Power Plants & Weapons: The Nuclear Connection

By Jerry Elmer and Hannah Harris

Increasingly, demonstrations commemorating the anniversaries of the atomic bombings of Hiroshima and Nagasaki have called not only for nuclear disarmament but also for an end to nuclear power plants. In response to such protests seeking to link these two issues, utility companies involved in nuclear plant construction have been quick to state that connections between the two issues do not exist. “We feel there is no more connection between nuclear power and the bombing of Hiroshima than there is between electricity and the electric chair,” said one spokesperson for New England Power Company (NEPCO) when confronted in 1978. “It’s like comparing air travel with a B-52 bomber,” said another NEPCO spokesperson.

Today, as the world community attempts to address the pressing issue of global climate change, the nuclear industry is hailing nuclear power as a green alternative to fossil fuels. With the industry calling for a “nuclear renaissance,” it is more important than ever to oppose nuclear power in favor of truly renewable energy that does not endanger our safety.

When utility companies say that nuclear power plants cannot explode like an atomic bomb, they are correct; such an explosion is a physical impossibility for conventional nuclear power plants. Nevertheless, there are valid links between the two issues with which many people are not familiar.

Nuclear Reactions

First, the nuclear reaction which takes place in nuclear power plants is identical to the nuclear reaction which took place in the Hiroshima bomb—the splitting of the uranium-235 atom. Thus, the radioactive “daughter” elements produced in the two reactions—including krypton-85, xenon-133, strontium-90, and cesium-137 among many others—are identical. Also, the dangerous radiation produced is the same.

This radiation is principally of four types: alpha particles (similar to helium nuclei), neutrons, beta particles (electrons), and gamma rays. This radiation does not penetrate directly through the walls of a nuclear power plants because the plant is too heavily shielded. However, significant amounts of radiation can and do penetrate from nuclear power plants into the environment because of emissions of radioactive daughter elements which, in turn, decompose by emitting radiation. At Hiroshima, enormous levels of radiation contributed to the deaths of tens of thousands of people immediately and produced the painful, lingering deaths from radiation sickness in countless others. Even with the very much lower levels that such radiation is emitted from nuclear power plants in the United States, such radiation has been linked to the dramatically increased incidence of cancer, leukemia, and terminal gastro-intestinal disorders.

Daughter elements produced in nuclear power plants can escape into the environment in two different ways: first, through “routine” emissions—that is, when the plant is operating normally and no mistakes occur; and, second, through accidents which suddenly release a large amount of radioactivity into the environment. Once released, radioactive elements contaminate the air and can leach into the soil and groundwater around nuclear power plants. Isotopes can then accumulate through the food chain, where they pose a risk to people, plants, and animals.

Data of the now-defunct Atomic Energy Commission reveal that the U.S. government believes that acceptable, routine emissions from a 1,000-megawatt boiling-water reactor can be as high as 315 curies[1] per year of radioactive krypton-85 (which concentrates in human fatty tissue and emits beta particles) and 28,000 curies per year of radioactive xenon-133 (also a beta emitter). A 1973 study by the National Academy of Sciences concluded that exposure by the entire U.S. population to what the government call acceptable, routine emissions could cause 15,000 additional cases of cancer *per year!*

The two elements produced in greatest quantity during the fissioning of the uranium-235 atom are strontium-90 and cesium-137. It is ironic that these are precisely the fission products that are most toxic to human beings. Cesium-137 decomposes by emitting dangerous beta particles. Its half-life[2] is 30 years; thus, cesium-137 remains radioactive and dangerous for hundreds of years after it is produced in a reactor.

Strontium-90, an isotope not found in nature, is even more dangerous than cesium-137. In addition to emitting beta particles as it disintegrates, it also produces gamma rays. Strontium-90 acts like calcium in biological processes. It gets into cow's milk (and human breast milk) and from there it concentrates in human bones and teeth. A 2003 study by the Radiation and Public Health Project found that strontium-90 levels accumulated in baby teeth were highest in U.S. counties located near nuclear reactors. With a half-life of 28 years, strontium-90 also remains deadly for hundreds of years after it has been produced.

