

# PHASE ONE
# HISTORICAL PERSPECTIVE

What has motivated the justification of peacetime use of the atom?

In this phase we shall consider why we, particularly in the United States, felt it was necessary to "redeem" nuclear energy use by layering on top of a military nuclear weapons industry the development of non-military uses of the atom. We should like to expose the issues arising from the emergence of the nuclear age. Here we focus on the peacetime use of the atom that has been initiated and promoted for a threefold justification: to replace the moral guilt resulting from the use of the atomic bombs on innocent Japanese people; to justify a continued weapons program that was intertied to generation of electricity through the exploitation of nuclear fission; and to make other nations regard the United States in a favorable light. The moral questions raised by construction, retention, testing and possible use of nuclear weapons have been thoroughly discussed elsewhere. The interconnections of the military and the civilian have been less exposed and so we present what is needed, namely the examination of our national "conscience" to see where we stand. Transparency and openness are a key to fuller understanding of how we proceed from here.

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Plainly put, the initial wartime use of nuclear energy involved tens of thousands of casualties at Hiroshima (about 66,000 deaths) and Nagasaki (about 87,000 deaths) along with one million injuries. These horrible events are still taking their toll in shortened lives decades after the 1945 events. A collective guilt felt by Americans has been at the heart of extending nuclear materials beyond initial wartime use to peaceful "use of the atom." Note that during that post-war period America did not need nuclear-generated electricity, since our needs were being met in 1950 by hydropower (30%) and fossil fuels mainly coal (70%).

Feeding on this national policy of justification were the additional motivations of legitimate peacetime electricity needs, the drive to profit from producing nuclear power generating equipment and constructing nuclear plants, and the future profits looming from a civilian industry -- especially with promises of the electricity being too cheap to meter. History shows the part played by private industry in developing the bomb and the subsequent nuclear power expansion.

Immediately after the war the public was euphoric about the possibilities of applying the power of the atom to civilian tasks. Good could come from the power that devastated Hiroshima and Nagasaki! The media spread the views of prominent Americans who had visions of a bright future, made possible by a peaceful atom. The Chancellor of the University of Chicago, Robert M. Hutchins, reflected the general optimism, "Heat will be so plentiful that it will even be used to melt snow as it falls. . . . A very few individuals working a few hours a day at very easy tasks in the central atomic power plant will provide all the heat, light, and power required by the community and these utilities will be so cheap that their cost can hardly be reckoned" [Quoted in Ford, p. 30].

In 1946 the federal government announced the transfer from Du Pont to General Electric (GE) of the contract for operating Hanford Engineer Works, which had produced the plutonium for the Nagasaki bomb; and the inauguration of a program for research and development in atomic energy. On this occasion Charles E. Wilson, president of GE, stated, "General Electric was engaged in atomic research for peacetime application before the war. With this background we are convinced that the quickest possible development of nonmilitary applications is the most constructive solution to the problem which atomic energy presented to the world" [Quoted in Miller, p. 232]. However, the central purpose of Hanford, an installation in the state of Washington, remained the production of military plutonium.

In practical terms, little progress in civilian applications was made for some eight years. The government concentrated on welding into a coherent production complex the scattered factories that had contributed to the creation of the first atomic bombs, on acquiring the fissile materials essentials for atomic weapons, on increasing the number of atomic bombs in its arsenal, and on developing and producing thermonuclear (hydrogen) bombs. The desire to acquire a powerful arsenal was spurred on by the Soviet's explosion of an atomic device in 1949 and the outbreak of the Korean War in 1950. The United States detonated its first thermonuclear device in November 1952; the Soviet's first such detonation occurred in August 1953.

GE, along with Du Pont, Union Carbide, and Westinghouse, was in the thick of the weapons work. In addition to managing Hanford, GE in 1947 began operating for the federal government the new Knolls Atomic Power Laboratory near Schenectady, New York. There GE initially worked on development of a "breeder" reactor designed to produce military plutonium in quantity, and created Purex, a method of separating plutonium from the fuel and targets in which it was produced. Purex was applied at the Savannah River plant and then at Hanford to obtain military plutonium.

An exception to the emphasis on bombs and their materials was work on submarine propulsion by a Navy officer, then Captain Hyman Rickover. During World War II, submarines were propelled by diesel engines while on the surface and by batteries while under water. This arrangement did not allow for lengthy under-sea voyages. Development of nuclear propulsion would put an end to this difficulty. Not wanting to work with government scientists, Rickover established relationships with the private companies that were responsible for the electrical systems and the turbines on naval vessels. He gave GE tasks to work on at Knolls, but he developed a particularly close relationship with Westinghouse, which set up for the government the Bettis Atomic Power Laboratory near Pittsburgh to work on naval propulsion. In 1953 a prototype submarine reactor, developed by Westinghouse and the Naval Reactors program, was tested on land in Idaho. Then in January, 1954, the Navy launched the *Nautilus*, the first submarine propelled by nuclear energy. The reactor was of the type known as a pressurized water reactor (PWR). (Pressurized water reactors (PWRs) and boiling water reactors (BWRs) are both fueled by low-enriched uranium and cooled and moderated by ordinary water, as opposed to heavy water. Thus they are both light water reactors. However, they differ from each other in such respects as the number of water cycles that each contains.)

Meanwhile, the public and their representatives in Congress were waiting to see the wonders of nuclear-generated electricity unfolding. The Atomic Energy Commission (AEC), which controlled nuclear projects, was afraid to squelch their hopes, but was well aware that research reports on the possibilities for the civilian atom showed that nuclear reactors would not be able to produce electricity economically for the foreseeable future. Industry was aware of this situation. C. G. Suits, director of research at GE, told the American Association for the Advancement of Science in 1950, "At present, atomic power presents an exceptionally costly and inconvenient means of obtaining energy which can be extracted more economically from conventional fuels. . . . The economics of atomic power are not attractive at present, nor are they likely to be for a long time in the future. This is expensive power, not cheap power as the public has been led to believe" [Quoted in Makhijani and Saleska, p. 50].

In 1953 the National Security Council canceled a joint project between Westinghouse and the Navy to build a pressurized water reactor to propel an aircraft carrier. The AEC and Congress's Joint Committee on Atomic Energy then assigned to Rickover the task of using the proposed reactor as the basis for an electricity-generating plant and provided him with the funding that would have been devoted to the aircraft carrier. Desires for a "peaceful" application of the atom's power were finally on the way to being realized.

In December 1953 Eisenhower delivered his famous "Atoms for Peace" speech at the United Nations, in which he offered other nations technical assistance in developing civilian nuclear programs and suggested that an international organization be established to receive and distribute nuclear materials. In 1954 Congress passed a revision of the Atomic Energy Act of 1946, the main purpose of which had been to protect the U.S. monopoly on nuclear weapons and technology. The revision laid the foundations for a domestic civilian program and authorized the AEC to cooperate with other nations on atomic energy, provided certain conditions were met. By 1956 some twenty-five agreements for nuclear cooperation had been negotiated. The U.S. civilian domestic program was developing in parallel with the U.S. program to export peaceful nuclear technology.

Why the interest on the part of the federal administration in both? In the eyes of the U.S. public the civilian nuclear program would help to justify the continuation of a military nuclear program; but the favorable attitude of the U.S. public towards nuclear energy had existed since the war. What was new was the desire of the United States, which was stepping up the pace of its nuclear arms race with the Soviet Union, to present itself in a favorable light on the international stage, and the fact that the United Kingdom and the Soviet Union were developing electricity-generating reactors. The United States wanted to be seen as the leading nuclear power. It could not retain this position if other nations had civilian programs, but the United States did not. Moreover, the United States had become aware that it did not want to be regarded overseas as a nuclear bully. The Soviet Union should be cast in this role. The United States would bestow peaceful nuclear energy on a grateful world. The basic impetus at this point was public relations.

Practical considerations were also present. At the time, the United States was dependent on other countries for natural uranium. If it was seen as wanting the uranium only for weapons, these countries might decide to cut off their supplies. Furthermore, by embarking on a program of light water reactors, which require low-enriched uranium, the United States could make other countries who chose to follow in its footsteps dependent on it, because the United States was the only nation with a free-market economy that at that time had the capacity to enrich uranium.

In addition, there was the personal angle. Eisenhower wanted to present a hopeful message to the world, and Lewis Strauss, chairman of the AEC, wanted to counter a proposal made by the scientist J. Robert Oppenheimer, whom Strauss was convinced was a communist. Oppenheimer had proposed Operation Candor, in which the federal government would share information on weapons with the public. Greatly fearing the spread of military nuclear secrets, Strauss worked for months in secrecy with the president's assistant for psychological warfare, developing, as an alternative, the plan for international cooperation that President Eisenhower set forth in his Atoms for Peace speech [McMillan, p. 183].

So desirous was Strauss to outmaneuver Oppenheimer that he failed to consider the likely contribution of his own plan (to generate "peaceful uses") to the eventual spread of nuclear weapons. Patricia J. McMillan in a biography of Oppenheimer notes, "The Russians, of course, did understand, and Soviet foreign minister Vyacheslav Molotov wasted no time asking Secretary of State John Foster Dulles what on earth the Americans thought they were doing proposing to spread weapons-grade nuclear material all over the world" [McMillan, p. 257.]

The first electricity generated anywhere in the world by a nuclear reactor had been produced in a breeder reactor at the U.S. government's National Reactor Testing Station (NRTS) in December, 1951. In October of 1957, a 30 MW boiling water reactor at Vallecitos, California, jointly owned by GE and Pacific Gas and Electric, became the first privately owned reactor in the United States to produce substantial amounts of electricity. The better-known 90 MW pressurized water reactor at Shippingport Station, Pennsylvania, developed and built by Westinghouse and the Navy for Duquesne Light Co., began operating in December 1957.

