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Nuclear Energy and the Care of the Earth

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Healing of the Earth is central to all our Quaker concerns. ... No peace without a planet. ... No justice without a planet. .... Those who care about the Earth must feel its woundedness as our own. ... How can we look our children and grandchildren in the eye unless we do all we can to give them a future? They need to know that we cared, and that we tried. —Elizabeth Watson (1991)

Mindful that we live on a finite planet, Friends are called to extend our concerns for other persons and species living not only now but in the future. How we choose to live today should leave the earth viable for all future generations. This is the basis of sustainability; it requires us to use the earth's resources at a level that provides a reasonable life for all now and maintains the capacity to provide such a life for all coming generations. We must not pollute the world with excess carbon dioxide, chlorofluorocarbons, chemicals, and radioactive elements that would threaten all species throughout the future; also, we must not use up or destroy the resources which provide our earth's matrix of life.

Friends have long been aware of the deleterious effects on the earth and biosphere of burning fossil fuels (primarily oil, coal, and natural gas), increased carbon dioxide concentration in the atmosphere (a main factor in global climate change), and the spread of toxic chemicals, such as mercury, in our air and water. Some Friends, environmentalists, and energy-policy experts argue that increasing the amount of electricity generated by nuclear power would be a way to reduce these negative effects, since they believe nuclear power produces little carbon dioxide compared to coal and oil. Nuclear energy's potential, however, for irreversible damage to present and future generations of life on earth should be of great concern to Friends. Nuclear energy is neither green, safe, cheap, nor inexhaustible, and it contributes to economic injustice and to war.

Resurgence of Support for Nuclear Energy

In 2000, fossil fuels produced 77 percent of the world's energy while nuclear power produced eight percent and renewable sources (wood, wind, photovoltaics, hydro, biomass, and geothermal) produced 17 percent (Sawin, 2004, 15). The use of fossil fuels has grown rapidly in the world since 1950, while the use of nuclear energy has grown very slowly (Worldwatch Institute, 2005, 30-33). Recently, however, the Bush Administration has touted nuclear energy as a safe, clean, and cheap source of energy in contrast to importing oil or burning coal. For the first time in nearly 30 years, energy companies in the United States are seeking permission to site and build new nuclear power

Nuclear Fuel Cycle

To generate electricity by nuclear energy, uranium must first be **mined**. The mined uranium ores are then **enriched** to increase the proportion of radioactive uranium-235 from its natural abundance of 0.71 percent to 3.5 percent for use in fuel rods for nuclear reactors. The **depleted uranium** that remains is 0.3 percent uranium-235 and is used to give weapons the capability of penetrating the armor plating of a tank.

A **chain reaction** occurs when one atom of uranium-235, bombarded by a neutron, gives off an average of two and a half neutrons, which go on to bombard other atoms of uranium-235, as well as, uranium-238 and any other atoms present. In a nuclear reactor this chain reaction is controlled by a "moderator" (either graphite or water) that absorbs the excess neutrons.

This and other side reactions release neutrons, radiation, and radioisotopes, including cesium-137, strontium-90, cobalt-60, iodine-129, iodine-131, technetium-99, and plutonium-239 (Table 1). Electricity is created when radioactive energy from all these reactions is transformed into thermal energy that heats water, which turns a turbine that generates electricity.

Plutonium-239, the most dangerous of the radioisotopes created in a nuclear reactor, is formed by neutron bombardment of uranium-238. Since U-238 constitutes more than 96 percent of the uranium in the fuel rods, fully one percent of the **"spent" fuel** is plutonium-239, which makes the "spent" fuel thousands of times more radioactive than the original uranium fuel (Caldicott, 1994, 50-59; Wiltshire, 1993, 13-22).

A nuclear reactor that produces 1,000 megawatts of electricity includes approximately 75 tons of enriched uranium. Approximately one-third of this fuel is replaced every year. Since "spent" fuel rods are highly radioactive and produce large amounts of heat, they are stored in large pools for long periods of time to dissipate the heat and radioactivity. Although this highly radioactive nuclear waste is re-processed in other countries, most nuclear waste in the United States is currently stored at nuclear power plants in on-site pools or massive air-cooled metal or concrete (dry) casks (Wiltshire, 1993, 221). There is no permanent nuclear waste deposit site in the United States. The Yucca Mountain site in Nevada selected for perpetual storage is highly controversial and has not been (and may never be) approved.