Although neither cesium-137 nor strontium-90 is *supposed* to be released into the environment during the normal operation of a nuclear power plant, these and other dangerous radioactive isotopes sometimes are when "mistakes" occur. The Millstone nuclear plant near New London, Connecticut, is one major offender in this regard. In July, 1976, for example, strontium-90 levels in milk coming from dairies near New London were shown to be nearly double the federally-established maximum "acceptable" level—following the release of radioactive particulates, including strontium-90, from the Millstone plant. The meltdown at Three Mile Island in 1979 is believed to have released 13 to 17 curies of radioactive iodine-131 (which accumulates in the thyroid) and 2.4 to 13 *million* curies of radioactive noble gasses including krypton, xenon, and argon. The release of cesium-137 throughout the 1970s and 1980s from a reactor at Brookhaven National Laboratory on Long Island is thought to be connected to incidences of the rare muscle cancer rhabdomyosarcoma. In 2010, levels of tritium (radioactive hydrogen), and the radioisotopes cobalt-60 and zinc-65 were detected at levels well above federal standards in the groundwater surrounding the Vermont Yankee nuclear power plant. Zinc-65 was found in levels 8 times higher than federal reportable levels; cobalt-60 was measured at levels *130 times higher* than federal standards in the same groundwater.

The risk of accidents increases as power plants age and the building materials become brittle or corroded. Many power plants in the U.S. today are nearing the end of their 40-year operating licenses. Several are now seeking 20-year operating extensions, and more are expected to do so in the coming years. Many experts, however, assert that aging management programs and inspection regimes are inadequate to ensure that plants will operate safely for an additional two decades. Only one week after being granted its 20-year extension, a leak was discovered in underground piping at the Oyster Creek reactor in New Jersey. The leak had caused standing water contaminated with tritium to accumulate. Similarly, leaks in underground piping at the Vermont Yankee power plant are thought to have contaminated surrounding groundwater with tritium. These are not isolated incidents. The effects

[1] A curie corresponds to the radioactivity of one gram of fresh radium; it represents the quantity of a radioactive isotope which undergoes 37 billion nuclear disintegrations per second.
[2] The half-life of a radioactive isotope is the period of time it takes for 50% of the atoms in any given mass of the isotope to decompose.

of global climate change, including erratic weather patterns, severe storms, and rising ocean levels, also threaten the integrity of existing nuclear infrastructure.

Since the attacks on September 11, 2001, a nuclear terrorist attack has been identified as one of the greatest security threats facing the United States. The explosion of even a primitive nuclear weapon would be physically, psychologically, and financially devastating. A strike against an American nuclear power plant or nuclear storage facility could be equally catastrophic, producing many of the same radiological consequences as a crude atomic bomb. The accidental explosion of a civilian reactor at Chernobyl in 1986, for example, released 400 times more radioactivity than was released in Hiroshima.

Tens of thousands of people were forcibly relocated from areas around Chernobyl; one hundred thousand square miles of land were contaminated by radioactive fallout; ultimately, billions of dollars have been spent on clean up, health costs, compensation to the victims, and lost productivity. Nearly 400 sheep farms in the United Kingdom, where approximately 1% of the radiation released from Chernobyl fell, are still subject to government inspections in order to monitor the accumulation of cesium-137 through the food chain. A 2004 report published by the Union of Concerned Scientists determined that a worst-case-scenario attack on the Indian Point nuclear power plant, located just 35 miles outside of Manhattan, could kill as many as 44,000 in the near term within up to a 60-mile radius, and cause over 100,000 additional long term deaths as a result of the radiation released.

The Nagasaki Bomb: Plutonium

Unlike the Hiroshima bomb which used uranium-235 as its fuel, the bomb which the United States dropped on Nagasaki used plutonium-239 as its nuclear fuel. The bomb contained between 13 and 14 pounds of plutonium; of that amount, less than one twentieth of an ounce fissioned at Nagasaki, producing the awesome effects of blast, heat storm, and some of the radiation. The remaining plutonium was blown apart by the blast and dissipated into the environment. Thus, it is reasonable to conclude that much of the damage done to the population of Nagasaki came from the radioactivity of this unfissioned plutonium.

