Nuclear Power, Fossil Fuels and Climate Change: The Long View

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1: The Nuclear Energy Debate So Far

Paul B. Thompson, writing in the early 1980s, elegantly summarized the debate over nuclear power: *proponents argue that it is both necessary and safe, opponents argue that it is neither, and each group rejects virtually every substantive premise of the other* (1984: 57-8). Over three decades later, that summary remains largely accurate.

Nuclear power is necessary, say its proponents, because demand for electricity is increasing, especially in developing nations. Ian Hore-Lacy, writing for the nuclear industry, contends that “*One-third of the world’s population does not have access to electricity supply, and a further third does not enjoy reliable supply. There is a huge need to address these shortcomings and expectations*” (2012: 8). Fossil fuels cannot meet this need, proponents say, because their reserves are dwindling, their cost is increasing, and they are the primary sources of climate change. Renewable energy sources, such as wind and sunlight, are available only intermittently—and, say nuclear proponents, they cannot be scaled up fast enough to meet the challenge of climate change. Energy efficiency is not a solution, since it decreases energy costs and hence encourages more consumption. It is, moreover, unrealistic to expect consumption to decrease (Hore-Lacy 2012: 9). There is thus, according to nuclear proponents, no prospect of meeting growing global demand, addressing climate change, and reducing world poverty without nuclear power. This argument is forceful. If foregoing nuclear power would indeed condemn large swaths of humanity to poverty, long-term climate change, or both, then necessity trumps safety, and proponents prevail on grounds of necessity alone.

Yet proponents also argue that nuclear power is safe. According to their risk assessments, the probability of a serious accident is extremely low. They contend that nuclear power causes, on average, fewer fatalities annually than coal, natural gas or hydropower (Hore-Lacy 2012: 93). They maintain that past accidents, such as those at Three Mile Island, Chernobyl, and Fukushima, have resulted from design flaws and/or procedural inadequacies that can be or have been corrected (Hore-Lacy 2012: 98-102; Murray 2009: 306-12). They argue that nuclear waste can be treated and disposed of safely (Ferguson 2011: ch. 7). They cite studies indicating that nuclear plants are robustly protected from terrorist attacks (Chapin et al. 2002; Hore-Lacy 2012: 102-3). And they argue that, with adequate international safeguards, increased nuclear power production need not foster nuclear weapons proliferation (Ferguson 2011: ch. 4; Hore-Lacy 2012: 104-113).

Opponents of nuclear power dispute nearly all of these safety claims, arguing that they are based on analyses from researchers whose ties to the nuclear industry constitute conflicts of interest. They contend that the actual frequency of accidents belies past risk assessments, and that (primarily because of the long latency period for radiation-induced cancers) fatalities from those accidents are orders of magnitude higher than industry estimates. They reject industry assurances that reactors are adequately protected from attack, that they need not contribute to nuclear weapons proliferation, and that nuclear waste can be processed, transported, and stored safely. And, in support of their own safety concerns, they note that banks are reluctant to loan money for nuclear reactors, that credit rating agencies downgrade utilities that operate them, and that utilities build them only when given generous legal protection from liability for accidents (Shrader-Frechette 2011a: chs. 2-4; and 2011b).
Opponents of nuclear power rebut the necessity argument by maintaining that energy needs can be met quickly enough to address climate change through conservation, efficiency, and renewable energy sources alone. They contend, moreover, that nuclear power plants take longer to build and are more expensive than renewable power sources—and, furthermore, that they are much more carbon-intensive over their life cycle (Shrader-Frechette 2011a: ch. 6).

Thompson’s characterization of the debate remains accurate: proponents still argue that nuclear power is both necessary and safe, opponents still argue that it is neither, and each group still rejects the other’s premises. Their arguments—complex, technical, and dependent on disputed empirical claims from the start—have not grown less so. To attempt a comprehensive assessment would require far more than a policy brief.

This much, however, is evident: in the three decades since Thompson wrote about this topic, intensifying climate change, continued population growth, and increasing energy demand have strengthened the case for necessity, and events at Chernobyl and Fukushima-Daiichi have weakened the case for safety. Hence a third, more disquieting position—one that Thompson (1984: 68) also, presciently, considered—has gained credibility: nuclear power is necessary but not safe. This third position, unlike the first two, has no enthusiastic proponents.

2: The Long View: Methodology

The potential effects of nuclear energy production and fossil fuel use are profound and extremely long-lasting—some of them on the order of centuries or millennia. Ethical energy policy must therefore take into account the welfare of people and of life on Earth far into the future. For this purpose the standard tools of economic policy analysis are inadequate.