Actually the United States had lost the race to be the first to feed electricity into a public grid. The Soviets connected a 5 MWe reactor to the grid at Obninsk in June 1954, and the British started up Calder Hall, which produced plutonium for the military and electricity for civilian purposes, in October 1956. (In 1958 the Soviets started up a large military/civilian reactor at Tomsk-7.)

Nevertheless, the United States won the race for influence. The British and the Soviet reactors were graphite moderated. A fire at a graphite-moderated reactor in Britain in 1957 and the lack of a program like Atoms for Peace in Britain and the Soviet Union meant that the light water reactor, which GE and Westinghouse marketed, became the leading type of reactor on the international scene.

The economists, scientists, and corporate executives who feared that the generation of electricity in nuclear reactors would not be economically successful in at least the short term turned out to be correct. In 1955 the AEC announced a Power Reactor Demonstration Program through which it assisted in the design and construction of several small commercial reactors, and two years later the nuclear industry received a major federal subsidy, which continues to this day, the Price Anderson Act. The act, periodically renewed, limits the liability of nuclear utilities and suppliers in the case of an accident. Nevertheless, utilities were reluctant to go nuclear; and the concept of a commercial nuclear power industry faltered. GE and Westinghouse with visions of a profitable market in the future finally saved the commercial industry. Starting in 1963, they sold thirteen plants at or below cost, making them competitive with coal plants. "By April 19, 1968, about one hundred reactors were operable, under construction, or being ordered" [Gyorgy, p. 14]. GE's 1972 Annual Report explained the thinking behind GE's investment: "Our potential revenue base in a nuclear plant, for example, is some six times that of a fossil plant because we can supply the reactor, the fuel, and fuel re-loads as well as turbine generators and their auxiliary equipment" [Quoted in Woodmansee et al., p. 10]. (For a brief history of the U.S. industry, see *Critical Hour* on this web site.)

Had the United States thoroughly thought through the peacetime atom many future problems would have been avoided. Instead of an unreal propagandist attitude (we saw movies of nuclear power in high school with optimistic forecasts of ease in construction of nuclear power plants), a go slow attitude could have prevailed -- but it did not. The conversion to peacetime uses was all the more complex because there loomed ahead legitimate uses of nuclear materials, though on a far smaller scale of production and processing than electric power generation (e.g., nuclear research and medicine). (See Appendix One).

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Our brief historic review is equivalent to the Ignatian "first week" of the Spiritual Exercise, Phase One, in which the person confronts the realities of his or her own life to learn where he or she has missed the mark in the purposes for being here on this Earth. In reality, with reference to this issue, justification of actions taken at the advent of the nuclear age has not been satisfactory and the continued dangers of weapons and military applications reaffirm that fact. Instead of going cold turkey and seeing the bombs as "never again," we were tempted to tinker with making, retaining and threatening to use such devices along with developing a utility system that has used nuclear reactors to produce a "benefit" called electricity. Amid the great temptations to use nuclear weapons for one or other conflict, a second series of nuclear atrocities during the cold war and its aftermath has been avoided (Mutually Assured Destruction). However, nuclear-related problems extend to health, safety and security issues; these are related to nuclear reactors and their waste products. We must extend our consideration to the risks of such peacetime uses and to the elements that go to make a good moral decision dealing with nuclear power generation.

## PHASE TWO
## MORALITY

Do nuclear power's peacetime uses involve moral considerations?

In this phase we shall consider the continuing use of nuclear materials for power generation as a lived experience that contains a number of defined risks. It is similar to problems associated with one's journey of faith that become hidden detours and barriers. For the Christian, a model person is addressed, and his life explored in detail. Here the concept of what is moral and good is applied to nuclear power. We affirm that time must be taken to weigh all sides and to see whether the panic conditions imposed by the present controversies are really the work of "the good spirit" or whether the panic is induced by wrong elements (power grabs or risky profit-motivation schemes). What is astounding is that the same spiritual process that should be at work in coming to a moral judgment on our own life experiences (pursuing a certain profession, educational track or partner choice) is also at work here. The temptation is to make an important and irreversible decision far too rapidly. When concerned citizens discover that there is current disturbance in our national "soul," we call for further reflection. We cannot forfeit discernment and yield to the panic of a hurried decision. Our nation and world deserve something better.

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Consideration of peacetime use of inherently dangerous and unsafe nuclear materials is like discussing matches that can fall into the hands of playful young people. Moral questions arise and take on more or less serious ramifications depending on benefits of the tools used, the maturity of the user, and the immediate and distant surroundings. We know some materials are dangerous and need special care in handling lest they hurt handlers and neighbors alike. As with all dangerous and toxic materials, handling of nuclear substances involves risks that may sometimes be tolerated out of necessity, but that should be avoided when unnecessary.

When practices involve the health and safety of people, we should engage in a careful discernment as to how much risk is allowed. This applies to all phases of life from driving vehicles (erratic weaving and tail-gating) to choice of toys for children. Stalin said one death is personal but a million are a statistic. In conceiving of risks we should not think only in terms of statistics. An unsafe product or practice could involve other people like ourselves, not statistics. Manufacturers and consumers are bearers of responsibility and at times generators of risks. In producing electricity, innocence is not presumed, because utility operations may involve risky fuel preparation, harmful emissions, risky facilities, and improperly stored long-lived waste materials.

## Risks and Problems with Nuclear Power

The following are risks associated with nuclear power plants and production as well as disposal of materials:

**Toxicity** -- The radioactive nuclear materials used are toxic and can be harmful when in direct contact with human beings or, at a distance, through the effects of irradiation. Note that both uranium and plutonium are chemically toxic heavy metals. Over the years various illnesses have resulted from all phases of the fuel chain from mining, initial processing, enrichment, and fuel production, through use of the materials as well as waste management, with some ailments only occurring years after contact. A massive literature has accumulated on this subject. Recent epidemiological research has provided limited evidence that the incidence of childhood leukemia increases near nuclear facilities [Baker and Hoel].

**Accidents through human error** -- Accidents have occurred and may continue to produce results (e.g., Three Mile Island in Pennsylvania (1979) and Chernobyl in the Ukraine (1986)). Human and animal lives and health and safety have been affected. Numerous instances of small accidents have been documented though full information as to extent is not well publicized. A flight error by an airplane pilot in his two-seater or even 500-seater is serious, but a nuclear power plant error could have an incalculably greater impact with long-term effects from radioactive contamination and tens of thousands of casualties. The risk of possible human error is magnified to the degree that the error will result in extensive loss of life and limb, making accidental error a major risk through sheer potential effects.

**Accidents through natural disasters** -- The sites of many nuclear facilities are earthquake-prone as evidenced in the summer of 2007 in northern Japan. Other examples of seismic risk have come to light because so many places have had minor or major earthquakes over the years. We cannot be one hundred percent confident that systems will shut down properly, which casts doubt again on whether a power facility (that is unneeded if proper renewable energy sources and proper energy conservation measures are operative) is worth the risk. Certainly many of the nuclear power facilities are near waterways due to need for cooling water, and for them flooding could have severe effects. However, a flood, unlike an earthquake, usually does not occur in an instant, so the critical time to shut the facilities down is available. Some few power plants are located near active volcanoes or on a seacoast affected by a possible tsunami -- or in hurricane-prone areas. The warning time for many natural disasters is short.

**Nuclear waste disposal** -- Waste materials furnish a still-insoluble problem because of their long-lived toxicity and accompanying dangers; they need to be sequestered and guarded for thousands of years. Guarantees that these sites will be secure for long lengths of time simply cannot be made with an absolute degree of certainty. Much time and effort have been devoted to designing safe sites at Yucca Mountain in Nevada and at a selected nuclear "laboratory" site in Bure in eastern France, but concerned citizens raise serious doubts about transporting the wastes to ultimate disposal sites and the safety and security of the sites themselves. For one thing, land moves and changes with time, and guaranteeing that changes will not happen at a given disposal site is impossible. Critics say that to initiate a process without thinking through to the waste end of it is the work of those who never changed diapers (Elizabeth Dodson Gray). Failing to regard risks stemming from waste disposal is a moral lapse, one among many associated with this issue.

**Possible targets for terrorism** -- The nuclear utility uses and (at least temporarily) stores enriched fuel and waste materials; these are enticing targets for terrorists. After irradiation, fuel rods are removed from the nuclear reactor and await final disposal. Currently, they are stored either in water- cooled tanks or in drum casks right on the power plant property. Modern suicide-inclined terrorists are bent on maximum publicity and damage, and so taking over nuclear power sites, and thus holding entire nearby populated regions hostage is not beyond their schemes. These vulnerable reactor sites can become prime targets for terrorists. Furthermore, most of these sites are subject to attack from land, sea or air -- and such an attack is just waiting to happen. Some of these power plants are reasonably well guarded but many are not, though it would be unethical to name alleged poorly guarded sites for fear of giving terrorists ideas. Tighter degrees of security demand larger outlays of resources for security guards. Ultimately little or nothing will stop a determined terrorist; only some more easily accessible targets may divert their attention.

**Erosion of the democratic process** -- A risk that is often overlooked is the erosion of our fragile democratic processes due to enhanced threat of terrorist attacks at vulnerable sites. The threats of terrorists make it appear necessary to introduce travel restrictions, institute wire tapping procedures, make random security checks, and conduct surveillance of both citizens and visitors. Inherent insecurity associated with both nuclear sites and nuclear materials opens possibilities that nuclear materials will fall into the hands of terrorists. Civil libertarians fear that tightening controls will lead to the erosion of our democratic liberties. No utility operator wants to turn the site into an armed camp with manned barricades and check points secured by armed guards with automatic weapons. The majority of the 104 American nuclear power plant sites are within fifty miles of a major metropolitan area. If what occurred at Three Mile Island on March 28, 1979, should recur, security would be in the headlines. Security against trespassing at private sites where large amounts of nuclear materials are present is always a problem, but a terrorist incident could heighten the security measures immensely. Must we end up militarizing our entire nation in order to make it safe for inherently unsafe materials?

