Comments Written for the Meeting of the Kentucky Environmental Quality Commission, January 29, 2009

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I should like to comment on Strategy 7 of Kentucky's *7-Point Strategy for Energy Independence: "*Examine the Use of Nuclear Power for Electricity Generation in Kentucky." This section of Governor Steve Beshear's plan reads like a piece of propaganda from the nuclear industry, for it is dotted with half truths, untruths, and omissions. The idea that residents of Kentucky will accept this document and be moved by it to facilitate the building of nuclear plants in the state is an insult to our intelligence. Kentuckians showed excellent sense in the past in rejecting the construction of nuclear plants in the state. I hope that they will understand that the presentation of Strategy 7 is unbalanced. I shall point some of the major flaws in the argument in roughly the order in which they occur.

NUCLEAR POWER IN THE WORLD

A theme of Strategy 7 is that nuclear power is enjoying a worldwide renaissance from which Kentucky cannot afford to be left out. As a matter of fact, the renaissance is an illusion. Worldwide the nuclear industry is on the decline.

The total capacity of the nuclear fleet worldwide increased 3 gigawatts a year between 2000 and 2004, 2 gigawatts a year between 2004 and 2007 and less than 1 gigawatt in 2008. Meanwhile, all electric generating capacity, including coal-fired plants, nuclear plants, and renewable energy, is increasing at an estimated 150 gigawatts per year. According to the World Wind Energy Association, wind generating capacity alone increased 14.9 gigawatts in 2006 and 19.7 gigawatts in 2007. Thus nuclear's increase of 2 gigawatts in 2007 is insignificant.

As of September 2008, 439 reactors were in operation across the world. The average age of these reactors was 24 years. The average age of the 119 reactors that had already shut down was 22 years, energy consultant Mycle Schneider points out. He notes that if one optimistically assumes that the reactors now operating (with the exception of the reactors in Germany where operation is limited by legislation) plus the twenty units under construction in January 2008 that have an official start-up date will operate for an average of 40 years each, one can calculate how many reactors need to be constructed just to keep the worldwide figure at 439. In addition to the twenty reactors under construction, seventy reactors, generating 40,000 megawatts) would have to be planned, completed and started up by 2015—one every month and a half—and an additional 192 units (168,000 megawatts) by 2025—or one every 18 days. This will not happen, for reasons we shall summarize below.

Currently the importance of nuclear energy worldwide is less than Strategy 7 indicates when it states that nuclear accounts "for approximately 17 percent of worldwide electricity generation." As a matter of fact the nuclear industry's share of electricity generation worldwide has declined in the past three years. In 2005 it was 16%; in 2006 it was 15%; and in 2007 it was

14%. We should note that the Strategy's figures refer only to electricity, a point often overlooked in discussion of nuclear power. In terms of energy as a whole, nuclear power contributes 6% of commercial primary energy and only 2% of final energy, the energy actually used by consumers.

The Strategy in effect congratulates the US industry for its performance. The capacity factor for nuclear reactors in the United States is high, as Strategy 7 accurately states. The high percentage, however, is in large measure due to the fact that the industry has shortened the spans of time that reactors are offline for refueling and for maintenance. Efficiency is admirable, but a question arises as to whether corners are being cut that should not be cut, particularly since the reactors are aging.

The fact that the nuclear industry has been able "to maintain its approximately 20 percent share of the growing U.S. electricity market without adding any new generating stations" is less a reflection of the capacity factor than it is of the fact that the NRC has been granting utilities uprates, i.e. increasing the amount of electricity that the power plants are authorized to generate. It has granted 124 uprates since 1977, some as high as 20%. These upgrades total some 5 gigawatts, equal to about four new plants, Schneider calculates. This practice also raises safety concerns. The Union of Concerned Scientists has raised questions in particular about whether boiling water plants can operate safely when the power is thus increased.

NUCLEAR POWER CHALLENGES

Safety and Security

The safety record of nuclear power plants does not deserve the "outstanding" rating awarded by the Strategy. Nuclear proponents choose to overlook the accident at Unit 2 of Three Mile Island in 1979 when fuel partially melted down, but whatever Three Mile Island's health effects, the accident was significant enough to mark an end for three decades to orders for reactors in the United States. Greenpeace compiled a report that lists incidents that could have led to a core meltdown and subsequent failure of containment at nuclear power reactors between 1875 and 2004, as determined by the NRC through its Accident Sequence Precursor (ASP) program. In the period covered, US reactors experienced 8 "significant" precursors or near misses, 49 "important" precursors, and 142 additional precursors. The most recent "significant" precursor was the corrosion of the reactor head at Davis Besse, which was discovered, in the nick of time, in 2002.