2.1: The Long-Term Ethical Inadequacy of Economic Methods

Economists customarily discount harms or benefits to future people as a function of their temporal distance from us. Since economics usually measures values monetarily, such discounting can often be justified by the dynamics of money (e.g., its tendency to yield return on investment). But the dynamics of money has little relevance to long-term ethical policymaking, for discounting is applied in economic analysis to all values, including the value of a human life, not just to the values of marketable goods and services. But the chief ethical concern with both nuclear power and fossil-fueled climate change is vast numbers of future human casualties. Unlike the benefits of money or marketable goods and services, the harms of suffering and death are not subject to interest rates; and they have no less ethical significance when they occur in the future than when they occur in the present (Nolt 2015b: sec. 4.1).

It is sometimes argued that if we invest money now instead of spending it on mitigating climate change, then that will enable us to compensate future generations for their losses by providing them with the fruits of increased economic growth. But it is doubtful that future people, faced with an irradiated landscape or the mortal dangers of an inhospitable climate, would find any such compensation adequate, even if it were feasible.

It is also sometimes argued that discounting is justified by the greater risk associated with more distant future events. But while both risk and the value or disvalue of future benefits or harms are essential factors in any rational decision, they are best conceived as distinct variables. The probability of an event does affect whether and how we rationally ought to act to prevent or promote it, but how beneficial or harmful the event would be if it occurred is independent of that probability. The most transparent analyses treat these two vari-
ables separately.

Various other justifications are given for discount rates, but none are ethically defensible when applied to the harms of bodily injury or death (Parfit (2004), Appendix F).

2.2: Casualty and Mortality Rates as Ethical Measures of Harm to Humans

Casualty or mortality rates are simple and crude, but objective and comprehensible, measures of the long-term effects of energy policies on human beings. A casualty rate is the number of people who die or suffer injury or illness from a given cause over a specified period of time. Mortality (fatality) rates are similarly defined, but count only deaths, not injuries or illnesses.

One immediate advantage of casualty and mortality data is that they require relatively little interpretation. When (as for many past or present events) actual counts can be made, the results are hard numbers, pure matters of fact. Where estimates are needed, they are still estimates of what are or will be hard facts.

A second advantage is that casualty and mortality estimates are familiar to everyone and much better understood by the public than any of the more technical measures introduced by economists. The news media report them daily for all sorts of calamitous events. Historians rightly use them to gauge the relative severities of disasters (battles, storms, earthquakes, plagues, etc.) across wide stretches of time.

A third advantage is that casualty and fatality estimates may be more likely than some other ways of assessing future dangers to elicit constructive public concern. A recent study comparing audience reactions to articles framed in terms of dangers to the environment, national security, or public health, found that... across audience segments, the public health focus was the most likely to elicit emotional reactions consistent with support for climate change mitigation and adaptation. Findings also indicated that the national security frame may possibly boomerang among audience segments already doubtful or dismissive of the issue, eliciting unintended feelings of anger (Myers, et. al. 2012). Death, disease and injury are, of course, matters of public health.

An ethically important consideration for any form of power generation, then, is the number or rate of casualties or fatalities it causes—or could cause under various scenarios. The likelihood of each scenario must, of course, also be factored into decision-making. A small probability of a given number of deaths, for example, is of proportionately less moral concern than the certainty of that number. But casualties and fatalities themselves are not reasonably subject to discounting. The certainty of a hundred thousand casualties two centuries from now is the ethical equivalent of hundred thousand casualties today.

The risks of power production must be balanced against the risks of failure to produce adequate power. Extreme energy conservation measures might lower casualties from environmental disruption but raise them overall by increasing poverty. Policymakers must avoid sins of omission, as well as sins of commission.

2.3: Extinction Rates as Ethical Measures of Harm to Non-Human Life

In the foreseeable future, many of the economic, political, and technological controversies that now occupy center stage in the nuclear power debate will largely be forgotten. People who live during the next few millennia—and who when their generations are totaled up will be many times more numerous than we are—will not be concerned with what consumption options were available to us, how much we paid per kilowatt
hour, which researchers were subject to conflicts of interest, why financial institutions were wary of nuclear power, or even how we dealt with poverty. In the long run, what will matter most about our energy policies is how they affect overall possibilities for all life on Earth.