**Opportunity costs** -- We often forget that the world would be a less polluted place had the enormous financial resources that went into nuclear power development and plant facilities been used in other ways for the past fifty years. In retrospect, had this seventy-seven billion dollars been used for conservation programs (insulation and efficient lighting technologies that have been known for decades), expansion of micro hydropower to include thousands of impoundments and streams, clean coal emission technologies, and renewable energy (solar, wind and geothermal), we would not have such elevated levels of carbon dioxide in our planet's atmosphere. Since the United States emphasized nuclear power, we actually lost the conservation and renewable energy technological initiative to other countries of Europe and Asia in both wind and solar development. Denmark, Germany and Spain took leadership in the wind field after resolute policy decisions to de-emphasize nuclear power to various degrees. America could have been way ahead in a carbon-free environment had the nuclear power enticement not entered the picture; and investing resources in nuclear power in coming years will again slow our adoption of renewable energy and conservation.

**Proliferation** -- Nuclear power plants and fuel chain facilities risk being used as sources of material and know-how for making weapons of mass destruction, namely atomic bombs (see Section Four).

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We always take some risks in daily life, like walking across the street or driving a car. Careless joy-riding has been noted as unacceptable. The focus in this paper is risk-taking with respect to expanded nuclear power production. Is this acceptable today? Is it acceptable tomorrow? First we note that if the risk is necessary even for a period and then becomes unnecessary, the risk can be taken, at least now. If our food supply is limited today, it may be necessary that we eat some possibly contaminated food to prevent starvation. Under such circumstances a risk is acceptable; when food is plentiful it is not acceptable. As we will see in the next section, the acceptability of nuclear power as risk could also change with time, and what is acceptable today may not be so tomorrow.

## Elements for Moral Consideration

Every decision-making process must be transparent and that means the various factors that go into advocating one or other position must be open to the decision-maker in all their raw reality. Personal discernment that never comes to terms with one's own faults can not succeed. Collective discernment must do the very same thing, namely, discover characteristics and influences that are below the surface that can change the outcome of the reflection. Decision-making as important as expanding nuclear power facilities must take all influences into consideration.

**Recognize biases.** On any issue the various protagonists and antagonists may have personal foibles such as headline hunting or egotistic gratification that could add to the complexity of the decision-making process; these should never be discounted. The same is said about public policy-making: the hidden influences come into play in decision-making whether biases of individual makers and shakers or group biases that color the outcome. If people want war, they can influence peacemaking activities and even cripple the effort to establish or preserve peace. If they want low-cost electricity, they will often accept risks to see that they obtain this perceived benefit.

**Know the facts.** The nation and world stand at a point of decision about safer and less harmful energy sources, and this calls for free and open discussion. The economic cost of maintaining traditional energy sources should not be the main determinant in energy choices because hidden environmental costs are virtually never completely included. For fuel choices, the safety and environmental factors must be factored in and made known to the public. All too often environmental factors are omitted in a public economic analysis. Citizens have the right to know all sides of issues, and should then realize that economics must be weighed together with environment, health and safety and even general community well being and fears.

**Acknowledge profit-motivation.** A company's foreign sub-boss who had substituted cheaper alternatives for specified materials recently confessed, "I only wanted to make a profit." Enormous corporate pressures can be brought to bear on national policy by highly profitable oil, gas, coal and nuclear firms. Billions of dollars of oil money can be diverted to "educate" the public on the benefits of a particular non-renewable fuel, and these educational initiatives cannot be matched by advocates of renewable energy and conservation who have equal motivation but far fewer educational resources. Highly profitable fuel-source industries such as oil companies cannot be expected to surrender their relative position in the national energy mix without a fight. As long as oil hovers above $80 a barrel, one can expect that ample financial resources will be put forward to continue the favorable position. These fossil energy companies are no longer contesting the global warming hypothesis; but they intend to be a major component of a total energy mix until the last drop of commercially available oil is consumed. The tragedy is that a major reserve of petroleum should be retained for future non-fuel manufacturing purposes.

**Consider the total economics.** The bottom line of many decisions is economics, and that is part of the present commercial world in which we live. Insurance rates for possible mishaps are so exorbitant that the government picks up a sizeable part of the coverage. In the nuclear enrichment field most of the construction and security costs have been borne by the federal government as part of its interconnected military weapons program. Both of these contributions greatly affect electric rates. Pro-nuclear arguments tout the low cost of electricity derived from nuclear power -- though prices are far higher than the original boast that it would be "too cheap to meter." Power plant costs include planning, siting, regulatory procedures, construction, testing, and start-up, all before a single electron flows. Such plants today cost in excess of one billion dollars and the price tag may go higher.

Undoubtedly, all electricity rates will increase in the coming years. Few current fuel sources can beat coal's electric rates, but hidden environmental costs such as health bills and effects on global warming could change that picture entirely. Coal producers stress coal gasification as a cleaner coal-burning source and speak of sequestering emitted carbon dioxide in ground storage cavities; both are costly propositions. As more and more environmental costs are factored into electric rates, the renewable sources will look better and better. Furthermore, new technology breakthroughs and economies of scale will make wind and solar far more enticing in the coming decade.

**Unearth governmental favoritism.** Those who have more money often have more influence in governmental agencies due to sophisticated lobbying efforts, which are out of the reach of non- profit public interest groups. The highly profitable and highly placed coal, oil and gas producers have skewed the total national energy mix in favor of non-renewable energy sources -- and in their camp one can include nuclear power. Governmental favors have included tax incentives for exploration, subsidies to fuel processing facilities, insurance rates that make nuclear power affordable despite the risk of accidents, and promotion schemes for such fuels or modifications (coal gasification, etc.). Leveling the field by removing subsidies available to non-renewable and nuclear energy sources and increasing grants and loans for developing renewable energy sources will allow for faster development of renewable energy and remove unfair advantages for the very energy sources that ought to be phased out.

**Know all environmental and societal costs.** Power plants emit air pollutants that cause injury to man and beast. And very little of the costs comes from corporate profits; the private citizens and the government pick up the medical costs. The arithmetic of cost accounting displays the truth: land is disturbed through surface coal mining; laborers' lives have been shortened by black lung or through deep mine accidents; emission products contaminate the water and air causing emphysema, asthma and a host of ailments. These costs are eliminated by converting to renewable energy sources. However, even there some consideration of costs must be included. Biofuels are combusted and thus emit carbon dioxide and some toxic materials as well. When biofuels are derived from food sources (e.g., corn), another ethical issue arises from increases in staple costs for the poor. All energy choices have gray areas.

**Realize other cost factors.** Electricity is electricity, and is not a different type if produced by nuclear or fossil fuel sources. It may differ in amount only, if the source is not uniformly operating (solar in the day and not at night or wind only when the wind is blowing -- though storage batteries can make the source more continuous). Electricity may be more expensive, if the fuel source is at a great distance and more difficult to transport due to lack of facilities or lack of access, or due to distance, utility line losses, friction and strife at the source or along routes. The truth is that consumer choices are not like a menu at a restaurant; all too often these are not made by unbiased thoughtful determination, but by subtle pressures on the part of the energy industries. Economic factors vary with time. A general rule is that it is a better choice if the fuel source is closer to the place of electric consumption. This rule favors renewable energy choices, for the fuel (wind and solar) is free for the taking -- though taking can involve currently expensive equipment and there are higher and lower quality renewable sources. However, for the greater part, limited production of solar and wind equipment is the bottle neck slowing increases in solar and wind energy use.

**Reveal the hollow "trust us" syndrome.** What complicates power plant safety is that the nuclear power industry has from its inception touted its own ability to handle the fuel safely and to protect the materials from theft and misuse. This "industry propaganda" has so mesmerized both workers and local residents that they have come to feel safe with nuclear power plants even after hearing of accidents. Note that in France, the major nation committed to nuclear power generation, 90% of polled nearby residents feel safe with their nuclear power plants, and a majority of American nuclear power plant neighbors feel the same, according to a British Broadcasting Program of August 4, 2007. However, concerned citizens within a given metropolitan area containing nuclear power plants do not share these comfortable neighborhood feelings. Furthermore, concerned citizens in areas distant from such power plants do not all share the desire that such facilities be built downwind from where they live, even a hundred or more miles away.

**Weigh technical versus common sense discussions**. In the battle over something as complex as nuclear power the technical matters soon leave the average citizen far behind. That technical battle could easily be a "snow job," for technical experts are quite slow to admit to their own basic uncertainties about the technology. However, much depends on the degree of sureness in voice and debate, and that can undermine the confidence of a citizen who admits to not understanding all the safety valves and computerized devices in the power plant. Even the experts whom citizens hire to study the technical materials may be outsiders when it comes to familiarity with technical details.

**Try to tackle addictive behavior.** Knowing information does not guarantee good decision-making, especially by people who are addicts (and even President Bush said in the 2007 State of the Union address that "America is addicted to oil"). Unfortunately, moral decisions dealing with important environmental matters suffer from this very affliction due to the impulsive desire to have convenient lower-priced fuels. Addicted consumers are not balanced in judgment on energy matters especially if they seek to defend their own wasteful practices. Addicts tend to be fixated and do not look beyond the present moment; they hardly plan for the future and so their good judgment has been impaired by desiring the status quo -- the cheap gasoline fix day after day. Should final decisions rest on people who exhibit such behavior?

