Should Greens Support Nuclear Energy?

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University of the West of England, Bristol

Jack Reardon
University of Wisconsin – Stout

Social Science Department

reardonj@uwstout.edu

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The signs of global warming are ubiquitous: in addition to glaciers melting and more severe storms, the growing season is lengthening by 2.3 days per decade, pushing species poleward an average of four miles per decade and up mountains 20 feet per decade (Flannery 2005). No ecosystem will escape the reach of global warming, from coral reefs, where at least one of every four ocean inhabitants spends at least part of their life, to polar regions where climate change is occurring twice the rate elsewhere. Species are literally scrambling to adjust to new conditions; and unfortunately the odds are stacked against them.

Unlike previous warming trends which occurred over hundreds and thousands of years, the current trend is happening very rapidly. When the last global ice age ended 10,000 years ago, the earth's temperature warmed nine degrees Celsius over a period of 7000 years; whereas today, the global warming rate is thirty times faster! Species do not have adequate time to adapt. We've already lost the golden toad to global warming and if nothing is done, we will lose three of every five species by the end of this century.

Geographically the effects of global warming will be erratic and unpredictable. Some areas will get more rainfall and others less. Warmer temperatures will increase sea levels and produce more severe storms, inundating coastal areas. The poor will suffer disproportionately since many depend on agriculture and fishing for their livelihoods. A somewhat paradoxical scenario is that melting glaciers will increase the fresh water content of the oceans diverting the Gulf Stream, the underwater conveyor of warm tropical water to northern latitudes, plunging Europe and the eastern United States in a mini ice age.

For approximately four billion years the earth's temperature has remained a stable 57 degrees. Despite natural and sometimes cataclysmic events (volcanic eruptions, change in the earth's tilt, decrease in sunlight intensity, etc.) the global temperature has consistently rebounded to this norm. Fossil fuel combustion, however, is jeopardizing Earth's resiliency. Conditions are changing so rapidly that we could reach a tipping point of no return. This is a sobering risk of global warming; a risk that no generation has the right to impose on the future.

Sir David King, chief scientific advisor for Tony Blair, eloquently pleaded, "Deploying a range of technologies to radically decarbonize our energy system over just a few decades is a challenge that should not be underestimated. We need every tool in the bag to address it. Even taking the most optimistic projections, dramatic investment in energy efficiency will not be enough. So I believe the goal is now right to revisit the question of new nuclear plants."

Should greens embrace this position?

The Basics of Nuclear Energy

In 1905, Albert Einstein offered the world an intriguing and novel equation: E=MC.^{2} Although scientists had previously studied mass and energy as unrelated entities. Einstein was the first to join mass and energy in the same equation. Mass and energy, according to this equation, are interchangeable. A little mass can produce a lot of energy since mass is multiplied by the square of the speed of light, equal to 186,000 miles per second.

Attention quickly turned to harassing the energy of the atom. Protons and neutrons, with positive and neutral charges respectively, constitute the nucleus which accounts for 99 percent of the atom's mass but less than one percent of the volume – the atom is mostly empty space. The uniqueness of an atom is determined by the number of protons. Hydrogen, for example has one proton; oxygen has eight protons and, carbon has nine. Atoms also contain electrons with a negative charge that occupy various shelves within an atom, each with a different energy level. The number of electrons in the outermost shelf determines the atom's bonding capacity.

A strong, nuclear force – the most powerful force in nature – operates at the subatomic level to keep the nucleus intact, otherwise the protons would repel each other and all matter would crumble. The strong force is 100 times greater than the electromagnetic force – which attracts opposite charges, i.e., protons and electrons, and repels like charges – and is 10^{42} times greater than the force of gravity[1]. The electromagnetic force operates on all protons in the nucleus; whereas the strong nuclear force operates only on nucleons (protons and neutrons) in its immediate vicinity. It is the tension between the electromagnetic and the strong force that makes nuclear reactions so powerful.