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QNL promotes government and corporate policies to help restore and protect Earth's biological integrity. It works within and through the Religious Society of Friends for policies that enable human communities to relate in mutually enhancing ways to the ecosystems of which they are a part. This witness seeks to be guided by the Spirit and grounded in reverence for God's creation.

QEB's purpose is to advance Friends' witness on government and corporate policy as it relates to the ecosystems that sustain us. Each issue is an article about timely legislative or corporate policy issues affecting our society's relationship to the earth.

Friends are invited to contact us about writing an article for ***QEB***. Submissions are subject to editing and should:

- Explain why the issue is a Friends' concern.
- Provide accurate, documented background information that reflects the complexity of the issue and is respectful toward other points of view.
- Relate the issue to legislation or corporate policy.
- List what Friends can do.
- Provide references and sources for additional information.

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plants. New nuclear power plants are proposed for three sites in Illinois, Virginia, and Mississippi. Many more are expected to follow. A new plant to enrich uranium ore into fuel for nuclear power has been proposed for New Mexico.

With rising oil prices and concern over use of fossil fuels, pro-nuclear interests in industry and government have sought to resuscitate nuclear power in many ways. Congress has attempted to include subsidies for nuclear energy in energy bills, which would pay for over half of the cost to research and prepare applications for new sites. The Nuclear Regulatory Commission has rewritten rules so that site permits and plant licenses are separated into two parts, thus permitting approval of a site without any knowledge of the type of nuclear reactor to be built there. Many safety issues, including long-term storage of nuclear waste, cannot be addressed in reviewing a site, according to the rules. The Nuclear Regulatory Commission has also weakened security and economic justice safeguards. Guidelines have been rewritten to permit low-level radiation to be put into regular landfills. The Price-Anderson Act, which severely limits liability for damages due to a nuclear accident, was renewed by Congress (Nuclear Information and Resource Service, 2005a, 1). Thus, with special supports from the government and a changing energy situation, interest in nuclear energy has been awakened.

Neither Clean Nor Green

While nuclear energy is being presented as a clean and green source of electricity, it is neither and cannot be the answer to global warming. When the entire fuel cycle is considered, the generation of electricity by nuclear energy creates considerable carbon dioxide and other greenhouse gases. Diesel fuel is used in the mining and milling of uranium, a large amount of coal is burned to generate electricity to enrich the uranium, and fossil fuel is needed either to transport nuclear wastes to a distant repository or safeguard its storage on site. The enrichment facility at Paducah, Kentucky, requires the entire electrical output of two coal-fired 1000-megawatt plants, which emit large quantities of carbon dioxide. According to the Öko Institute, when all aspects of producing electricity by nuclear energy are considered, carbon-dioxide emissions are about two times greater than by wind and hydroelectric, although much less than gas and oil (Ward, 2005, 9). If poorer uranium ores were used, as they would have to be in the future if nuclear energy actually replaced coal as a major source of electricity, nuclear energy would contribute an even larger amount of carbon dioxide to the atmosphere.

More significantly, the two United States enrichment facilities (Paducah, Kentucky, and Portsmouth, Ohio) release 93 percent of the chlorofluorocarbon gas emitted yearly in the United States. Chlorofluorocarbon, a significant cause of ozone depletion, is also a global warmer, 10,000 to 20,000 times more potent than carbon dioxide (Bruggers, 2001). Nuclear energy also generates enormous heat, only to boil water to turn the turbines. When the entire fuel cycle is considered, nuclear power adds significantly to greenhouse-gas emissions and to global warming.