## Moral Decision-Making

Decision-making may be slow or quick depending on what emerges in the initial gathering stage. However, human beings are who they are; some want quick answers; other procrastinate for a long time. Some reflection is needed; some deliberate speed is needed; and we must balance all this with respect to the issue at hand. Our collective policy decisions must include the following:

Know where there is agreement and disagreement. Opposing parties most likely agree that one cannot legislate morality or decide what is moral or immoral through a popular election. But they will attempt to have their view win in any policy debate. It is wise to agree where possible and not pretend to agree where there are major differences.

a) Nuclear issues of greater agreement -- keep nuclear weapons and other materials that could be used as weapons out of the hands of terrorists (all reasonable non-terrorists will agree); place effective controls on the production and retention of such nuclear materials; avoid any unnecessary risks that would allow existing materials to fall into the hands of terrorists; and halt the proliferation of nuclear weapons to non-possessing nations.

b) Energy issues of emerging agreement -- Accessible and reasonably priced energy sources are needed for the health of the economy; some amount of electricity is needed for meeting the basic needs of all people; energy sources that allow for the emission of greenhouse gases should be curtailed and replaced whenever possible; all things considered, emphasis should be placed on a carbon-free energy economy when it comes to electricity generation.

c) Moral issues without current agreement -- Nuclear weapons should never be produced, stored or used even by nuclear possessing nations; the spread of nuclear enrichment and fuel processing facilities should be stopped, and strict international controls on reactors established; the historic use of atomic weapons at Hiroshima and Nagasaki was immoral; due to possibilities of proliferation of nuclear weapons, it is morally wrong to use unsafe electricity-generating processes when other sources are available for basic needs.

Moralists with strong pacifist leaning argue against the production, retention and use of nuclear weapons. The only use to date of nuclear weapons (in 1945) was against civilians to scare an enemy government into surrender. The morality of that use (in contrast to first scaring Japan by dropping bombs off the coast to show the destructive power of such weapons) is questionable. The moral arguments are concise and clear for most to understand, but history is past and errors have been made. How we see these faulty moral judgments reveals our own openness to questions related to the peacetime use of the atom.

**Allow all input**. Some say that listing only pro arguments and only con arguments with prayerful reflection in between is a highly successful way to resolve many moral difficulties. We need to allow the truth to emerge and most often it happens when all sides are clearly articulated. However, one who is intolerant to another side can discourage free discussion. The current nuclear debate must hear from all sides, and what is emerging in this presentation is one such position that is most necessary in the court of public opinion. With far more resources representatives of the pro-nuclear position can have greater access to the public media and are making their case at this time.

The ancient Greeks allowed only certain free males to vote, and to some extent early Americans practiced such limitations along with restricting the vote to property holders. A far wider deciding public exists in our country today, and all ought to help decide energy policy issues -- not just powerful energy CEOs in a back room. An informed public is necessary, for we hardly want elites to judge for us on this matter. The burden falls on the concerned citizen to make his or her voice known in this national and global debate -- and to educate and enlist support from those who have freed themselves from "energy addiction." The proper choice of energy sources is something that affects us all (health and safety wise, planetary life and well-being, future generations, and through our pocketbooks). Thus the broad constituency must be encouraged to take part in the discussion.

**Expose hypocrisy.** Hypocrisy can arise when one nation has and another does not have access to nuclear processing capabilities. China, India, Pakistan and Israel have nuclear weaponry; why should Iran remain nuclear free? That's the patriotic Iranian question that we find difficult to answer. Why should one possessor of such weaponry decide that another nation should not at least possess peacetime nuclear fuel generating capabilities? Does Israel refuse to press for a nuclear-free Middle East because it possesses nuclear weapons in secret? And shouldn't the existing nuclear free-zones be extended to more and more regions until the whole world is nuclear weapons free? And then the additional question: is the jealous guarding of a nuclear power generating enterprise helping to hold back long-term disarmament and multilateral nonproliferation initiatives?

**Consider prudent fears.** Some fears are unfounded; some are blown out of proportion; some are rightly expressed not just for one's own neck but for neighbors near and far. We must not reject fear as solely emotional and irrational but investigate its cause. Some appear fearless to prove that they have mastered the situation -- but that is pretending. Fears of prudently concerned citizens may be well founded and even a virtue. These people realize that we cannot act through unwarranted risky behavior, and the greater the possible risk, the more hesitant we ought to be in acting --and that hesitancy is interpreted as "healthy fear." The fear of nuclear power misuse is quite real, for history has already shown such misuse in Hiroshima and Nagasaki in 1945. Thus legitimate fear colors nuclear weaponry and nuclear peacetime uses, because a history of misuse exists. Nuclear power proponents may argue that the fears of people are unjustified and that the dispelling of these fears works to the betterment of everyone; they may claim that past mistakes have been rectified, new regulations now correct old deficiencies, human error has all but been eliminated, and the technologies are highly improved. Such arguments recall "trust us" in pre-Three Mile Island days. We fear that they are not true.

**Weigh all sides carefully.** As a decision-making step draws closer the various sides must be given full consideration. Some national policy decisions have omitted the moral discernment process, and this has resulted in unfortunate consequences. What if railroad expansion on the Great Plains had included the morality of killing the bison herds that were the life blood of the Sioux nations? Much injustice to the Native Americans would have been avoided. What if recognition of the moral implications of tobacco smoking had occurred sooner, thus resulting in lives saved and improved health? -- but recent tobacco smoking policy decisions had to overcome a massive propaganda barrage on the part of the tobacco industry in the last third of the twentieth century. A total discernment can be achieved after all sides are allowed to speak. Nuclear power expansion needs this period of listening and deliberate discernment, and all sides including this one need to be heard -- even when the other side is highly endowed with educational resources and access to the media.

## PHASE THREE
## NECESSITY CONSIDERATIONS

Is nuclear power production necessary for electric generation?

Where there are life and death situations, the moral decision takes on added significance. Such is the case here. Some nuclear power advocates argue that nuclear power is "necessary" to help operate respirators and air conditioners needed to save lives of the sick in hospitals. At least, considering electricity to prevent suffering and death as necessity over and above the use of hair dryers and electric pencil sharpeners is a positive step. We must consider what constitutes this necessity and how it can possibly be met by less risky procedures. The discussion actually enters into what is regarded as the discernment process (the Third Week of the Spiritual Exercises). The Second Week (the previous section on morality) deals with modeling our judgments after a perfect moral model and so the ideal good person is actually reflected upon (for the Christian this is Christ himself).

Here we turn to public policy-making. What constitutes a proper moral act in respect to periods of risks? What constitutes an acceptable risk? Does this change in the course of history? Is it possible that what has been acceptable for the last forty years is no longer so? So much depends on "necessity" in which we again confine our imagery to the morally good person who is willing to confront life and death situations -- and some have done this quite well and become our models for how we ought to act.

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A panic is building in our society over the need for energy and over global warming. This panic and the desire to do something about it make some turn to nuclear power. The nuclear establishment itself has, in great part, generated the panic. Instead of putting forward a rational plan for a national renewable energy thrust that would be similar to the man on the moon space program of the 1960s, these nuclear power advocates are seeking to stampede people who need to be assured of their electricity supplies into opting for nuclear power at this moment. Thus the road is wide open for panic choices much like those made at the end of World War II. And this is not the work of the ideal moral person -- but of the irrational with us as a people.

**Perfect storm for current "necessities."** We recall the panic of the 1950s after our Soviet rivals acquired the atomic bomb in 1949. We remember that this brought on more and more armaments and upgrades from atomic to hydrogen bombs, an increase in open air testing of materials (five such post-war tests had occurred before the Soviet detonation) and the cost to health that resulted, the deployment of nuclear weapons at far-flung bases in Europe and elsewhere, and the eventual development of nuclear power generating facilities. As is becoming evident in following the current news coverage, the situation is different today than it was fifty years ago, but a similar panic may be developing.

Some factors precipitating panic on the part of policy-makers and voters include the following: the awareness of climate change and global warming; numerous terrorist threats to sabotage existing or new centralized facilities; the interconnection between the civilian and the military atom; the willingness to punish enemies (Iran, etc.) through first strike procedures (this can also panic peacemakers); and the rapid growth of electricity demand throughout the world. To all of these can be added a few names of so-called environmentalists who have recently converted to the nuclear cause. Why they changed is hard to fathom but not worth speculation; for one thing it makes good media copy. A swing has occurred in public opinion; increasing numbers believe that the so-called necessity of electricity is worth the risk of nuclear power facilities; they accept the policy that nuclear wastes can be out of sight and out of mind in a deep mine shaft in the clay of eastern France or Yucca Mountain, Nevada.

**Culture-driven "discernment."** A combination of this current panic and supposed energy needs that must be met immediately sets up conditions that will only result in more bad choices that lack prayerful reflection and rational discernment. Few realize that the power behind both panic and especially the supposed necessities is based on deficient cultural assumptions about necessity and tolerance for energy waste within current American and western lifestyles. We as a people have had our democratic processing and judgments eroded by biased media and extravagant economic considerations. Furthermore, we do not have a tradition of stopping to discern matters carefully and thus are prey to panic and quick decisions. A major problem is failure to read not by the functionally illiterate but by the culturally illiterate who no longer read and ponder serious materials. A nuclear-powered "perfect storm" (right conditions for reintroducing a nuclear building program) is ready to take place and has been engineered by proponents of nuclear power at this precise moment.