Since 2004, the frequency of precursors as identified by the NRC seems to have been dropping: 15 in 2005; 14 in 2006; 9 in 2007; and 6 or more in 2008 (as of January 2008, analysis of 2008 is incomplete). However, a look into the NRC's descriptions of the precursor incidents does not inspire confidence. For example, July 31, 2008 at Prairie Island a reactor tripped (shut down) when a component of the reactor trip safety system failed. An auxiliary feed water pump that sends back-up water to the reactor then started up and tripped. August 5, 2008 at the Palisades Plant five people inspecting safety-related equipment found themselves locked into and unable to escape from or telephone out of the containment area. They were released by another worker who happened to enter the area. Minor incidents, an industry supporter would say; but hardly indicative of an industry operating with a high degree of rigor.

One group of safety issues at nuclear plants is computer problems. The computer systems that control the operation of reactors are in some cases in communication with computer systems that control business operations. June 5, 2008, the Hatch nuclear power plant in Georgia underwent an unplanned shutdown, because someone installed new software in a computer on the plant's business network. Such an event could lead to an accident. Perhaps more frightening, by hacking into a plant's control system through the networks to which it is connected, terrorists might be able to sabotage a plant's operation.

Utilities planning to construct new nuclear reactors in the near future will use what are known as Generation III or Generation III+ designs and appear to be particularly interested in the AP-1000 from Westinghouse, the Economic Simplified Boiling Water Reactor (ESBWR) from General Electric, and the Evolutionary Pressurized Water Reactor (EPR) from Areva NC. Generation III reactors are based on the designs of operating boiling water and pressurized water reactors. Their promoters claim that the new reactors will be safer than Generation II reactors, but, since none are in operation, the vaunted advantages have not been tested and some already appear questionable. Areva NP's EPR has a core catcher intended to hold melted fuel in the case of a core meltdown. However, a steam explosion could take place before or after the melted fuel reaches the core-catcher and it is not clear that the fuel that is caught by the catcher will not eat through it. The AP-100 is praised for having passive safety features (safety features that function automatically and without electricity), but it nevertheless relies on valves and on active heating, cooling, and ventilating units, Helmut Hirsch et al. have pointed out.

Of course, the reason why the nuclear industry must operate safely is the unique degree of risk that goes with it, an aspect of the industry not mentioned in the Strategy. In fact, the industry and also federal agencies have long tried to prevent discussion of the possible effects of accidents. The Atomic Energy Commission (AEC) published in 1957 but never fully recognized a study conducted for it by its Brookhaven National Laboratory, WASH-740, "Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants"; and the AEC never released or even admitted the existence of an update by Brookhaven National Laboratory and the AEC, begun in 1964. The update came to light in 1973 when an attorney threatened to sue the AEC under the Freedom of Information Act. The study found that a major accident at a 1000 MW reactor could kill as many as 45,000 people, injure 100,000 and cause property damage as high as $280 billion. Planned reactors today are on the order of 1600 MW, and inflation has changed the value of the dollar.

These figures become more vivid if we think in terms of where in Kentucky nuclear plants would be sited. The Strategy suggests eight plants at four sites. Four sites? Where? Each of the sites must have a large supply of water that will not be severely impacted by the droughts that global climate change can be expected to cause. Two of the sites mentioned in the Strategy do not have enough water. The most obvious locations would be along the Ohio River. What does this mean in terms of the risk to residents of Kentucky? The river corridor is highly industrialized and populated, with Paducah, Owensboro, Louisville, Covington, and Maysville among other towns and cities along it. Placing a plant in an urban area would put a large number of people and industrial facilities at risk; placing it in rural area could mean that an accident would have a major impact on the state's agricultural base. The Price Anderson Act, renewed in 2005, protects the nuclear industry but not the public against the financial effects of an accident.

Also little discussed in the Strategy is the danger of terrorist attack. The Strategy accurately states that since September 11, 2001, "the nuclear energy industry has substantially enhanced security at nuclear plants." What it does not note is that the industry has done so only under sustained pressure from public interest organizations and finally in response to legislation. The Energy Policy Act of 2005 dictates improvements. It also does not state that security measures are still incomplete. For instance, the Nuclear Regulatory Commission (NRC) rejected a demand by the Union of Concerned Scientists that existing plants be protected against attack by airplanes, although their containment structures were not built to withstand attacks by airliners such as Boeing 757s or 767s.