Even though nuclear power releases less carbon dioxide per kilowatt-hour of electricity than coal, replacing coal generating plants with nuclear plants to reduce carbon-dioxide emissions is not feasible. Perhaps 2,000 large new nuclear reactors of 1,000 megawatts each would be needed worldwide in the next 30-50 years to produce a suitable reduction in global carbon-dioxide emissions. That is a minimum of 40 each year, but only a total of 15 new reactors have been built in the last 20 years. With the billions of dollars in cost of each new reactor and the huge technical problems to build so many new reactors each year, converting electric production to nuclear energy is quite unlikely and undesirable. If so many new nuclear power plants were built, the supply of uranium would be exhausted within a few years and the waste created would be monumental (Ward, 2005,

Table 1. Radioactive Isotopes Involved in Nuclear Energy

Isotope	Half-Life (years)	Target Organ	Health Effects
Naturally Occurring Radioisotopes			
Uranium-238	4,470,000,000	kidney, bone	kidney damage, cancer
Uranium-235	704,000,000	kidney, bone	kidney damage, cancer
Man-made Radioisotopes in Nuclear "Spent" Fuel and Other Wastes			
Plutonium-239	24,300	liver, lung, bone	cancer, death
Cesium-137	30	entire body	cancer, death
Strontium-90	29	bone	Leukemia, bone cancer
Cobalt-60	5	kidney, liver, bone	kidney damage, leukemia
Iodine-129	15,700,000	thyroid	thyroiditis, cancer
Iodine-131	8 days	thyroid	thyroiditis, cancer
Technetium-99	212,000	thyroid, intestine	thyroiditis, cancer
Tritium (Hydrogen-3)	12	entire body	cancer

Source: Environmental Protection Agency <www.epa.gov/radiation/radionuclides>

9-11). Using wind energy to generate electricity instead of coal-fired plants would be far more effective than nuclear energy in reducing greenhouse-gas emissions.

Not Safe

Although nuclear power is neither clean, green, nor a solution to climate change, most crucially, nuclear power is simply not a safe way to produce electricity. It is dangerous at all stages, from the mining of uranium to storing its radioactive wastes. Even in ordinary daily operations, nuclear power routinely releases millions of curies of radioactive isotopes into the air and water (Caldicott, 1994, 30; Nuclear Information and Resource Service, 2004, 1-2). Radioactive isotopes are carcinogenic and mutagenic. Due to the nature of the biological damage done by radiation, it takes only one radioactive action, one cell, one gene to initiate the cancer or mutation cycle. The incubation time for cancer is five to 60 years following exposure to radiation. Some isotopes are extremely toxic and long-lived. Plutonium-239, for example, is so deadly that one-millionth of a gram is carcinogenic, and plutonium-239 has a half-life of 24,300 years (Caldicott, 1994, 33-40, 81; Nuclear Information and Resource Service, 2004, 1-2; Wiltshire, 1993, 11-18).

In recent preliminary studies, infant mortality rates for counties downwind of all of the nuclear plants studied are higher when the plants are operating than when they are closed down, while there is little difference in counties upwind (Mangano *et al.*, 2002, 1-3; Mangano *et al.*, 2003, 1-3). Thyroid cancer rates are unusually high in France, where about 75 percent of electricity comes from nuclear power and where no prevention against thyroid cancer was taken after the Chernobyl accident (Leenhart, Grosclude, and Cherie-Challine, 2004, 1050-1060), and in Belarus, near Chernobyl (Ward, 2005,16). Certainly one cannot prove that radiation from nuclear power plants *causes* these higher mortality rates, but in the 1950s, with the evidence available, neither could one *prove* that smoking or living near chemical spills increased mortality. Over 50 years of evidence, however, suggests strongly that smoking does lead to higher illness and death rates. With many associations linking nuclear power with increased illness and higher mortality, certainly we cannot conclude that nuclear power is *safe*.