**The "stability through diversity" argument**. Only a convincing argument from necessity could overrule the many real risks and threats to health, safety, security and democratic process listed in the previous section. An argument for stability within the diverse energy supply system in which nuclear power (a major contender today) would be a component is somewhat convincing to many. That is at least a tangible argument but one must be convinced that each component of the diverse grouping will hold its own weight over time. No one denies that a host of renewable energy sources are more stable than only one or two. The question is whether the grouping of acceptable energy sources should be all inclusive.

**Necessary now?** With respect to the maintenance and development of nuclear power, two aspects of necessity arise: what is necessary at this moment due to current reliance on nuclear power facilities, and what is necessary in the foreseeable future as part of the total energy mix of our nation and world. The 104 functioning U.S. nuclear power plants account for about one-fifth of our current electricity needs. Several nations obtain a greater portion of their electricity from nuclear power: France (four-fifths), Sweden and Ukraine (about half), Germany, Finland and Great Britain (about one-quarter). Policy-makers in some countries like Germany vacillate between continuing existing nuclear production at current percentages and developing a moratorium and retirement of nuclear facilities, as power plants reach the end of their useful lives. Other countries call nuclear power an energy "necessity" in the light of fossil fuel plants producing greenhouse gases. The nuclear industry claims that a newer generation of nuclear power plants will be both improved and necessary to meet growing energy needs in the age of global warming and of de-emphasis on fossil fuel for electric generation.

**Necessity has to be defined**: a broad definition focuses on keeping current electricity demands satisfied even if some of them are luxury demands; a restricted definition is keeping current basic service needs that are for the basic essential use of customers without consideration of luxuries. Expanded necessity has come to mean things not dreamed of a century ago when electricity use was in its infancy. Then the elderly did not expect to have air conditioning, since it was unavailable and they suffered through heat waves in cooler places or as best they could in the heat of their residences. The "necessity" of electricity grew in definition through the years from illumination to cooking food, from basic refrigeration and fans to air conditioning. Thus with time and extended power facilities, more and more of the world's people entered the field of available electricity, and former luxuries were turned into necessities due to consumers' extended expectations. To meet these demands, electricity generation expanded beyond the sources of early day hydroelectric facilities and coal-burning facilities and included a broad mix of gas and oil-burning plants, geothermal facilities, and even the use of biofuels of various types. And nuclear power facilities were incorporated into that "necessary" mix in and after the 1960s.

Current necessity refers to the need for power plants today to meet current energy needs; this involves the willingness to take risks that should be reduced as nuclear power plants are retired and other safer and less polluting forms of fuel sources are utilized. Thus an installed nuclear economy may not be able to be shut down abruptly lest it cause a major disruption of an economy, and the fuel source -- though risky -- may currently be regarded as relatively necessary. An analogy is that of a home where some residents serve in a militia and keep automatic weapons around though with some degree of insecurity. Young children could be regarded as being at risk because of the presence of these weapons at the domestic scene. If the national or regional emergency is so great, the risk of readily available arms may have to be tolerated for a certain period, but in prolonged periods of peacetime the necessity of keeping these dangerous instruments at hand recedes; then the weapons have to be stored in a more secure place.

**Conservation overcomes necessity**. Americans waste energy and especially electricity, even though the total amount is somewhat uncertain due to different assumptions related to energy needs and efficiency. Some estimate that one-quarter of American energy is wasted, but the total could be higher. An example of energy waste is the dominant use of old-fashioned heat-generating and –losing incandescent light bulbs; these could be easily replaced by compact fluorescent bulbs in our homes and businesses. The U.S. Department of Energy talks about the number of power plants that need not be built if every home replaces the five most used bulbs. Abundant literature, including *Critical Hour* and its update, indicates that construction of power plants can be avoided for a significant length of time if both utilities and governmental policy are geared to conservation measures. An underlying problem is whether the consumer (addicted to energy waste) will adopt the advantages of a more conservationist ethic and do this in a rational manner. Instead of supporting the building of more "necessary" power plants of any type, all indicators point to conservation as meeting so-called increased demand for at least the next decade. But the question is: will this occur given the current levels of energy debate and global warming discussion? The jury is out.

**Coexisting responsible energy sources.** In a consuming society some people will "need" only basic electric services and others will waste a high portion of the electricity they now consume in their homes -- even when they think they "need" it. Equipment is on standby, lights burn without the room being used, insulation is poor, much domestic space is excessively air-conditioned in summer and heated in winter, heated water is wasted, and on and on. This waste is not always addressed by raising the consumer's electric rates. The mingling of conservation-conscious and energy-wasting people with little outward distinction makes pinpointing the wasters somewhat difficult -- though their utility companies could do a fair job in such determinations.

Should we tolerate this parable-like field of the intermingling of the good grain and the weeds (tares)? The utility itself, if primarily conceived to be a deliverer of electricity and not a producer of electricity, would benefit by conservation, if that means not requiring extra electricity from new power plants. Energy conservation could work to the overall benefit and even profit of such a utility as well as of the consumer. Thus conservation could become something more than a collection of individual energy use choices. The electric utility would become alarmed over heavy electric use by wasters within their service population. It is similar to a water utility notifying customers when a severe water leak occurs; the electric provider would look into the usage of customers and tactfully address the waste of certain residences and businesses. In extreme cases the utility could levy surcharges on culprits and even notify the public about those who are major electric wasters.

**Potential enhanced geothermal sources.** An M.I.T.-led study of the potential of geothermal energy obtainable from the hard rock under much of this country (especially the western half of the continental United States) shows that geothermal could meet a portion of future electricity needs. The EGS resource base is enormous, or 130,000 times the current U.S. annual consumption of primary energy. This base is calculated for a drilled depth of ten kilometers though technical drilling limits can reach three times that depth. Well costs are the significant economic component, and these and other factors determine how much of that vast resource can be tapped at a given time. The study shows that break even costs (based on competitive energy market prices) will occur within ten years -- the time for a new generation of nuclear power plants to become operational [Massachusetts].

The potential for renewable energy replacement from geothermal sources alone is immense. Advantages over nuclear power development include: safety of method; lack of incentive to terrorist actions; use of currently available oil and gas drilling expertise for the work of geothermal drilling; underground location of energy capture and extraction; and lack of emissions or disposal problems. An advantage over solar and wind is that the geothermal process works well day and night offering an uninterrupted source of energy. Some environmental problems such as quantity of water injected to obtain the steam or hot water from the well and possible seismic effects in certain locations will have to be worked out over time. Also, this energy source is more accessible in the western part of the United States.

**Solar and wind breakthroughs.** As mentioned in the *Critical Hour* update on this website, both solar energy and wind are now undergoing breakthroughs in technical innovation that are introducing more easily available and processed materials and reducing the end product's price substantially. Right now in many parts of this nation wind is competitive with other fuels and it is becoming more so with each passing year. The major hurdle is that the manufacturing base to allow for enhanced wind power growth in this country is in short supply. New coating for use on roofs after all technical challenges have been worked through should make solar energy, when tied into existing electric grids, a major contributor to the total energy mix. One of the great advantages of both solar and wind is that they can be either centralized or decentralized and, in the latter case, reduce immensely the threat from terrorist attack on the integrated electric grid system.

In conclusion, a combination of energy conservation that forestalls the need for new electricity generating capacity and of encouragement of renewable energy sources could hasten the replacement of nuclear power plants and outmoded fossil fuel-burning plants at the end of their respective lifetimes. A level energy playing field should be established reflecting the true costs of all fuels, those that are more commercially available, those requiring more security, those causing environmental pollution, and those that have other reasons for being currently profitable. For this reason a carbon plus waste generation tax that is proportional to the amount of carbon dioxide emitted and nuclear wastes generated should be imposed on all fossil fuel burning and nuclear waste generating facilities. The tax money should go to a renewable energy development project.

**Man on the Moon Energy Project**. We are in a crisis situation. This is a perfect time for a Man-on-the-Moon-style renewable project. But since much of this terrorism is caused by disparities in power bases and resource controls, a way to peace may be through sharing of resources on a humane level. Renewable energy is non-polluting and can be more decentralized and less threatening than either large-scale fossil fuel or nuclear power plants. Renewable energy sources that are generally accepted could be furthered by focusing on them much more of our national resources (and those of the European and other developed countries). A refusal to foster panic and yet a willingness to perform a planned project of immense proportions (tens of billions of dollars) would accelerate the movement to a renewable energy economy at a very rapid rate. Such a Man on the Moon-style project could subsidize the building of solar and wind equipment manufacturing facilities with tax credits and loans, assist research in lower cost solar and wind designs, assist in deep drilling for geothermal deposits, give grants for the installation of tidal energy projects, encourage the production of biofuels from waste products, and initiate innovative energy conservation measures.

**Moral conclusions.** Obviously, it is wrong to take unnecessary risks that could involve the health or safety of ourselves or others. A person is certainly acting irresponsibly if he or she leaves a loaded gun lying around where it is accessible to young children. Suppose a person is a member of the militia and in a time of emergency the gun must be retrieved quickly; a time of added risk exists that makes accessibility of the weapon important. A similar situation could be envisioned with electric power production: if the facility is risky but electricity is necessary, there is reason to run the generating facility. However, if the electricity is "needed" for luxurious or inherently wasteful practices that could be easily changed, the unnecessary risk should not be tolerated. To reduce this relative necessity and hasten the day of renewable energy for the sake of the planet, positive actions must be taken. We must install renewable alternatives.

**Save our Earth**. Prudence is needed when dealing with the health and safety of people and Earth herself. The issue of health and safety extends to a wider group of electricity-generating sources than just oil, gas and coal; it includes nuclear energy as well. Because of the toxic wastes generated, nuclear energy must be included in this energy-priority discussion. Besides, one must note that fossil fuels have been an important component of nuclear production (see Appendix Two). Furthermore, a "good" safety record for nuclear power is not enough; the high degree of performance demands that risks that involve the health and safety of various numbers of people should never be taken if alternatives are available. Prudence dictates the phasing out of nuclear power, and certainly not its extended or even accelerated use. This message is seen clearly by those who are willing to act, to take to the streets to convince a rather energy-addicted public to wake from their stupor, and do something meaningful in the name of our troubled Earth that is being harmed by their wanton energy use.