The Strategy entirely overlooks the question of health. Nuclear reactors, even when they are operating correctly, release low levels of radioactivity, in particular in the form of tritium, carbon 14, rare gases, and iodine. Whether low levels can have an adverse health effect has long been controversial, but the 2005 report on Biological Effects of Ionizing Radiation (BEIR) from the National Academy of Sciences' Research Council goes far to settle the issue. Based on a review of biological and biophysical data, it found that there is no threshold of exposure below which ionizing radiation can be considered to be harmless. An article by Joseph Mangano and Janette Sherman published in the *European Journal of Cancer Care* in July 2008 provides new support for this position. The authors found that children living near U.S. nuclear plants have higher than normal rates of death from leukemia.

Spent Fuel Storage, Transportation, and Disposition

The strategy attempts to minimize and gloss over the radioactive waste problem caused by nuclear power plants. The only waste it discusses is the approximately twenty metric tons of "solid" fuel each power plant discharges yearly. However, this fuel is by no means the only waste produced by nuclear power plants. Power plants also produce a great variety of so-called low-level wastes, which range from the resins used to clean water in pools storing irradiated fuel to the metal in the reactor itself. The resins have a hazardous life of more than 100,000 years, because of the radioactive iodine-129 that they contain; the contaminants of the reactor vessel include, among other radioactive isotopes, nickel-59 with a half-life of 80,000 years.

As of January 2009, it is not clear where low-level waste from Kentucky power plants would be disposed of. The least contaminated waste can go to a site operated by Envirocare of Utah, Inc. The more radioactive waste, classes B and C, would have gone to a site in Barnwell, South Carolina, but this site now accepts waste only from states that already belong to a compact with South Carolina. Waste Control Specialists has just been licensed to open a large site in Andrews County, Texas, for waste from the compact states of Texas and Vermont and from the US Department of Energy. Whether waste from other states will be accepted and, if so, what the cost will be are not known as of this writing.

It is also not known what would happen to the irradiated fuel from Kentucky power plants. The repository site at Yucca Mountain was a political choice and from a geologic standpoint is not suited to storing fuel safely for hundreds of thousands of years, as has become evident. The Strategy mentions three alternatives to an underground repository: "on-site dry storage, centralized dry storage, and possible recycling of spent fuel."

The first two alternatives offer, at best, only a temporary solution. The Strategy is incorrect in saying that currently "used fuel is stored safely at plant sites," although the degree of danger varies from site to site. For the first five years after removal from the reactor, the fuel is stored under water. The pools are almost always in buildings that are outside the reactor's containment structure. The buildings are designed to resist natural events, but not aircraft impacts and explosions. Pools at boiling water reactors are above ground, so that if a pool is cracked, water may drain out, allowing the fuel to overheat and either melt or catch fire. To prevent overheating during normal operation, the pools require artificial cooling of their water. Dry casks are generally safer, because they rely on passive cooling. However, at some current plants, casks are visible from the plant boundaries, and, according to the Union of Concerned Scientists, explosives or weapons that are available on the black market or, in some cases, available legally inside the United States could "cause the casks to be penetrated resulting in the release of large amounts of radiation." Bringing together all the irradiated fuel in the nation and storing it in one place above ground would present a huge security risk, both in transport and at the site.

The third alternative is no solution at all. Advanced methods of recycling, more accurately called reprocessing, can separate the components of irradiated fuel from one another. The plutonium and the uranium can be reused, though the reuse raises problems. Some of the other components can be transformed or transmuted into inert or less radioactive substances by irradiation in special reactors. However, not all of the components can be so transformed. They will have to be disposed of in a deep underground repository, if they are to be disposed of at all. The French know this and, although they are already reprocessing irradiated fuel, the authorities are conducting research on and preparing to construct a deep underground repository.

Any centralized repository or above-ground storage will involve a massive amount of transportation. In February 2006 the National Academies Press released a report entitled *Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States* by a committee of its National Research Council. The committee concluded that, if terrorist attacks are excluded, the transportation of nuclear waste by truck and train is probably safe. (A conclusion some scientists strenuously disagree with.) However, it admitted that terrorism is a big exception. The committee had to make this exception, it said, because the NRC refused to give the researchers access to information that would have enabled them to evaluate the terrorist risk. The committee "recommends that an independent examination of the security of spent fuel and high-level waste transportation be carried out with an investigation team made up of people with security clearances, prior to the commencement of large-quantity shipments to a federal repository or to interim storage."