Plutonium is widely regarded as the most toxic substance known. An artificial element, Plutoium-239 is an alpha-particle emitter. Although alpha particles are heavy and therefore have little penetrating power, they are emitted from plutonium with so much energy—5 to 6 million electron volts—that they can do tremendous damage to human somatic and gonadal tissue. Microgram quantities (one millionth of a gram) absorbed in the skin will cause skin cancer; deposited in the bone it causes bone cancer (biologically, plutonium is a bone-seeker). A piece of plutonium the size of a grain of pollen will, if inhaled, almost invariably produce lung cancer. Although adequate distribution would by nearly impossible, one pound of plutonium would be enough to kill 9 billion people— nearly one and a half times the population of the entire world.

Plutonium is one of the elements produced as a byproduct in civilian nuclear power plants. A typical 1000-megawatt light-water reactor produces 400 to 600 pounds of plutonium each year. In order to be used as nuclear fuel (in either a reactor or a bomb) plutonium must be extracted from spent fuel. As of 2009 the global stockpile of separated plutonium has reached 1,102,500 pounds, about evenly divided between civilian and military supplies. Taken together, this is enough fuel to produce over 60,000 nuclear weapons. These numbers do not include additional tons of plutonium that remain locked in the millions of pounds of spent nuclear fuel around the world.

Plutonium has a half-life of 24,000 years; that is, it remains radioactive for literally hundreds of thousands of years. Because of its extreme toxicity, every ounce of plutonium will have to be kept safe from accidental leakage, earthquakes, sabotage, terrorism, and acts of God for that entire period. The leakage of even a fraction of one percent of our plutonium could have disastrous consequences. The mediocre record of the nuclear industry to date in safeguarding against environmental leakage of radioactive materials provides considerable cause for concern.

Nuclear Power and Disease

Nuclear radiation also causes genetic damage. We learned this in the aftermath of the atomic bombing of Hiroshima. Babies who were *in utero* when the bomb exploded showed increases in several types of congenital malformations. The most common of these was microcephaly, abnormally small cranial capacity resulting in mental retardation. High levels of radiation are known to induce genetic mutations that can lead to cancer or other diseases as well as “double strand breaks” in chromosomes, which are particularly difficult for our cells to repair. Studies of the survivors of Hiroshima and Nagasaki have also identified a connection between radiation and increased risk of cataracts and cardiovascular problems. Of all species on earth, humans are the most susceptible to genetic damage.

Though the dangers of high levels of radiation have been thoroughly explored, it is more difficult to investigate the effects of low-level radiation, such as that emitted from nuclear power plants. Much of the existing data come from extrapolating information obtained from animal studies or from victims exposed to higher doses. Yet, growing numbers of scientists are convinced that low levels of radiation are also dangerous. A 2005 report published by the National Academy of Sciences endorsed a linear-no-threshold cancer risk model from exposure to radiation. This means that the risk of developing cancer increases as one is exposed to increasingly higher levels of radiation, and that there is *no minimal level* of radiation that can be considered perfectly safe. The **1973 report** of the National Academy of Sciences estimated that exposure by the general population to levels of radiation from nuclear power plants considered routine and acceptable would result in as many as 27,000 cases of serious genetically induced disease annually. Because of the recessive nature of certain kinds of chromosomal mutations, genetic damage sometimes does not show up for 3 or even 4 generations. That is, the damage we are doing now may not show up until our grandchildren’s grandchildren are born!

The catastrophe at Chernobyl demonstrates the destructive potential and severe health consequences of nuclear power. Thirty plant workers and fire fighters died quickly in the aftermath of the accident from lethal doses of radiation. Others involved in the cleanup process were exposed to lifetime doses of radiation and suffered many symptoms of radiation sickness. The incident is associated with a huge spike in the occurrence of thyroid cancer—especially among children—induced by radioactive iodine. Cataracts and heart disease are also on the rise among populations close to Chernobyl. Radiation released in the accident spread across the entire northern hemisphere. Ultimately thousands more are expected to die prematurely as a result of the accident. Considering that radiation-induced cancer cancan take years or even decades to develop, we may be just beginning to observe the full force of increased cancer rates resulting from the Chernobyl disaster. The physical toll of the accident is further compounded by the psychological trauma caused by forced relocations and fear of contamination and illness.