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In the next section (the "Fourth Week" of discernment) we go beyond saving our planet and include a second and greater reason -- a giving of new life through a greater ensuring of peaceful conditions to allow for meeting the needs of all people and creatures. This must be done by looking at the interconnections of the military and peacetime uses of nuclear materials. Cutting out civilian uses allows the strengthening of nonproliferation initiatives and thus the discernment reaches into the deeper brotherhood and sisterhood of all the planet's inhabitants. Let us discuss this issue next.

## PHASE FOUR
## PROLIFERATION

Is nuclear weapon proliferation an inevitable consequence of nuclear electric generation?

The final section deals with the need to face the issue of life itself. To choose life means we see the need for doing those things that are necessary to renew and resurrect the hopes of a peaceful world; we are willing to act now, in order to give new life to a troubled world. The drama here involves going cold turkey on any new nuclear power plants and phasing out the existing ones in a reasonable span of time. That affords an option for proper energy use in our troubled world, a use that will help save our endangered planet.

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Today it is generally agreed that the difficult part of producing a simple nuclear weapon or an improvised nuclear device (IND) is obtaining sufficient fissile material. The technical knowledge to build a device, once the material has been acquired, is widely available, in part through the Internet. Civilian nuclear programs may, in a variety of ways, help nations to obtain these materials. This fact is illustrated by nations that have acquired or tried to acquire nuclear weapons since January 1, 1967. (The five nations that exploded a nuclear device before that date, China, France, Russia, the United Kingdom, and the United States, are classified by the Nuclear Non-Proliferation Treaty [NPT] as nuclear weapons states. India and Pakistan have acquired nuclear weapons since that date without signing the NPT. Israel has also not signed the treaty. It has never acknowledged having nuclear weapons but is “indisputably regarded as a de facto nuclear weapon state” [Cirincione, p. 259]. North Korea exploded a poor-performing nuclear device in 2006 after withdrawing from the treaty.)

Perhaps the most obvious way in which civilian reactors give rise to nuclear weapons is that equipment or materials obtained openly for civilian programs are turned to military use. The plutonium produced in civilian reactors may be used for military purposes; highly enriched uranium for military use may be produced in a plant ostensibly intended to enrich uranium only to the level required for civilian use.

India obtained its fissile material with the help of Atoms for Peace. Canada supplied India with a research reactor, fueled by natural uranium but dependent on heavy water as a moderator. The United States sold India a part of the required heavy water. Both Canada and the United States received written assurances from India that the reactor and the heavy water would be used only for peaceful purposes; but India used the plutonium produced in the reactor and separated in an ostensibly civilian plant for its first nuclear explosion and for weapons.

Another way in which civilian programs can facilitate military programs in states trying to obtain nuclear weapons is that they act as a cover. This has happened in the case of North Korea, a state that claims to have nuclear weapons, and of South Africa, a state that produced nuclear devices and then voluntarily gave them up. North Korea is believed to have begun a nuclear research program in the 1950s; but not until the mid 1980s did the international community realize that North Korea intended to make nuclear weapons. South Africa ostensibly began its nuclear effort with a program to use nuclear explosives to help dig mines. It acquired a reactor from the United States under the Atoms for Peace program. Later it developed enrichment technology, which it used to produce highly enriched uranium for weapons [Cirincione, pp. 409-11].

A third way is that civilian programs may be the source of information and parts needed to build plants to produce highly enriched uranium or to separate plutonium from irradiated fuel for weapons. Pakistan, concentrating on acquiring the ability to enrich uranium, obtained the knowledge necessary to construct a particular type of enrichment plant, gas centrifuge, from civilian plants in Europe in the 1970s and 1980s. In fact, Abdul Qadeer Khan, who oversaw the construction and operation of a gas-centrifuge plant at Kahuta in Pakistan, had been employed at the Urenco enrichment plant in the Netherlands. He was able to arrange for Pakistan to obtain from West Germany a complete plant to produce the uranium hexafluoride used in enrichment and equipment from Canada, China, France, Italy, Switzerland, the United Kingdom, and the United States.

Given the fact that in nations seeking weapons, civilian programs can lay the groundwork for military programs, civilian programs, carried on in the NPT weapons states and in nations with no intention of making weapons, facilitate proliferation of nuclear weapons by encouraging developing nations to use nuclear power. It goes without saying that plans to meet energy “needs” with additional nuclear reactors in countries like the United States are an incentive to developing nations to use nuclear power also.

Furthermore, the risk is not limited to the question of whether sovereign states will develop weapons by means of civilian programs. The danger of sufficient material to build an IND falling into the hands of terrorists is vastly increased by the spread of nuclear materials throughout the world. The United States does not do as good a job as it should of guarding material at nuclear power plants and civilian research centers. How well then are countries like Thailand and the Democratic Republic of the Congo protecting their fissile materials? Some scenarios even envisage a sovereign state with weapons capability deliberately aiding a terrorist group to make an IND. Furthermore, the more widely spread civilian facilities are, the more transportation of nuclear materials occurs. Material in transport is harder to guard successfully than material within an installation.

The Nuclear Non-Proliferation Treaty, which was signed in 1968, has a dual purpose: to encourage peaceful use of nuclear energy and to prevent non nuclear-weapons states from acquiring nuclear weapons. Parties to the treaty are to assist in spreading peaceful applications of nuclear energy but not to spread or assist in spreading nuclear weapons. As we have just discussed, civilian programs can lead to military use. Therefore, the two purposes of the treaty are not compatible with one another.

The United States and the other nuclear weapons states, however, cannot consider themselves innocently trapped between incompatible demands. They negotiated the NPT, which, in fact reflects President Eisenhower's belief that the United States should help other nations develop the peaceful application of nuclear energy but should keep to itself nuclear weapons and military know how. Furthermore, the United States and other weapons states flagrantly and willfully neglect the sixth article of the treaty, which states that each party to the treaty is to negotiate "in good faith, on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control." As we write, the Bush administration is attempting to modernize its nuclear arsenal. It has no intention of engaging in "general and complete disarmament."

The argument made by the current Bush Administration that the enrichment of uranium by Iran can lead to making materials for nuclear weapons is one of the best that can be made that ostensibly civilian programs can lead to the proliferation of nuclear weapons. The same concern has been shown not only by the United States but also by other nations against North Korea's drive to become a nuclear power. However, the president of Iran has a response that has a bite to it: if some countries can have the bomb, why can't we -- if we so decide?

Yes, Iran should not be enriching uranium; nor should other nations on their own. All enrichment needed for medical and other legitimate purposes should be handled through direct supervision by the IAEA and the United Nations using existing facilities, which are more than capable of such operations. The fact that a superpower decides who can or cannot be in the club is outside the multilateralism that should help protect and preserve the human family. To tolerate nuclear weapons by some and encourage nuclear power facilities apparently for all under limits, is obviously duplicitous to the unbiased. The current world situation results in a catch twenty-two: we must simultaneously have and not have nuclear materials. Is Israel's nuclear program overlooked while attention is given to Iran? What about the manner in which North Korea was treated when regarded also as a rogue state? Does failing to address a nuclear-free world and especially a nuclear-free Middle East result from this attitude of unilateralism?

The problem of inevitable nuclear proliferation leads to a still more frightening question. Is nuclear technology so sophisticated that it defies control by a democratic people and needs to be handled by a highly experienced elite that can overrule the will of the people? And in the same arena, are strict controls on nuclear weapons a progressive "militarization" of the peacetime uses of the atom? No one who seeks to protect civil liberties should take these questions lightly. For some experts, the horror of outside agents wielding destructive nuclear power or the inherent dangers in safety issues are a temptation to keep these matters from the hands of the people. Should the names of unsafe nuclear power facilities be released to the public and thus fall into the hands of terrorists? Do not citizens in a democracy have the right to know? Should such rights be so restricted to a few citizens that the broader public is successfully excluded? Everyone knows in this age of free-flowing information that such restrictive measures are virtually impossible to secure.

Information cannot be retained by a select few forever. Some think that only the enlightened should know, and that only the super-enlightened have the power to decide who should be in the inner circle. The divine right of kings now appears to extend to the divine right of the knowing elite of select "developed" nations. For them, the decision-making capability is obvious and the peons are to be excluded. With such thinking, democracy erodes. The intertwining of military and corporate interests was highly feared by such statesmen as Dwight D. Eisenhower who coined the term "military-industrial complex." Are there hidden forces at work in the intertwining of military and peacetime use of the atom that erode world peace efforts? Certain corporations play key roles in both the civilian and the military nuclear areas.

This basic moral problem of nuclear proliferation determines the entire moral argument of nuclear materials. Nuclear weaponry is "allowed" among certain present possessors (the United States, Russia, the United Kingdom, France, China, India, Pakistan, and presumably Israel) and not among the aspiring ones. (Israel has not admitted that it has nuclear weapons, but it is “indisputably regarded as a de facto nuclear weapon state” [Cirincione, p. 259]). In recent years the efforts to curtail nuclear proliferation seem noble at first sight. However, it is hypocrisy to allow some possessors to go unchallenged and then give total attention to those who are aspiring nuclear weapons possessors(Iran and North Korea). If the aspiring nuclear power does not have the processing capability, then the nuclear weaponry will not develop. Proliferation of wartime weaponry and uranium processing for peacetime purposes go hand-in-hand. This "fungibility" of nuclear materials is at the heart of the nuclear accessibility question; most fail to connect the two since they regard peacetime uses as necessities and military weaponry as a different sphere.