Nuclear reactor accidents, while fortunately rare thus far, do happen, as they did at Three Mile Island and Chernobyl. When accidents do occur, the results can be disastrous to humans and all species. Both accidents involved mechanical failure and human error. The Three Mile Island accident in 1979 involved valves that were stuck open, so the coolant water was draining from the reactor core. Operators did not realize this and made decisions that worsened the situation and the reactor core began melting. The situation was only brought under control after 2.4 to 13.0 million curies of noble gases—Xenon and Krypton—had been released into the atmosphere, 13 to 17 curies of radioactive iodine escaped, and one-third of the core had melted. (Caldicott, 1994, 113-120). In Chernobyl, the operators were conducting a test of plant operation at an unstable low power output. Design failure and human error were cited as the causes of the accident, which resulted in the release of massive amounts of radioactivity detected all over Europe and across the world, thousands of deaths ultimately, resettlement of hundreds of thousands of people, and contamination of 43,000 square kilometers, which is now uninhabitable (Caldicott, 1994, 126-135). Some sheep in Wales are still too radioactive to be eaten.

Near misses of potentially serious accidents occur all the time and will increase as the United States' 103 current reactors age. For example, the Nuclear Regulatory Commission has recently granted licenses for nuclear power plants to operate at an increased capacity, as much as 20 percent higher than the original license. This involves using more highly enriched uranium fuel, higher steam production, and increased flows through the system. Since the Quad Cities Power Station has been operating at the increased power levels, the two reactors "have experienced numerous unplanned shutdowns to repair equipment that was literally shaking itself apart." (Lochbaum, 2004, 1-6). Nuclear plants are often off-line for repairs when problems have occurred and the plants are not operating normally; at these times unexplained radioactive releases are most likely to happen. While the design of new nuclear power plants contains many safety features, people operate the plants. No matter how careful they are, people do make mistakes.

Nuclear reactors and the radioactive wastes stored at the plants are potential targets of terrorists, with the resulting horrendous damage that an airplane, missile, or sabotage attack of a nuclear power plant could do. Security measures at reactor sites are highly insufficient; evacuation plans are often non-existent or unworkable.

There is *no* place to put the highly concentrated nuclear wastes from a power plant. After several years of nuclear fission, the "spent" fuel rods are thousands of times more radioactive than new fuel rods. The repository chosen by the Department of Energy for "spent" fuel, Yucca Mountain in Nevada, is a volcanic mountain made of permeable stone, transected by earthquake faults. A Federal Court has ruled that the current guidelines for this site are inadequate and must be revised, perhaps making it impossible to use this site (Public Citizen, 2004, 1-6). Recently it has been revealed that United States Geological Survey personnel falsified the data by which the site was deemed to be safe (Nuclear Information and Resource Service, 2005b, 1). Yucca Mountain is unlikely to be the repository of nuclear waste, nor could it safely contain nuclear wastes which will remain radioactive for hundreds of thousands of years.

Even if there were a safe repository site, waste would have to be transported to it, creating "mobile Chernobyls" on major highways, railways, and some waterways throughout the United States. A truck cask contains up to 40 times the radioactivity of the Hiroshima bomb, and a train cask over 200 times that amount. To transport the waste which *currently* exists would take thirty years of multiple shipments per day or week (Kamps, 2004). Another alternative is to keep nuclear wastes onsite at each reactor, where eventually they could leak into the nearby water supply and the atmosphere. As indicated by the half-lives of some radioactive isotopes listed in Table 1, these risks will remain *forever* into the future (Environmental Protection Agency). Most of these isotopes are man-made products of nuclear fission, not found in nature. Thus in many ways, nuclear power increases forever the risk of illness, mortality, and genetic damage.

Not Cheap

Nuclear power is a very expensive way to generate electricity. To use nuclear energy to boil water to turn a turbine is like cutting soft butter with a chain saw. To make nuclear power profitable, the nuclear industry must have billions of dollars in subsidies from the federal government. It also relies on the Price-Anderson Act, passed by the United States Congress, which limits the liability of a nuclear company to $9.1 billion for any one nuclear accident, less than two percent of the $560 billion estimated as the cost of a single serious nuclear disaster. The various federal, state, and local governments—and ultimately the individual citizens affected—will absorb the difference. If the nuclear industry had to take full financial responsibility for potential disasters, the cost of insurance would be prohibitive, thus greatly increasing the cost of nuclear energy (Ward, 2005, 12). The cost (not including considerable expenses for security, wastes, and accidents) per kilowatt-hour to generate electricity by nuclear power is estimated to be between 10 and 15 cents compared to electricity generated by coal at six to 22 cents and wind at three to six cents, according to Table 2, which shows most external costs as well as the direct costs of generating electricity (Sawin, 2004, 12-14). Currently the cost of electricity from nuclear power and coal is more than from wind or biomass. Costs for wind and photovoltaics are declining, however, while costs for nuclear power are increasing.