As the number of protons in an atom increases, the electromagnetic force continuously increases; whereas the strong force per proton first increases, then stabilizes before decreasing, eventually reaching a point where the nucleus is unstable, due to the preponderance of the electromagnetic force. The strong nuclear force per proton is most binding for iron with 26 protons (with and an equal number of electrons) and weakest for uranium, the heaviest naturally occurring element with 92 protons. Uranium, discovered in 1789 and named after the planet Uranus, is so heavy with protons that it is unstable due to the preponderance of the electromagnetic force (the more protons, the more electrons). More technically, uranium naturally decays and it is radioactive. Left on its own, uranium will eventually decay into lead, an element with half the mass and interestingly used as a

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[1] Of the four forces in nature operate at the subatomic level: the nuclear, the electromagnetic and the weak radiation. The other force of nature is gravity.

heavy dense shield to protect against nuclear radiation. We know from Einstein's equation that this mass has an enormous amount of energy which makes radiation so dangerous. The high energy of radioactive decay causes extensive damage to living cells. Radiation fractures proteins and nuclei acids, inhibiting their function and resulting in loss of cell vitality. Radiation can also rupture cell membranes, decrease enzyme activity and in some cases, initiate cancer.

All elements with more protons than uranium are transuranic and must be manufactured synthetically, although trace amounts of Plutonium and Neptunian (atomic number 93) are found in uranium ore. Transuranic elements are also radioactive with much shorter half-lives than uranium and more intense radiation.

The energy of the atom can be harnessed by either fission or fusion. Fission (from the Latin to split) involves hurling a neutron at the nucleus of an unstable atom such as uranium. Since neutrons have no electric charge they will not be affected by protons or electrons. The resulting decrease in mass will unleash an enormous amount of energy equal to its mass times the speed of light squared. The energy released is far greater than fossil fuel combustion. One atom of fissionable uranium produces 10 million times more energy than a single carbon atom. Stated a little differently, one ton of uranium produces 45 million kilowatt hours of electricity; whereas the same amount of electricity requires 20,000 tons of coal and 30 million cubic meters of natural gas. In addition, nuclear fission energy consumes less than ten percent of the energy it eventually creates, far better than fossil fuels.

Fusion involves smashing two atoms together to produce a new slightly heavier atom. Think of two snowballs smashed together to form a third – some of the initial mass is lost (with the urgency of global warming, perhaps this is not an apt metaphor). We know from Eienstein's equation that the resulting loss in mass has energy equal to the speed of light squared. Hydrogen, the lightest atom with only one proton in its nucleus, is the most logical candidate for fusion. In fact the sun, is nothing but a nuclear reactor, smashing together hydrogen atoms to produce the slightly heavier helium.

When the hydrogen atoms fuse together part of the mass is lost; its energy heats and lights the earth, 90 million miles away. Fusion also generates ultraviolet radiation, which can significantly damage human skin and can alter DNA. Ultraviolet radiation is so named because only light within a narrow band of wavelength is visible to the human eye. Ultraviolet has a smaller wavelength length and thus invisible, but since the wavelength is smaller it has more energy; i.e., radiation.

The fusion fuel cycle utilizes the hydrogen isotopes deuterium and tritium since they fuse easier than hydrogen. (Isotopes have identical chemical properties but differ in the number of neutrons in the nucleus, thus their masses are slightly different.). Deuterium, also called heavy water, is chemically identical to water except that it has one extra neutron and thus a greater mass. Deuterium constitutes 0.015 percent of all water, but since water is abundant, the global supply of deuterium -- ten million million tons, is practically unlimited. Tritium, is radioactive and made from Lithium, the lightest metal and plentiful within the earth's crust.

For the same amount of inputs, a fusion power plant produces ten times more energy than fission with at about 1000 times less waste. A 1000 megawatt coal plant in one year uses 9000 tons of coal and generates 30,000 tons of carbon dioxide waste, 600 tons of sulphur dioxide and 80 tons of nitric oxide. A 1000 nuclear fission reactor utilizes 147 pounds of uranium and generates 6.6 pounds of radioactive waste. A fusion plant uses 1 lb. of deuterium and 1.5 lbs of tritium and generates 4.0 pounds of helium waste and trace amounts of radioactivity (Princeton Plasma Physics Laboratory 2005). Another advantage of fusion, is that it is not possible to use fusion products for nuclear weapons.