Non-proliferation safeguards

The statement in the Strategy that "the international nuclear energy community has put in place rigid, redundant controls to ensure that it can fully account for nuclear materials . . . through the entire fuel cycle" (p. 101) is wishful thinking, if not deliberate deception.

Nations that did not explode a nuclear weapon before January 1, 1967 are known as non-weapons states. If these states sign the Nuclear Non-Proliferation Treaty (NPT), they are obligated not to acquire nuclear weapons and to declare their nuclear materials and nuclear-related activities to the International Atomic Energy Agency (IAEA), which verifies the accuracy and completeness of the declarations by means of physical inspections and analysis of data. If the IAEA detects a use of materials for military or other undeclared purposes, it informs the governing board of the IAEA, which must then decide what action to take. The IAEA is underfunded and understaffed. It cannot perform as many physical inspections as would be desirable. Furthermore, not all nuclear materials in all situations can be measured.

The amount of uranium and plutonium in irradiated fuel cannot be accurately determined until the fuel has been cut apart during reprocessing. Therefore, the exact amount of plutonium arriving at a reprocessing plant is unknown; and in reprocessing plants some plutonium sticks to the pipes and equipment and becomes mixed into the waste. It is thus conceivable that sufficient plutonium to make a nuclear device could be diverted without the International Atomic Energy Agency being any the wiser. Furthermore, even if the IAEA detects a diversion, it may do so too late to prevent the material's being used in a device or successfully hidden.

Nuclear weapons states (China, France, Russia, the United Kingdom, and the United States), all of whom have signed the NPT, are not required to submit their installations to safeguards, although they may choose to do so. In China, which, in the past, has exported technology and materials to non-weapons states, only imported nuclear reactors and an enrichment plant supplied by the Soviet Union are subject to IAEA safeguards. No plants in Russia are, according to the WorldNuclear Association.

An Additional Protocol strengthening the NPT in such ways as allowing the IAEA increased access to a nation's nuclear sites is, as of January 2009, in effect in 89 of the nations who have signed the NPT. However, the authors of the authoritative *Deadly Arsenals: Nuclear, Biological, and Chemical Weapons*, state that even the Additional Protocol "cannot prevent a determined state from acquiring a nuclear weapons capability."

The last words in the Strategy's sentence, "These controls include global monitoring by international inspectors and stringent national inspection programs" is ludicrous from the point of view of non-proliferation. A national inspection program will reflect the views of the government of the country in question. If a nation wants to acquire nuclear weapons, its national inspection program will be a sham. The United States government takes this position, in fact. Whatever Iran's true intentions, the United States has refused to accept its word that its nuclear program is peaceful.

The statement that commercial reactor fuel "cannot be used to make a nuclear weapon" is true if one takes it to refer to commercial reactor fuel as it comes from the reactor. It is also true that the uranium in the fuel, even if extracted, cannot be used to make a weapon. The plutonium that nuclear power plants create in their fuel, however, is, if extracted, weapons material. The presence of isotopes other than the most desirable, plutonium 239, would pose some problems, but they are not insurmountable. In fact the International Atomic Energy Agency regards all plutonium, except that created specifically to serve as a source of heat and high in the isotope plutonium-238, as equally sensitive.

Could terrorists separate plutonium from irradiated fuel if they could get hold of the fuel? As the Strategy states, separation of plutonium from irradiated fuel is normally carried out in large "highly sophisticated chemical processing" installations (p. 101). Nevertheless, a "'simple and quick'" reprocessing plant is also feasible, as a 1997 study at Oak Ridge National Laboratory indicated.

Extraction of plutonium from irradiated fuel would be dangerous, because irradiated fuel is highly radioactive. Shielding to protect the workers would be essential. The extraction of plutonium from unused Mixed oxide (MOX) fuel would be easier and, for the operators, far safer. If the United States decides to reuse the plutonium and uranium in irradiated fuel, as some would like to do, the use of MOX will become widespread. MOX has, in fact, been tested at Catawba in South Carolina. Therefore, it is untrue that "commercial reactor fuel poses no risk of proliferation" (p. 101).

The operation of nuclear power plants automatically increases the risk that a nuclear device or weapon will be exploded. The civilian industry and the military industry handle the same materials and use a number of the same types of facilities. The civilian industry can thus be used and has been used to hide military activities. The handling and transportation of nuclear materials also increases the likelihood that they will fall into the hands of terrorists or of a nation intent on building weapons. The fact that the United States operates civilian plants and that U.S. utilities are planning to build more encourages nations undergoing development to acquire nuclear power and these nations may not have the infrastructure to guard their nuclear materials adequately.