Nuclear fuel processing for peacetime purposes can and does lead to the proliferation of nuclear weapons. While a nuclear power like the United States continues to develop weapons of mass destruction, some regard Iran's doing so as horrifying. Let us not deny it: continuing weapons production by any nation is horrifying. Just the thought that the United States and other nations are committed to develop ever more sophisticated nuclear weapons is equally horrifying. We shudder at the consequences of such continued actions. Ultimately, the morality of nuclear power production rests on this proliferation issue, an issue of immense importance for peace throughout the world.

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Hidden costs down the road were down-played and experts were left with inevitable problems that could not be handled by lower echelon bureaucrats or workers. Just as handling unsafe and dangerous materials always requires careful consideration, so waste materials that could be around for thousands of years demanded thoughtful planning as to whether they should be produced in the first place. A moral question emerges in regard to unborn future generations who will have to care for our radioactive waste, thus receiving a legacy that they will most certainly not appreciate.

The problem of haste that makes waste, or here, unplanned-for disposal of waste, is unparalleled in human history. Merely saying "peace, peace" does not justify a practice. The peacetime use of the atom, conceived in the guilt of the bombing of Nagasaki and Hiroshima, eventually became a massive moral cover-up, an immense national and international effort that has attempted to prove that the end did justify the loss of lives in those two Japanese cities. And the final costs have not yet been calculated. The temptation to use nuclear weaponry will always haunt us. The United States reportedly considered using nuclear weapons nineteen times between World War II and the recent crisis with Iran over its nuclear program, as Rosemary Ruether has pointed out [Ruether; Peace Web].

## CONCLUSION

We have been engaged in a discernment process that must be undertaken prior to any advance or enhancement of nuclear power facilities and for definitive retiring of existing facilities.

A wrong was committed. The moral issues were present in the very inception of nuclear weapons and yet the wartime secrecy leading up to the bombing of Hiroshima and Nagasaki precluded a dispassionate moral discussion. The deaths of almost two hundred thousand civilian Japanese cannot be easily dismissed, and thus we see these deaths as the underlying background that leads us to an attempt to justify the peacetime use of the atom.

Two wrongs don't make a right. Peacetime nuclear use emerged from an assortment of economic and political pressures with no noticeable public debate of moral issues. The propagandistic approach to nuclear electric generation hit the public before such discussion could be initiated, but, as the power plants were being built, the public became more keenly aware of health and safety issues both as to the actual plant functioning and the disposal of nuclear waste materials. During the 1960s and 1970s many voices were heard calling for safeguards, controls and regulations, and some people took to the streets. Lawsuits, legal actions and public demonstrations resulted in delays and cancellations of dozens of nuclear power facilities to such a degree that none have been licensed in the United States for three decades. There were, of course, additional factors at work, particularly economic. What is important is that citizen action caused delays that held back construction of additional reactors until the lack of feasibility from an economic standpoint became obvious.

Today, the necessity issue has again surfaced with the effects of global warming now so evident. Any form of electricity production that omits carbon dioxide emission is regarded by some as good, and so the phoenix of nuclear power has risen again. The presence of government subsidy and support, along with encouragement on the part of some who regard themselves as environmentalists, has led to active consideration of this source of electricity. However, moral problems still persist: the materials are toxic; accidents can still happen either by human error or through natural occurrences that may involve mechanical failure; the materials are desirable to terrorists; the facilities are targets for terrorism; and the waste materials are still problems. A morally aware person says that risks can only be tolerated if absolutely necessary. And that is precisely not the case with electricity generated from nuclear power. Any consideration of necessity allows existing plants to continue, but an orderly phase out and replacement by available low-cost renewable energy coupled with energy conservation measures should be undertaken. This alternative renewable energy electricity-generating system could be instituted with the urgency of the original Man on the Moon project or the race to the moon. Added to this is the urgency of phasing out all nuclear power projects throughout the world for fear that proliferation of weapons will result.

In order to gain and sustain a nuclear-free world we must rise to an unusual level of self-denial and restraint. The world must go "cold turkey" on expanding nuclear power facilities and eliminate weapons production, retention and use. Anything otherwise takes us further down the slippery slope to nuclear annihilation. We must begin the disarmament process that has been stalled for only too long; and at the same time we must initiate a process of phasing out nuclear power plants. Will these joint processes be successful? Nuclear power plants can and must be replaced in suitable time by conservation and renewable energy measures. Finding a safe way to manage the irradiated nuclear fuel now at numerous reactor sites is a major task in itself and fraught with its own risks. At present keeping this waste material in place seems the best option.

Future action steps: The nuclear production of electricity is costly, unsafe, insecure, and unnecessary -- and it only tempts some nations to become nuclear weapons possessors. Merely coming to tentative solutions in decision-making ventures is not sufficient; we must also replace the current status quo with practical actions that need to be implemented quite soon. The following solutions require further discernment:

* Eliminate the use of nuclear weapons as soon as possible through renewed efforts at disarmament involving all nations that have nuclear weapons (United States, Russia, United Kingdom, France, China, India, Pakistan and Israel). Leaving out one or other of these at this time is detrimental to world peace.

* Halt all construction of new nuclear power plants and replace existing facilities with renewable energy sources and conservation measures;

* Expand renewable energy use through a Man-on-the-Moon-style equivalent renewable energy program, a true peacetime use of energy sources. This could be funded through an energy (carbon) tax based on emissions of carbon dioxide.

* Insist that all nations with nuclear weapons ratify the Comprehensive Test Ban Treaty (CTBT). (In order for the CTBT to go into effect, forty-four specific nations, listed in annex 2 of the treaty, must ratify it. The following eight nations in annex 2 have signed but not ratified the treaty: China, Columbia, Egypt, Indonesia, Iran, Israel, the United States, and Vietnam. The following three nations in annex 2 have not signed it: Democratic People's Republic of Korea, India, Pakistan. China, Israel, the United States, India, and Pakistan have nuclear weapons.)

* Place all nuclear-related research and academic facilities under tight international control with police enforcement powers to close such facilities if poorly maintained or insecure. Establish international standards for national agencies to implement in regulating the use of nuclear materials within medical, commercial, and scientific research agencies.

* Place control of all nuclear fuel stockpiles under strict international controls with strong safeguards against diversion to rogue states or terrorist groups.

* Take to the streets and defend democracy with your feet, for this shows the rightness of this cause, for morality is not voted for by rational choices alone, but also by pro-active measures. Such activism changed the economic nuclear power calculus in the 1960s and 70s, and in the twenty-first century demonstrations remain a democratic option that must be implemented one more time, if other means are not sufficient.

# APPENDIXES

## Appendix One: Necessity and other Peacetime Atom Uses

On Sunday, July 29, 2007, Pope Benedict XVI marked the fiftieth anniversary of the International Atomic Energy Agency (IAEA) by calling for progressive and agreed nuclear disarmament and asking that the peaceful and assured use of nuclear technology for real development be favored. This leads us to ask what is this real development? Yes, nuclear disarmament must be a real peacetime pursuit. Many will concede that there are currently beneficial uses of nuclear technology whether as nuclear medicine, for research into the composition of matter in fields of theoretical physics, or in a variety of industrial and commercial uses. The U.S. Department of Energy has four national labs at Oak Ridge, TN, Idaho Falls, ID, Los Alamos, NM and Upton (Brookhaven), NY that produce, process and distribute isotopes for isotope programs.

Nuclear Medicine. Currently, most American medical procedures use isotopes generated at the Oak Ridge National Laboratories and other federal facilities. Remember that not all nuclear medicine is dependent on dangerous nuclear reactors as a source of materials for diagnoses and therapy. X-ray machines used for diagnostic and therapeutic purposes and for sterilization of insects were operated in large numbers a half century before the first nuclear reactor; these generate no nuclear wastes and cannot be used for producing explosive materials. Likewise we must remember that some radio-isotopes such as radium-226, radium-224, polonium-210, tritium and carbon-14 in trace amounts are naturally occurring. Likewise, particle accelerators (beginning with the cyclotron of Ernest Lawrence in California) produce a host of artificial radio-isotopes that are used in medicine and scientific research. There is some lingering radioactivity in materials from these accelerators, but the massive nuclear wastes that come from reactors are not produced.

* Radiation therapy for cancer is known to many of us along with other treatments using nuclear medicine. Cells are severely affected by ionizing radiation and multiply at different rates. Many forms of cancer involve rapidly dividing cells and can be treated with radioactive materials as can neighboring cells which must be protected during these treatments.

* PET (Positron Emission Tomography) is now a common medical means to scan for cancer and to allow the medical expert to look inside the human body without using invasive techniques. PET produces images of the body by detecting radiation emitted from short-lived radioactive substances (e.g., Carbon-11, Fluorine-18, Oxygen-15, or Nitrogen-13); PET detects the gamma rays given off at the site where a positron emitted from the substance collides with an electron in the tissue.

* SPECT (Single Proton Emission Computed Tomography) can render information about blood flow and the distribution of radioactive substances in the body. This technique uses Xenon-133, Technetium-99 and Iodine-123 that have longer decay rates than the materials used in PET, but the results are less detailed. SPECT application centers do not have to be located near a particle accelerator as do PET centers.

* Tracer nuclear materials also have another use not so much in treatment as in the detection of illnesses. Radioactive tracers can be injected into the bloodstream and allow the structure of the blood vessels to be viewed and thus make possible detection of blood clots and other abnormalities. Likewise, certain organs concentrate certain elements (e.g., iodine in the thyroid gland) and the tracer radioactive iodine will concentrate in thyroid tumors. Furthermore, the radioactive phosphorus-32 isotope will detect tumors where the phosphorus materials concentrate.