Dr. Albert Szent-Gyorgi, the biologist who received the Nobel Prize in 1937 for the discovery of Vitamin C, has commented aptly on the tremendous significance of such genetic damage: “DNA, the genetic material, is the most wonderful thing in the world, guarded by nature in the most careful manner. Mankind [sic] went through epidemics, famine, and all sorts of trials, yet nature kept this material intact, because all life depends on it. Today is the first time in history that man has found a means to damage it. High energy radiation does this."

Hiroshima and Nagasaki survivors have suffered from discrimination and often had trouble marrying because of the fear of genetically deformed babies. This remains the case with many of their descendents today. It is the cumulative amount of radiation one is exposed to that ultimately determines health risks, whether the radiation is received in one large dose or in recurring small doses over time. Even if humanity avoids the quick annihilation of a nuclear holocaust, it is surely tragic that we may be doing some of the same damage to ourselves through the use of nuclear power.

Power Plants and Proliferation

One of the strongest links between nuclear weapons and nuclear power concerns the relationship between the civilian nuclear power industry and worldwide proliferation of nuclear weapons. Simply stated, nuclear power plants, and the education of those who design and operate them, spread both the technological know-how and the raw materials needed to build atomic bombs.

On May 18, 1974, India became the sixth nation in the world to explode an atomic bomb; the bomb was built from materials supplied to India for its program of civilian atomic power. Today nine nations possess nuclear weapons[3], four of which (India, Israel, North Korea, and Pakistan) never signed or have withdrawn from the Nuclear Nonproliferation Treaty. Since acquiring nuclear capabilities, Pakistan has been accused of disseminating nuclear technology to North Korea, Iran, and Libya. Today Iran's quest for an alleged civilian uranium enrichment program has raised profound concerns; Libya went on to secretly develop a nuclear weapons program, which it voluntarily abandoned in 2004; and North Korea succeeded in developing and testing its first nuclear weapon in 2006.

[3] China, France, India, Israel, North Korea, Pakistan, Russia, the United Kingdom, and the United States

In addition to weapons states, twenty four countries operate nuclear power plants, thereby providing much of the fuel and technological expertise that could be used to build bombs at any time. Uranium enrichment is one of the most financially and technologically demanding steps in the production of nuclear energy and nuclear weapons. Twelve states currently operate or soon plan to operate uranium enrichment facilities[4]. Five of those twelve[5] are non-weapons states, but according to the Director General of the International Atomic Energy Agency, countries with the capability to enrich uranium can be considered "virtual nuclear weapon states."

The other crucial element in this connection is plutonium-239: the same plutonium manufactured in such quantities by nuclear power plants is the fuel used in most atomic bombs manufactured today. Imposing safeguards on exported nuclear material, something periodically debated in Congress, is not likely to be successful. India's atomic bomb was made from plutonium extracted from spent nuclear fuel which had been supplied by Canada—at a time when Canada imposed stricter safeguards on nuclear material than the United States had yet to impose. Today ten states operate or are currently planning reprocessing facilities that extract fissile plutonium from spent

[4] Brazil, China, France, Germany, India, Iran, Japan, the Netherlands, Pakistan, Russia, the United Kingdom, and the United States

[5] Brazil, Germany, Iran, Japan, and the Netherlands

fuel[6]. Canadian authorities were convinced that such diversion by India to make a bomb was impossible. Nevertheless, it happened.

To date, six nations have been involved in (legally) exporting nuclear reactors[7]. The United States and other nuclear powers have exported more than 100 nuclear power plants to at least 25 recipient nations. Each exported reactor produces enough plutonium to build an atomic bomb approximately every two weeks. Naturally, with such tremendously increased quantities of fissionable material around, the danger of nuclear fuel falling into the hands of private terrorist organizations is also significantly increased. International and domestic sanctions and safeguards against the movement of nuclear fuel and nuclear technology have repeatedly proved inadequate. Many scientists fear that if present trends continue, nuclear weapons may become for the next generation of terrorists what machine guns are today.