Just as casualty and mortality rates are simple and crude, but objective and comprehensible, measures of the long-term effects of energy policies on human beings and non-human life, species extinction rates are simple and crude, but objective and comprehensible, measures of the effects of our policies on non-human life. The analysis below uses both casualty and mortality rates and extinction rates as criteria to evaluate long-term energy policy options.

3: Potential Harms of Power Sources

Over the next few decades humanity will generate large amounts of power somehow. Much of it will be distributed through electrical grids, and the benefits of its use will be similar regardless of its source. Of course, the monetary costs of fossil power, nuclear energy, and renewables differ. But at present they are all of the same order of magnitude, and in the long term—that is, on scales of centuries or more—these differences, however important to us today, will fade into insignificance. What distinguishes the various forms of power generation most significantly for ethical purposes, then, is the long-term harm they may do. This section assesses that harm, using the methodology outlined above.

3.1: Potential Harms of Nuclear Power

All nuclear power operations, from mining though power generation to waste disposal, deal with radioactive materials. These materials pose health hazards via emission of ionizing radiation—subatomic particles energetic enough to strip electrons from atoms upon impact. Such particles normally do not travel far from their sources, but dangerous quantities of radioactive materials can be dispersed into the environment from power plants or nuclear waste repositories as a result of accident (as in the cases Chernobyl or Fukushima-Daiichi) or deliberate attack.

Though all life has evolved with and adapted to low-level background radiation from cosmic rays and a variety of natural terrestrial sources, very high radiation doses are quickly lethal, and no amount is absolutely safe. Ionizing radiation harms organisms by damaging the machinery of cells, most notably DNA and RNA molecules. Cells can repair some of this damage, but what is not correctly repaired may cause mutations or cancers. The probability of many types of cancer increases with an individual’s cumulative lifetime exposure to ionizing radiation (National Research Council 2006: 11-12).

The radioactivity of nuclear materials decreases over time. How quickly it decreases depends on the radioisotopes they contain. The rate of decrease for a given isotope is measured by its half-life—the average time required for half of its atoms to decay into a different isotope. That isotope itself may or may not be radioactive. The most harmful contaminants from nuclear weapons explosions (which is relevant here because of the danger of nuclear weapons proliferation, discussed below) or reactor melt-downs are cesium 137 and strontium 90, each with a half-life of about 30 years, and iodine 131, whose half-life is about eight days. Radiation from iodine 131 decreases quickly; ninety-nine percent decays away within two months. But to eliminate 99 percent of the radiation from cesium 137 or strontium 90 takes a couple of centuries. Soils, flora, and fauna in parts of Europe and the former Soviet Union are still dangerously contaminated with cesium 137 from the Chernobyl melt-down in 1986, forcing the inhabitants of these regions to take special precautions with food sources (Yablokov, et al. 2009: chs. I and IV). Melt-downs and nuclear explosions also produce longer-lived
radioisotopes—including plutonium 239, with a half-life of 24,100 years—though in much smaller quantities (Yablokov, et al. 2009: 19).

High-level nuclear waste (e.g., spent fuel rods from nuclear power plants) also contains long-lived radio-isotopes—including several isotopes each of uranium and plutonium (Murray 2009: 366-7). Unless the waste is reprocessed, it takes about 10,000 years for its radioactivity to subside to the level of the ore from which the fuel originated (NEA 1989).

High-level waste, most of which is currently stored onsite at power plants, must constantly be protected against such natural dangers as earthquakes, tsunamis or floods, and against military attack. It cannot be used to make nuclear explosives, although it might be incorporated into “dirty bombs” that use conventional explosives to disperse radioactive contaminants. The likelihood that, over thousands of years, high-level waste somehow will produce casualties or environmental damage is, no doubt, high, but the geographical extent of such damage would probably be relatively small.

Nuclear power plants have in operation belied their proponents’ assurances of safety. Chernobyl and Fukushima-Daiichi were the worst accidents, but there have been a number of others (Shrader-Frechette 2011a: 117-122). Reactor melt-downs have caused many deaths—hundreds of thousands, mostly from radiation-induced cancers, according to high-end estimates for Chernobyl (Shrader-Frechette 2011a: 64-5; Yablokov, et al. 2009: 192-216)—though the estimates of nuclear proponents are much smaller. Nuclear accidents have also done considerable biological damage. In a survey of 521 biological studies of the Chernobyl event, von Wehrden, et al. (2012) document widespread deaths of individual organisms and radiation damage to habitat and natural systems. They do not, however, report any species extinctions.