Table 2: Costs of Electricity With and Without External Costs

Electricity Source	Generating Costs[a]		External Costs[b]		Total Costs	
	Min[c]	Max	Min	Max	Min	Max
Wind	3.0[d]	5.0	0.1	0.3	3.1	5.3
Hydropower	2.4	7.7	0.0	1.1	2.4	8.8
Natural gas	3.4	5.0	1.1	4.5	4.5	9.5
Biomass	7.0	9.0	0.2	3.4	7.2	12.4
Nuclear	10.0	14.0	0.2	0.8	10.2	14.8
Coal/lignite	5.3	4.8	2.3	16.9	6.6	21.7
Photovoltaics	24.0	48.0	0.7	0.7	24.7	48.7

[a]Generating costs are for the United States and/or Europe.
[b]External costs are environmental and health costs for 15 countries in Europe. Considerable expenses of security, accidents, waste, and weapons proliferation are not included in the costs for nuclear energy.
[c]A range of cost estimates are given. Min=minimum; Max=maximum
[d]All costs in U. S. Cents per Kilowatt-hour. Eurocents are converted at the 2003 exchange rate of U.S. $1.00 = 0.8854.
Source: adapted from Sawin, 2004, pp 54-55, endnote 15.

Not Inexhaustible

Nuclear energy is not a long-term solution for producing electricity, since supplies of good quality uranium are not inexhaustible. At present rates of use, the world would run out of suitable uranium in 30 to 50 years. If enough nuclear power plants were built to replace all electric plants burning fossil fuel, the available supply of economically viable uranium could be used up in three to five years (Ward, 2005, 3)

If fast breeder reactors, which use plutonium from nuclear reactors' "spent" fuel as a fuel source, were used to generate electricity, the fuel supply would be extended, and the limits of uranium resources would be virtually eliminated. Fast-breeder reactors, however, are much more dangerous because of reprocessing highly radioactive fuel, and are prohibitively expensive because of special safety needs. Such reactors which have been tried in the United Kingdom and France have been closed. No fast-breeder reactor is in use today anywhere in the world and none is on the horizon (Ward, 2005, 11).

Economic Injustice

Nuclear power plants, nuclear waste dumps, toxic incinerators, and other similar facilities tend to be located where land and facilities are cheap and there is little organized opposition. Often these sites are in areas with a high proportion of minorities or poor people. The jobs and tax benefits offered by these facilities may be welcomed by communities, in which unemployment rates are high, at the cost of risk to health from these facilities. The Yucca Mountain site proposed for *permanent* storage of the nuclear wastes from power plants is on the sacred lands of the Western Shoshone Native Americans. Even with the economic benefits that a facility might bring at the beginning, the assessed value of some plants have been lowered when the plants are sold at a value well below the cost of construction; thus the taxes they pay to the community are greatly reduced. Nuclear power, like many other polluting industries, has a disproportionate effect on minorities, the poor, and the economically disadvantaged, thus contributing to economic injustice.

Part of the War Machine

The plutonium from the "spent" fuel can be further enriched to form the core of a nuclear bomb. This is one reason for world attention to the "peaceful" nuclear programs of Iran and North Korea. Friends should be very concerned that the products of nuclear power form the basis for nuclear weapons throughout the world.