The world's 437 nuclear reactors use fission. In June 2005, a six-nation consortium (US, Russia, China, Japan, South Korea and the European Union) selected Cadarache in southern France to build a prototype fusion reactor. It is expected to begin operation in 2016 with an estimated cost of 10 billion Euros. The Consortium promises to build a commercial reactor in Japan. Realistically, however, energy from fusion is decades away, perhaps by 2050.

Currently nuclear energy provides only 19 percent of the world's electricity. With energy demand expected to increase at 1-2 percent per annum, the construction of nuclear power plants might at best meet the incremental energy demand rather than reduce consumption of fossil fuels. (Leake 2007: 29).Electricity demand, which accounts for 40 percent of energy demand (transportation and heat each account for 30 percent) is expected to double by 2025, increasing faster than total energy demand. Much of this growth will occur in developing nations where the demand for electricity is expected to increase 3.5 percent annually, compared to 1.6 percent for developed nations. Electricity is the fastest and most compact form of energy since it is necessary to activate microwaves, lasers, X-Rays, magnetic pulses, silicon chips, magnetic resonance imaging, highspeed wireless and much more (Huber and Mills 2005:, p. 16).

A popular argument in favor of nuclear energy is that it does not contribute to global warming. This is true if only the reactor stage of the nuclear fuel cycle is considered, but false and disingenuous if we consider the entire nuclear fuel cycle from mining to waste disposal. Uranium must first be extracted from the earth, which is one of the earth's most energy-intensive industries, a point conveniently overlooked by nuclear advocates. Although Uranium is naturally found everywhere on the surface of the earth and in the seawater, the mining of ore is economical in greater concentrations. Nevertheless, uranium ore contains less than 0.1 percent uranium; the rest mostly rock is waste. Ninety-nine percent of the extracted ore is the non-fissile isotope U-238 and one percent is the fissile isotope U-235. Both isotopes are radioactive: U-238 emits alpha radiation with a half-life equal to the age of the earth and U235 emits gamma rays with a half-life of 704 million years.

Energy is also needed to process the raw uranium into something usable : it must be washed, and chemically transformed into uranium enriched pellets (usually at 4 percent) suitable for producing electricity. Coal-fired generators typically power the process, releasing significant greenhouse gases into the atmosphere. The finished pellets must then be transported to the nuclear reactor, which expends energy.

The enriched uranium pellets are stacked into fuel rods, typically about 1 cm wide by 3.5 meters. Several hundred rods are bundled together and placed in the reactor core, made of reinforced steel and concrete. A fission chain reaction is initiated by shooting neutrons at the rods in order to dislodge a neutron from the nucleus, which in turn will dislodge other neutrons from other nuclei to start a chain reaction. Each freed neutron has the energy equivalent of its mass times the speed of light squared. The energy form the fission process can either be used to produce heated water or electricity via a turbine just like conventional oil and gas.

To prevent a runaway chain reaction several controls are utilized. First the uranium is only enriched to 4 percent. Second, a rod, made of non-fissile material such as cadmium, is placed in the reactor to control the speed of the fissile reaction by absorbing neutrons. Third, a coolant, usually water, liquid sodium, or helium gas removes the heat generated by fission reactions. Unfortunately, the coolant becomes radioactive and cannot leave the premise, so a series of pipes transfer the heated contaminated water to uncontaminated water. The contaminated water is continuously circulated within the nuclear plant; while the uncontaminated water is either released into a large body of water or transmitted through a steam tower to cool before release. The heat from the fission process converts uncontaminated water into steam which then drives a turbine connected to a generator to produce electricity. A fifth control is human operators.

These controls add about thirty percent to the cost of the average reactor, without completely eliminating risk. Paradoxically, it has been argued that inculcation of safety rules and procedures can breed over-confidence bordering on arrogance which inures against the possibility of failure enabling risks otherwise not taken (Dorner 1996: 34).