Economic sustainability

New nuclear plants cost more than the Statement indicates. In late 2007, Florida Power and Light in its filing with Florida regulators estimated the capital cost of building new nuclear power plants as $5,000 to $8,000 per kilowatt. The following May the credit rating agency Moody's gave the figure of approximately $7,500 per kilowatt hour as the cost of building a new plant. At this rate a 1600 MW plant would cost $11 billion. The capital costs are rising rapidly, not because of the increasing cost of nuclear materials, but because of the lack of a global infrastructure to support the building, management, and operation of nuclear plants. For instance, only one steel plant in the world, in Japan, can make the 450-ton ingots needed for the new generation of reactors like the Evolutionary Pressurized Water Reactor

(EPR). The major equipment for these reactors will not in the near term be manufactured in the United States; and utilities will have to compete against each other for components.

Moreover, constructing a plant is so risky that Wall Street has refused to invest in nuclear power, and utilities refuse to order plants unless taxpayers promise to bail them out if the plants fail. March 10, 2008, Gregory Jaczko, a member of the NRC, stated that the US government would have to put up $500 billion in federal loan guarantees if it wants a nuclear renaissance. Just to cover twenty-one proposed reactors, the nuclear industry is demanding $122 billion in federal loan guarantees. Failure rates are forecast to be very high. The Congressional Budget Office has estimated that 50 percent of all new reactor projects are likely to fail. This means that for the 21 current proposals, U.S. taxpayers would be forced to bail out the nuclear industry for at least $61 billion. “Sustainable” is not a word that can accurately be used to describe the vaunted nuclear renaissance.

The most shocking drawback of the economics of nuclear power is, however, the opportunity factor. The Strategy claims that nuclear power “avoids” carbon dioxide emissions. However, money spent on nuclear power cannot be spent on efficiency and renewables. Efficiency and renewables are dollar for dollar far more effective in reducing the emission of greenhouse gases than are nuclear power plants, both because they are actually less expensive per kilowatt hour and because they can be put into use far more rapidly than nuclear power plants can be constructed.

The cost effectiveness is not made apparent in the presentation, because the Seventh Strategy contains no comparisons of the costs of nuclear power with the costs of efficiency and renewables, although the earliest parts of the governor’s proposal talk about the need for these approaches. All the comparisons in the Seventh Strategy are between nuclear and fossil fuels. Amory Lovins et al. summarized the many existing comparisons of nuclear to efficiency and renewables in “Nuclear Power: Climate Fix or Folly” in December 2008, “Firmed windpower and cogeneration are at least 1.5 times more cost-effective than nuclear at displacing CO2—or about 3 times using the latest nuclear cost estimates. So is efficiency at even an almost unheard-of-seven cents per kWh. Efficiency at normally observed costs, say around one cent per kWh, beats nuclear by about 10-20 fold.” Thus paying to build nuclear plants rather than to invest in more rapidly implemented and less costly efficiency measures and solar, wind installations actually slows reduction of emissions of global warming gases and accelerates climate change.

ENVIRONMENTAL BENEFITS AND LIMITATIONS

The Strategy refers to nuclear energy as a “zero-emission alternative.” This is dishonest. Each stage of the fuel cycle uses electricity, usually generated from fossil fuels. Particularly gluttonous in respect to energy is uranium enrichment by means of gaseous diffusion. The only operating enrichment plant in the United States is at Paducah, Kentucky. USEC, which operates the plant, states in its quarterly report filed with the Securities and Exchange Commission November 5, 2008, that “We are one of the largest industrial consumers of electric power in the United States.” The cost of electricity represents seventy percent of its cost of production. In 2007 the power load at Padacuah averaged 1510 MW, and the average in 2008 was expected to be 1680 MW. The Eurodif plant in France absorbs the production of four nuclear reactors, which were constructed to supply it. The Paducah and Eurodif plants will be replaced in the coming years by centrifuge plants now under construction. They will use much less electricity than the gaseous diffusion plants but they will use electricity.

REFERENCES

The references for the section are unbalanced, as they do not include material by entities and individuals who oppose the use of nuclear power and show that efficiency and renewables should be used in its place or who cover relevant subjects that the report largely ignores. Below are a selection of the works that I consulted in writing these comments.

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