Another weapon that comes from nuclear power is depleted uranium, the nuclear waste left behind in the enrichment of uranium. Depleted uranium is used to coat and strengthen missiles and artillery, to allow them to penetrate targets more easily. Once detonated, depleted uranium pulverizes into a fine dust that is carried on the wind and contaminates air, soil, water, and plants well away from battlefields, affecting citizens as well as soldiers. Depleted uranium can cause kidney failure, various cancers, reproductive problems, genetic damage, and a weakened immune system (Caldicott, 1994, 56). Since the 1991 Iraq war, the number of deformed babies, cancer rates, and infant mortality in Iraq has increased dramatically. It is estimated that thousands of American soldiers have been affected by depleted uranium (Ericson, 2003, 1-2). Because of the very long half-lives of the radioactive isotopes in depleted uranium, the impacted areas will remain radioactive far into the future. Nuclear power is the basis for this silent but lethal weapon.

Beyond Nuclear Power

If the fossil fuels of coal, oil, and gas contribute greatly to global warming, and nuclear energy as a source for electricity is not clean, safe, cheap, nor inexhaustible, what *can* we do for energy in the future? Currently electricity accounts for only a small portion of the world's energy use; ways to reduce greenhouse-emissions and wastes radioactive for millennia must include all energy sources. To be sustainable sources, they must be renewable. Without question, the most effective way to reduce emissions and nuclear pollution is to reduce energy demand through conservation—not wasting energy—and through energy efficiency. Learning and practicing energy conservation would be our greatest contribution to future generations.

For the energy we need, we must ultimately use only what the sun provides for us, which if we could just capture and store it well, would be vastly more than we could use. Wind, biomass, hydro, and photovoltaics are promising sources of energy, particularly electrical energy. While each of these sources creates some greenhouse-emissions in the construction of facilities, in generating electricity they contribute very little, if any, carbon dioxide to the atmosphere, and even may remove some. As Table 2 shows, all these sources except photovoltaics cost less to produce electricity than nuclear and probably coal. The costs of photovoltaics are diminishing rapidly (Sawin, 2004, 11-12). None of these sources produce toxic wastes that will poison the earth for longer than humanity has even existed. Morally, spiritually, and practically, we must move immediately to these renewable forms of energy which use the earth's resources at a level that provides a reasonable life for all now and maintains the capacity to provide such a life for coming generations.

For Further Information

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Other Organizations Concerned about Nuclear Energy

Environmental Law and Policy Center, 35 East Wacker Dr., Suite 1300, Chicago, IL 61601 <www.elpc.org>

No New Nukes, <www.nonewnukes.org>

Nuclear Energy Information Service, P.O. Box 1637, Evanston, IL 61204-1637 <www.neis.org>

Nuclear Information and Resource Service, 124 16th NW, Suite 404, Washington, DC 20036 <www.nirs.org>

Nukewatch (The Progressive Foundation), P.O. Box 649, Luck, WI 54853 <www.nukewatch.com>

Public Citizen, 1600 20th St. NW, Washington, DC. 20009 <www.citizen.org>

Union of Concerned Scientists, 2 Brattle Square, Cambridge, MA 02238-9105 <www.ucsusa.org>

What Friends Can Do

1. *Friends can make the invisible visible!* Like radiation itself, the problems of radioactivity are invisible. People are largely unaware of the dangers and problems of nuclear power. The nuclear industry and the government, including the very government agencies supposed to *safeguard* our nation from its dangers, disregard or minimize the dangers of nuclear power. Problems, accidents, and near misses are largely unreported in our media; health effects are downplayed, and neither government nor industry will perform epidemiological studies which could indicate and document those health effects.

2. Friends thus can *wake up* to awareness of the problems. We can inform ourselves, form study/action groups, and dialog with and educate others at every opportunity. We can dispel myths about nuclear power. We can become vigilant regarding all aspects of nuclear power and energy policy.

3. We can *act* however and whenever possible to stop further proliferation of nuclear power, to decommission existing reactors (103 in the United States, 440 worldwide), and to find ways to safeguard forever the existing nuclear wastes which we have already created and bequeathed to our children, grandchildren, and to the next ten thousand generations.

4. The most effective way to decrease the need for more energy production is to decrease the demand for it through energy conservation. This change begins with each one of us, in the choices we make to live our own lives simply and sustainably.

5. Also, in every way possible, we can support development of renewable energy.