A nuclear weapon utilizing fission initiates the same chain reaction but absent all controls. An ordinary explosive surrounds a small amount of fissile material. Whereas reactors use only 4 percent enriched U-235, in order to decrease the probability of a runaway reaction; nuclear weapons require either 90 percent U-235 or Plutonium to increase the probability of a self-sustaining nuclear reaction. The International Atomic Energy Agency safeguards the enrichment process and fortunately few countries possess the technical expertise to produce weapons grade Uranium. The explosive is detonated and is blown inward, crushing the fissile material, thereby increasing its energy and the chance that a stray neutron will strike a nucleus. A neutron gun is also fired to add more neutrons, increasing the chance of a chain reaction. When the heat/pressure becomes too intense the bomb rips apart the casing, bursting heat, light, and lethal radiation able to penetrate human skin causing immediate death and/or altering DNA to cause cancer. Plutonium is highly fissile and given its propensity to self-ignite, it is ideal for bombmaking. It is also used peacefully in radioisotopes and thermonuclear generators.

Fusion, requires extremely high temperatures to overcome the strong force (temperature is a measure of energy, therefore the higher the temperature the higher the energy) in order to keep and confine the hot gas. At extremely high temperatures the fuel is no longer a gas but a plasma whereby the atoms have become ionized – separated from their atomic nuclei and incapable of bonding. A magnetic field confines the gas and prevents it from touching the reactor. For a fusion reaction to be viable, it must produce more tritium than it consumes. This could be accomplished by coating the reactor lining with a blanket of lithium three feet thick; as the neutrons are thrown off, they strike the lithium and produce tritium. However, fusion requires far more energy than fission to produce the hot temperatures and keep the plasma self-sustaining. The technique of cold fusion could potentially obviate the need for high temperatures and thus high energy, but claims of initiating cold fusion have not been replicated.

Converting raw material to energy generates waste and nuclear fission is no exception.

Simply put: there is no known method to dissipate nuclear waste, “no chemical reaction, no physical interference, only the passage of time reduces the intensity of radiation” (Schumacher 1989: 144). Four types of waste are generated during the fission process: (1) High level – containing mostly fuel rods. The fuel in the highly radioactive rods is spent after 12-24 months and is either stored temporarily on-site in water for immediate cooling (and later in concrete casings) or reprocessed;

(2) Intermediate – containing the chemical sludges, metal fuel cladding and contaminated materials from reactor decommissioning; (3) Low Level – the rags, filter, gloves, clothing from reactors, hospitals and industry; and (4) The reactor itself, which has a life of approximately 40 years due to constant bombardment from errant neutrons missing the uranium rods. The final step in the fuel cycle is decommissioning the reactor and disposing the high level waste. High level waste accounts for three percent of the total nuclear waste but 95 percent of the radioactivity with half-lives in thousands of years; whereas low level waste comprises 90 percent of the waste volume and only one percent of the radioactivity.

One solution is to bury the waste underground, but this is unsatisfactory because the half-life ranges anywhere from 90 years to several thousand, necessitating a geological secure and politically safe storage. It is also possible to reprocess the waste, a slightly misleading term since the second law of thermodynamics is not violated. Reprocessing collects the five percent fissile products and separates them into their constituent components. Ninety-five percent of the spent fuel rods is U-238; one percent is Pl 239; one percent is U-235 that did not fissile; and 3 percent other fissile products.

Arguments Against Nuclear Energy

Probably the most attractive argument in favor of nuclear energy is that it decreases global warming gases. However, as discussed in the last section, this is true only for the reactor stage of the fuel cycle. Whether nuclear energy emits more global warming gases than fossil fuels depends on the entire fuel cycle, especially the mining stage. For rich ores, of at least 1 percent uranium, the nuclear cycle emits thirty percent less global warming gases. Unfortunately, the supply of rich ore, based on current rates of consumption, is projected to last only fifty years (Van Leeuwen and Smith 2004: 6). Ore with less than 1 percent uranium results in more CO_2 emission. Accordingly, Van Leeuwen and Smith write, “Nuclear power is not a viable way to substantially reduce CO_2 emission. It is no exaggeration to say that nuclear power can only exist because it is fueled by fossil fuels” (2004: 3).