Some elements of nuclear power infrastructure (e.g., uranium enrichment facilities or fast breeder reactors) can be used to manufacture weapons-grade fissionable material. Nuclear power development may therefore spur nuclear weapons proliferation and hence increase the risk of nuclear war. Nuclear conflicts could vary widely in severity. A thermonuclear exchange among superpowers would kill billions of people and deplete biodiversity worldwide. Atmospheric disturbances, including perhaps nuclear winter, would continue for years, and radioactive contaminants, mostly cesium 137 and strontium 90, would, though decaying, create hazards peppering much of the globe for more than a century. Many lesser forms of nuclear conflict are also possible (Pittock, et. al. 1986: 14-16 and 208-10; Robock, et al. 2007; Toon, et al. 2007; Robock 2010; Robock and Toon 2012).

But nuclear weapons can be—and, indeed, originally were—produced and used militarily in the absence nuclear power generation. Consequently, what matters for the nuclear energy debate is not the probability of nuclear conflict per se, but how much that probability is increased by the dissemination of nuclear energy. Clearly the widespread development of nuclear energy does not make nuclear conflict inevitable, but it does make it more likely.

### 3.2: Potential Harms of Fossil Fuels

Though nuclear power is dangerous, fossil power is more dangerous, and its dangers are more immediate, more prolonged, and more certain. Worldwide, emissions from fossil plants now cause hundreds of thousands of deaths annually. A substantial fraction of the world’s outdoor air pollution, which kills well over a million people annually (Silva et al. 2013)—some 500,000 in China alone (DARA 2012: 256-8)—is produced by coal-fired power plants.

Coal-fired power plants also produce about a quarter of worldwide greenhouse gas emissions (IPCC 2007: Figure 2.1: 36), and the various effects of climate change are estimated to kill about 400,000 people anu-
ally (DARA 2012: 17). Hence about 100,000 of these deaths, too, are attributable to coal-fired power plants.

Annual fatalities from nuclear power have not been of the same order of magnitude, even assuming the highest of nuclear opponents’ death toll estimates for nuclear accidents. Of course, fossil plants, being more numerous, produce about five times as much electricity as nuclear plants do. But, even when that is taken into account, **fossil plants still cause many more deaths each year per unit of electricity.** Indeed, it has been argued that nuclear power is already saving millions of lives by preventing air pollution that would otherwise occur from the burning of fossil fuels (Kharecha and Hansen 2013).

On the positive side, fossil-fueled climate change increases crop production in some regions, in the short term. This may save lives; but, globally and in the long term, these agricultural gains will be swamped by agricultural losses, so that they cannot be accounted an overall advantage of fossil fuels (Nelson, et al. 2009; Liu, et al. 2013).

On the positive side, too, are the substantial benefits of the generated electricity, especially for reduction of poverty in developing nations; but, as was noted above, these are essentially the same regardless of the power source, and hence do not differentiate nuclear from fossil energy or renewables.

The further into the future we look, the more the picture darkens. Climate change mortality is forecast to reach 700,000 annually by 2030 (DARA 2012: 17). Hence, **even ignoring air pollution, the cumulative death toll by the end of the century from fossil plants (which produce about a quarter of the greenhouse gases) is likely to be in the tens of millions** (Broome 2012: 32-3). Climate disruption will, however, last far longer than that, even if we stop burning fossil fuels within decades. Assuming the likely climate sensitivity of 3°C for doubling of CO₂, elevated temperatures will persist, according to a recent estimate (Zeebe 2013), for 23,000 to 165,000 years. **Burning all fossil fuel reserves could render most of the planet uninhabitable by humans** (Hansen, et al. 2013).

The **total number of casualties resulting over the coming millennia from greenhouse gas emissions during the relatively brief fossil fuel era is in any case likely to be astronomical** (Nolt 2011, 2013, 2015a). Among the dangers of nuclear power, only a large-scale nuclear war could produce comparable numbers. Yet the expansion of nuclear power generation does not inevitably entail nuclear war, and the harmful physical effects of nuclear war would dissipate within centuries—as opposed to tens of millennia for climate change. (It is noteworthy in this regard that Hiroshima and Nagasaki, the only places on Earth ever to suffer nuclear attack, are thriving cities today.)

Climate change is, moreover, making it increasingly difficult to preserve species. As the earth heats up, species ranges are shifting to higher elevations or toward the poles (SCBD 2010: 10). This causes ecosystems to disintegrate as their current inhabitants move out at different rates and new inhabitants move in. Species that do not move or adapt quickly enough will be lost. Extinctions are, predictably, accelerating.