More than 30 years ago there was already there enough plutonium circulating that it was apparently impossible to keep track of it all. On **December 24, 1974**, the *New York Times* reported that as much as 60 pounds of plutonium was unaccounted for at the Cimarron nuclear power plant in Oklahoma. Another report of missing fissionable fuel was in the *Times* on **March 24, 1978**, saying that 202 pounds of highly enriched, bomb-grade uranium—enough for at least 10 bombs—was missing from a nuclear facility in Apollo, Pennsylvania. No one seems to know if this material was stolen in one big robbery or pilfered by staff over a period of time; no one knows if this discrepancy resulted from a “bookkeeping” error or if the fissionable material has already found its way into bombs. On **August 6, 1977**, the *Norwich* [Connecticut] *Bulletin* reported that 160 pounds of bomb-grade uranium was unaccounted for from Connecticut’s four nuclear power plants over the previous 18 years. (Governer Ella Grasso’s press secretary issued a statement that there was no cause for alarm since this represented ½ % [one half of one percent] of the nuclear fuel used in Connecticut over that period and, thus, was well within U.S. government guidelines!)

Contrary to claims by the nuclear industry, building bombs is not extraordinarily difficult once the necessary fuel has been obtained. In 1977, John Phillips, a Princeton undergraduate who ran a pizza business, wrote a paper on how to construct a homemade bomb and received inquiries about his design from two foreign powers. His design was based on publicly available information. Dmitri Rostow, a Harvard student, designed a series of 22 atomic bombs in 5 months; two bomb designers for the U.S. government called his designs “highly credible.” The development and growth of the internet has aided the black market in nuclear technology, making the necessary information to construct a nuclear weapon more widely available than ever before.

Many Americans feel that nuclear proliferation is dangerous because, they believe, leaders of Third World countries are inherently less intelligent or responsible than leaders of big powers. It is useful, therefore, to remember that to date the U. S. is the only nation which has used nuclear weapons on human populations—more than once and on civilian targets, at that. Since the bombings of Hiroshima and Nagasaki, the United States has threatened or prepared to use nuclear weapons on at least 40 separate occasions. It is also useful to recall that the failure of the Nonproliferation Treaty of 1970 (NPT) is largely attributable to the nuclear superpowers rather than to smaller, non-nuclear nations. The NPT called for a three-part bargain: the nuclear powers promised to work actively toward nuclear disarmament and to provide non-nuclear nations with the technologies needed for nuclear power generation for “peaceful purposes.” In exchange, the non-nuclear nations promised to forego the option of developing nuclear weapons. In the years since the NPT was signed, the world’s nuclear powers have continued designing and testing a wide range of new nuclear weapons and new delivery systems. The repeated refusal of the major weapons states to honor their obligations under the NPT to initiate negotiations toward the abolition of nuclear weapons has only fueled

[6] China, France, India, Israel, Japan, North Korea, Pakistan, Russia, the United Kingdom, and the United States
[7] Canada, France, Japan, Russia, South Korea, and the United States

nuclear proliferation. The image of nuclear super-powers, each with the capacity to wipe out all life on this planet, preaching proliferation to non-nuclear Third World countries would be comical if it were not so tragic. In this context, the pressure felt by many nations to develop nuclear weapons is understandable.

Nevertheless, continued proliferation of nuclear weapons does pose many hazards. The more nations that have nuclear weapons, the more likely that a local war (such as between India and Pakistan, in the Middle East, or between North and South Korea) could cross the brink from conventional to nuclear. Such a confrontation could, in turn, draw in the super-powers with their vast nuclear arsenals. And, of course, the more nuclear material there is circulating in more countries, the greater the chance of fissionable material falling into the hands of private terrorist organizations.

Despite the obvious problems created by export of nuclear power plants, there are several reasons why such export is not likely to stop. Major U.S. corporations account for a large proportion of the total international sales of nuclear power plants. These companies count on such foreign sales for a significant portion of their profits. Furthermore, in order to bring the per-unit cost of power plants down for the domestic market, these corporations try to increase total sales volume by increasing foreign sales. In addition, nuclear exports are important to the United States balance of trade.

New Technologies

Another important connection between nuclear weapons and nuclear power is that new technologies developed to help the civilian nuclear industry can also help countries (or private terrorist organizations) develop nuclear capability for non-peaceful purposes. The best-known example of this is the development of the “breeder reactor,” designed to help the nuclear industry overcome the impending shortage of uranium as nuclear fuel. The breeder reactor uses plutonium as fuel to convert non-fissile (but naturally abundant) uranium-238 into fissile plutonium. Theoretically, such a process would produce more plutonium than it consumes, yielding an almost limitless supply of fuel.