Scientific research. High energy physic laboratories and other scientific facilities now use radioactive materials on a rather frequent and routine basis, and the scientific results are meant for the general benefit of the entire human family. Again, the substances are dangerous though here again the amounts are relatively small, and can be fairly safely segregated from other laboratory materials and kept from the hands of thieves. The mischief that a terrorist can do is not small if the deed is to poison numbers of people, but the extent is small compared with the possible results of access to the radioactive material in a uranium processing plant or a nuclear power plant.

Other commercial uses. Cobalt-60 is used to detect structural flaws in metal parts. It is used in sterilization of spices and certain foods, and the gamma rays kill pathogens. Existing nuclear reactors (as at Oak Ridge National Laboratory) produce commercially available cobalt-60. It must be noted that the Energy Policy Act of 2005 has mandated a study of the feasibility of procuring supplies of medical isotopes from commercial sources that do not use highly enriched uranium and of the cost differentials for such production. *A.F.*

## Appendix Two: The Myth That Nuclear Power is Totally Carbon-Free

Global warming has severe moral consequences, especially for poor people in many parts of the world (Arctic, Bangladesh, Pacific island nations, etc.) as well as for many plants and animals that find dealing with rapid increases in climatic temperatures difficult. Efforts are being made to reduce the greenhouse gases that cause this global warming, from the coal and other fossil fuel-burning sources of electricity. Thus the non-carbon dioxide emitting sources are given higher priority, and in this way nuclear power has again become popular.

A current myth is that nuclear power is to be grouped among clean renewable energy sources (wind, solar, geothermal, hydropower, etc.). Amid efforts to make nuclear power generation again popular let's consider certain facts: arriving at the nuclear production capabilities that we have today has required uranium mining and processing as well as nuclear plant construction and the disposal of nuclear waste materials. These activities necessitated an immense outlay of non-nuclear power, that is through electricity produced from coal-burning power plants. The enrichment of uranium for nuclear fuels in particular has used huge amounts of electricity from coal-burning power plants.

Ridiculous say the opponents! Certainly the energy needed has been somewhat interchangeable and so some coal-derived electricity has been used, but the net effect over years is energy added by the nuclear power plants that do not use fossil fuels. And these nuclear facilities contribute one-fifth of our total electricity supply, otherwise more coal-burning power plants would be necessary.

Not so ridiculous! The mining and processing of uranium and the preparation of fuel continues and is not an activity of the past. The nuclear industry has used coal-derived electricity as for instance within the Paducah, Kentucky, enrichment facility (the largest single user of electricity in Kentucky, which has no nuclear power plants present) and at Oak Ridge, Tennessee, where an enrichment plant was another major electricity user. And this is more than a matter of substituting one fuel for another. Two further considerations ought to be mentioned.

Solar and wind devices do require some small amounts of coal-derived electricity for equipment manufacture, but an important difference between them and nuclear plants exists -- the fuel source is from the sun and wind, and these do not require increments of coal-derived electricity to process or capture. Thus it is a matter of immense difference; nuclear plants have been coal-dependent for their basic fuel. Furthermore, the discussion could go beyond coal (or other non-renewable fossil fuels) versus nuclear, and become rather energy conservation versus nuclear. The portion of fuel for generating electricity attributed to nuclear fuel could be saved through conservation -- if conservation were accepted. If the money to create and maintain the nuclear economy were used to reduce energy use, the amount of carbon dioxide released (from fossil fuels) for processing nuclear fuel would be eliminated -- and the climate would improve to some degree. *A.F.*

## Appendix Three: Fission and Fusion

To understand the reason why civilian nuclear programs may increase the spread of nuclear weapons we need to understand the basic materials used to generate power and produce weapons.

Both nuclear reactors and nuclear weapons are based on a self-sustaining series of fission reactions known as a chain reaction. A fission reaction is the splitting of the nuclei of atoms into fragments. A chain reaction can only take place in fissile materials, materials that can be split by either fast or slow-moving (low-energy) neutrons, releasing energy. In a reactor, the fission reaction is controlled and the energy is released slowly; in nuclear weapons an enormous quantity of energy is released suddenly.

The only fissile materials are uranium 235, uranium 233, plutonium 239, and plutonium 241. Without one of them a reactor cannot operate or a nuclear weapon or device be detonated. Furthermore, the fissile material must be present in at least the minimal amount necessary to sustain a chain reaction in the given material. This quantity is known as a critical mass.

The early atomic bombs involved only a fission reaction. The “boosted” weapons and the thermonuclear (hydrogen) weapons developed later added a fusion reaction to increase the amount of energy released. In a fusion reaction the nuclei of tritium and deuterium fuse to form heavier nuclei, releasing energy and helium. Fusion can only take place at extremely high temperature and pressure, conditions produced in a weapon by a fission reaction.

Some scientists would like to use the power of fusion to generate electricity, and an international consortium is preparing to construct a fusion reactor (a tokemak) in

France to try to prove that fusion is a potential source of electricity. However, the harnessing of fusion for civilian purposes is decades away and may never be achieved.

Uranium, one of the two elements with fissile isotopes (forms), is a heavy metal that exists widely in nature, always combined with other elements. Natural uranium is composed 99.28% of uranium 238 and 0.71% of uranium 235, with traces of other isotopes (forms). In order to use uranium in a reactor or weapons, it must be separated from the materials with which it is found, concentrated, and refined. The percentage of uranium 235 in relation to uranium 238 is then usually increased through what is known as an enrichment process. For fuel for electricity-generating light water reactors, the percentage of uranium 235 is normally raised to around 3.5%. (The Candu [Canadian deuterium-uranium] reactors use natural uranium.) For weapons or an improvised nuclear device (IND), the percentage of uranium 235 must be at least 20%, i.e. the uranium must be what is known as highly enriched. Many research reactors also use highly enriched uranium (HEU); but an international program is developing fuels to replace HEU in these reactors.

The International Atomic Energy Agency (IAEA) states that twenty-five kilograms of HEU are required to make a nuclear weapon. However, it is possible to assemble a device with a yield of one kiloton using between 2.5 and 8 kilograms of HEU, the exact amount depending on the skill of the person doing the work [ Cochran and Paine; Cirincione, p. 47].

Plutonium, the other element with fissile isotopes, is, like uranium, a heavy metal, but unlike uranium it is found only in trace amounts in nature. The plutonium that exists today is virtually all man made. Plutonium 239 is created in nuclear reactors when the uranium 238 in the fuel or in special targets placed in the reactors absorbs neutrons released by the fission reaction. The plutonium 239, once created, begins to absorb neutrons to form plutonium 241 and even-numbered isotopes undesirable for weapons. Therefore, when a reactor is being used specifically to create plutonium for military purposes, the fuel and targets are removed after a short time.

The grade of plutonium is determined by the percentage of the contaminant plutonium 240 that it contains. Weapons grade has less than 7% plutonium 240; fuel grade, 7-19%; and reactor grade, 19% or more. However, these categories are deceptive. According to the International Atomic Energy Association, even plutonium irradiated from a nuclear power plant can be used for powerful nuclear weapons. The IAEA considers all plutonium, except plutonium created as a source of heat and thus having 80% or more plutonium 238, equally sensitive in terms of proliferation.

To be of use in reactor fuel or in a full-fledged weapon or a nuclear device, the plutonium must be separated from the fuel or target in which it was formed. The separation is a chemical process, normally carried out in what are known as reprocessing plants, large, complex, expensive facilities. However, according to a 1997 report from Oak Ridge National Laboratory, a “simple and quick” plant could be constructed from readily available industrial equipment within four months and could extract sufficient plutonium for a weapon within a week [Ferguson and Potter, p. 121]. Therefore, reprocessing may not be beyond the capacity of some terrorists.

The IAEA gives eight kilograms as the quantity of plutonium necessary for a nuclear weapon. However, some scientists state that to achieve a yield of one kiloton requires only one to three kilograms of military quality plutonium [Cochran]. Theodore Taylor, a former weapons designer, claims that it is possible to replace military quality plutonium with reactor grade plutonium in all weapons manufactured. All that is necessary is between zero and twice as much plutonium and certain other changes [Taylor].

Uranium 233, which is produced by the irradiation of thorium 232, is more costly and difficult to make than uranium 235 and plutonium 239. It therefore has been little used for reactors or bombs. *M.D.*

## Appendix Four: The Fuel Cycle

What is known as the fuel chain or fuel cycle is composed of a number of stages, stretching from the mining of uranium to waste management. Proponents of the reprocessing of irradiated fuel claim that it creates a closed circle by separating irradiated fuel into its components for reuse. Except for the actual reactor/weapons stage, elements of the chain are roughly similar whether the purpose is civilian or military; and particular installations within the cycle may be devoted to civilian purposes, military purposes, or both. In the United States enrichment of uranium for fuel for power plants took place until 1985 in the three plants used to enrich uranium for weapons and submarine fuel: the huge gaseous diffusion enrichment plants at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. (Oak Ridge ceased operation in 1985 and Portsmouth is now also shut down.) The N reactor at Hanford, designed by GE, produced steam that generated electricity for the Washington Public Power Supply System, while the reactor irradiated fuel and targets to produce military plutonium. Today the U.S. Department of Energy (DOE) is producing tritium for military use in civilian reactors belonging to the Tennessee Valley Authority and separating the tritium from the lithium targets in which it is made at DOE’s Savannah River weapons production site. Some military as well as civilian radioactive waste is expected to be buried at the Yucca Mountain Repository in Nevada if it ever opens. The supposed separation between the civilian and military atoms is largely a figment of the imagination. *M.D.*

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