Continued burning of fossil fuels, along with continued habitat destruction could ultimately precipitate a mass extinction—loss of three-quarters or more of Earth’s species. Biodiversity loss from mass extinctions, five of which are known from the fossil record, is extremely long-lasting. Recovery generally takes millions of years (Zeebe and Zachos 2013: 13; Bellard, et al., 2012; Barnosky et al. 2011: 51).

A large-scale nuclear war would, no doubt, produce many extinctions, but no responsible treatment suggests the possibility of mass extinction (Harwell and Hutchinson 1985: 252-3; ch. 7; Robock, et al., 2007; Robock 2010; Robock and Toon 2012; Westing 2013).
In sum, the harms of fossil power greatly exceed in probability, severity and spatiotemporal scale those of nuclear power.

3.3: Potential Harms of Renewables

The main alternatives to nuclear and fossil power are solar, wind, hydroelectric, tidal, plant-based, and geothermal energy sources—collectively known as “renewables.” None of these are as harmful by the criteria outlined above as fossil-fueled energy sources. None poses risks as great as those of nuclear power.

It may seem, then, that we should generate all of our power with renewables. But here the necessity argument intrudes. About 68 percent of the world’s electricity and 81.3 percent of its energy is supplied by fossil fuels (IEA 2013: 7, 24). The finitude of fossil reserves and the enormous long-term consequences of burning them all make deep reductions in fossil fuel use both urgent and inevitable. Yet energy demand and use are still escalating, primarily in developing nations, and must continue to increase if we are to eradicate poverty in a global population that is likely to continue growing through the end of this century (Gerland, et al. 2104). Nuclear advocates argue that we cannot generate nearly enough electricity with renewables alone, since wind and sunlight vary geographically and produce power only intermittently. Only nuclear reactors, they say, can generate enough reliable base-load to replace fossil fuels (Fox 2014: 73-117).

Opponents of nuclear power question whether nuclear reactors can be built quickly enough and whether, if they could, they would be reliable. They maintain, moreover, that energy demand can be reduced by conservation and efficiency, and that renewables alone can be scaled up quickly enough to address the problem of climate change (Shrader-Frechette 2011a: ch. 6).

Once again, the premises of both sides turn on empirical matters that cannot be adjudicated here. Yet, as the next section shows, even without answers to these empirical questions, assessment of the competing energy sources in accord with long-term criteria yields substantive policy implications.

4: Policy Implications

To summarize: judged by the criteria of sustaining the possibility of low extinction and casualty rates, fossil fuels are, among the available energy options, likely to produce by far the worst long-term consequences. Hence fossil fuel use must be drastically reduced and ultimately eliminated well before reserves run out. Since how hot the earth gets will be roughly proportional to humanity’s cumulative carbon emissions (Stocke 2013), since harm varies continuously with temperature, and since temperature elevation will last for millennia, the more carbon we emit, the more casualties and extinctions we will produce (Nolt 2015a). Fossil fuels, once extracted, will almost inevitably be burned. We must, therefore, stop using fossil fuels relatively quickly and leave the remainder in the ground (Nolt 2015b, sec. 7.1.1).

These considerations reveal the importance of a long-term perspective. Relative to narrower and shorter-term concerns, the needs of today’s poor might, for example, seem to justify the construction of new fossil plants in developing regions. But given the ethical equivalence of present and future people and the vast and prolonged damages of climate change, it makes little sense to reduce poverty now by measures that will worsen the human condition over millennia.

But if we eliminate fossil fuels without replacing them with other energy sources, then we will not only fail to alleviate global poverty, but radically deepen it. Whether nuclear power should be part of the replacement mix depends upon whether we can deploy conservation and efficiency measures and renewables quickly enough to take the place of fossil energy. If we can’t, then nuclear power is necessary not only to alleviate pov-
erty, but to protect both nature and humanity, since without it we will almost certainly persist in burning fossil fuels, with dire long-term consequences. The best policy, therefore, prioritizes conservation, efficiency, and renewables as means of displacing fossil fuels, but does not neglect the need for nuclear energy.

These conclusions depend on several assumptions that could turn out to be wrong. Among the most important are:

• Nuclear fission, fossil, and renewable sources are the only large-scale energy options available, at least for the next few decades.
• Despite efforts at carbon capture and storage, most large-scale fossil power systems will continue to produce large carbon emissions.
• The effects of carbon emissions will not be greatly reduced by geo-engineering.
• Human population will not decrease over the remainder of the fossil fuel era.

These assumptions are all probable, but if any of them proves false, then the conclusions of this policy brief would need to be modified accordingly.
References