Obtaining the plutonium fuel for breeder reactors requires reprocessing of spent fuel from traditional nuclear reactors. Reprocessing is the most dangerous portion of the fuel cycle because of the intense radiation field surrounding spent fuel. Additionally, reprocessing contributes enormously to the potential proliferation of nuclear weapons by generating massive amounts of separated plutonium that can be incorporated into nuclear weapons. Once separated, plutonium can be handled without radioactive shielding, making theft a real concern.

Though the concept of the breeder reactor has existed since early in the atomic age, it has yet to be proven commercially viable. Several countries have attempted to build successful reactors but the process has been repeatedly plagued by high costs and safety concerns. Nonetheless, the technical advances necessary to produce successful breeder reactors continue to be pursued by the nuclear industry.

Another less-known but very important example of technology aiding proliferation is the current development of new technologies for uranium enrichment. When it is mined from the ground, natural uranium contains two isotopes: uranium-235 which is fissionable and can be used either in power plants or in bombs, and uranium-238 which is not fissionable. When mined, natural uranium consists of 0.7% (seven tenths of one percent) U-235 and 99.3% U-238. Before it can be used, the uranium must be enriched, that is, have the level of fissionable U-235 increased to at least 3% for power plants or at least 20% for bombs. The same processes can be used to enrich uranium to any level, which means that any nation with the ability to enrich uranium for civilian purposes also has the ability to produce fuel for nuclear weapons.

The original means of uranium enrichment is called gaseous diffusion—a gasified uranium compound (uranium hexafluoride) is passed through a series of filters which separate the two isotopes. This process is vastly expensive, consumes massive amounts of electricity, and can never be done secretly. Gaseous diffusion plants cost billions of dollars and take up literally acres of land; such a facility could easily be identified through satellite imagery. The astronomical cost of uranium enrichment has been one of the primary obstacles to many small countries building their own bombs; the super-powers had the monopoly on uranium enrichment. The high cost of uranium enrichment has also been an important factor in keeping the cost of nuclear-produced electricity high.

As a result, the American nuclear industry is constantly searching for ways to bring down the high cost of enrichment. Today, the dominant uranium enrichment technology is the gas centrifuge. Centrifugation is a technique that separates materials based on differences in mass. Inside a centrifuge uranium hexafluoride gas is spun at high speeds so that molecules concentrate against the walls of the centrifuge. Spinning causes the U-238 and U-235 to separate, with heavier U-238 settling at the bottom of the centrifuge and U-235 settling on top, much like oil floats on top of water. Centrifuge technology is more economical and efficient than old gaseous diffusion, requires much less electricity, and can be performed on a much smaller scale. All of these factors increase the risk of proliferation because centrifuge enrichment can be done clandestinely.

A newer enrichment method utilizes laser beams and can separate uranium isotopes even more effectively than centrifugation. Scientists take advantage of the different resonating frequencies of U-235 and U-238 by directing a finely tuned laser at the unenriched uranium (also in the form of “hex” gas) to excite the molecules of one isotope and not the other. From there, separation is a quick and relatively cheap process. Currently laser-isotope separation is not commercially competitive with gas centrifuge technology, but that may soon change. In 2006, General Electric-Hitachi acquired a laser enrichment process from an Australian group and is currently planning to build a laser enrichment plant in the United States. If this facility proves successful, the technology could spread rapidly around the world.

So promising is this laser enrichment of uranium that some scientists fear that in the future pilferage or theft of fissionable material will cease to be a threat—because manufacture of fissionable material will be so easy! One of the major obstacles to the uncontrolled spread of nuclear weapons to other countries or private terrorist organizations—the production of weapons-grade fuel—is being eroded as a result of technological developments for the civilian nuclear power industry.

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Since the atomic bombings of Hiroshima and Nagasaki, many peace-loving people the world over have fervently hoped that it would be possible to use nuclear energy for exclusively peaceful purposes—that is, that nuclear energy for civilian purposes could be separated from nuclear power for military purposes. This has not proved possible. It is now clear that many of the same health, genetic, and environmental problems created by nuclear bombs are also inherent in the civilian nuclear industry. It is also clear that the goal of nonproliferation of nuclear weapons is virtually unattainable so long as there is a civilian nuclear power industry.

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