Pertaining to the second myth, at current levels of technology, rich uranium supplies will last forty years, but low grade will last at least another hundred. Although the future supply of potential energy sources is virtually unlimited, from the dark matter of the universe to deuterium in the sea, the important point they require more energy to extract, which exacerbate global warming.

The third myth, that nuclear energy will increase energy security and independence tantalizes fossil fuel addicts such as the United States. Nevertheless, most of the uranium deposits are found concentrated in Canada (29 percent), Australia (21 percent) and Kazakstan, Niger and Russia, each with 9 percent. Although more benign than most oil exporting countries, every major nuclear nation will have to import uranium.

A cogent argument against nuclear energy power is nuclear waste which must be stored for thousands of years and is “easily the most lasting insignia of the 20th century and the longest lien on the future that any generation of humanity has yet imposed” (McNeil 2000: .313). Even if secure geological sites can be found, how can this be guaranteed to the future? And “what social institution will watch over this nuclear legacy with guaranteed integrity?” (Commoner 1974: 97) A recent report found that spent nuclear fuel in US reactors is somewhat vulnerable to either a direct terrorist attack or theft by terrorists (National Academy of Sciences 2005). The report recommended a number of provisions to attenuate risk, including reconfiguring the fuel rod assemblies and additional water spray cooling systems. Schumacher’s warning is still germane, “there will be a continuous traffic of radioactive substances from the ‘hot’ chemical plants to the nuclear stations and back again; from the stations to waste processing plants; and from there to disposal sites. A serious accident, whether during transport or production, can cause a major catastrophe; and the radiation levels throughout the world will rise from generation to generation” (1989: 147).

The nuclear industry violates the Green precepts of democracy and fairness. Since its inception the nuclear industry has been secretive and has arrogantly imposed its will on the public and future generations. The nuclear industry is an oligopoly with tremendous market and lobbying power and thus contravenes the Green preference for localized production and distribution. Nuclear energy requires a significant capital investment (approximately between four and seven billion dollars) and thus is not an option for poor countries. Of the world’s 440 nuclear reactors the United States has 104, while Central and South America have none; Africa has 2 both in South Africa, while the Middle East has none, although one is under construction in Iran.

Although all types of energy have dual military and civilian purposes, only nuclear energy has the capacity to immediately destroy civilization. Only a fine line exists between ‘peaceful’ nuclear energy and nuclear weapons. The Nuclear Non-Proliferation Treaty (1968) designed to promote the peaceful use of nuclear energy and The Nuclear Suppliers Group (1974) designed to prevent the export of nuclear raw materials into the wrong hands, are weak and losing their efficacy. The Treaty has jurisdiction over declared activity while undeclared activity is beyond its purview and can provide a ruse to develop nuclear weapons while ostensibly using uranium for peaceful purposes. It is speculated that North Korea and Iran developed nuclear weapons through this Treaty loophole. Non-signatory nations have no obligation and can develop nuclear weapons on their own as did India, Pakistan and Israel. As a consequence of the high profile cases of Iran and North Korea, and the risk of terrorist acquisition of nuclear weapons, the Treaty should be revamped.

The treaty signed between the Bush administration and India might very well undermine the efficacy of the Nuclear Support Group by enticing other nation's to circumvent it for the sake of increasing profits. According to one analyst, "the more proliferation concerns grow, the greater the need to tighten export controls. Yet the Bush Administration is reversing this equation for India's benefit with the very real consequence that the whole control system might fall apart. (Krepan 2007: 17).

The increase of nuclear nations increases the likelihood of war and the possibility of a backdoor sale of nuclear weapons to terrorists. At the same time, the current geopolitical situation with one superpower encourages the development of nuclear weapons to assert national sovereignty. The Indian Foreign Minister, for example, asserted after India successfully tested a nuclear bomb in 1998, that there will no longer be no "nuclear apartheid in the world." the proliferation of nuclear weapons can only increase the potential of catastrophe by a conventional state or terrorist organization. The only solution from a green perspective is to destroy the weapons. In addition, the development of nuclear energy stamps a nation with the imprimatur of modernity: it is national pride, signaling that the nation possesses the intellectual sophistication of the modern age. In this sense, the desire to become a nuclear nation acquires its own momentum.

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