NUCLEAR INFORMATION AND RESOURCE SERVICE

6930 Carroll Avenue, Suite 340, Takoma Park, MD 20912
301-270-NIRS (301-270-6477); Fax: 301-270-4291
nirsnet@nirs.org; www.nirs.org

Briefing Paper

NUCLEAR ENERGY IS DIRTY ENERGY (and does not fit into a "clean energy standard")

The nuclear power industry spent more than $650 million on lobbying, campaign contributions and advertising from 2000-2010 in its persistent effort to achieve a nuclear "renaissance."[1]

Now that the nuclear "renaissance" has sputtered, with only 5 of some 35 reactor proposals currently being pursued, the industry is turning its attention—and money--toward preventing the shutdown of many aging reactors unable to compete economically with wind and solar power.

One of the industry's primary goals has been to convince federal and state legislators, regulatory officials, and the media that nuclear power is somehow "clean" energy, because nuclear reactors emit little carbon dioxide into the atmosphere. But this disregards the alphabet soup of other cancer-causing pollutants spewed into our air and water by nuclear facilities. Unfortunately, lobbying campaigns backed by so much money often attain some success.

Thus, there are increasing calls from nuclear industry backers, inside and outside of government, to include nuclear power in Renewable Energy Standards (or new "Clean Energy Standards") intended to boost use of clean renewables, or to permit nuclear to trade emissions credits in regional cap-and-trade emissions programs. This is occurring at both the federal and state levels to encourage use of nuclear power (and for some proponents, coal and natural gas as well) to the detriment of genuinely clean and affordable technologies like wind, solar, energy efficiency and others.[2]

This trend is likely to accelerate as states prepare plans to implement the Environmental Protection Agency's carbon reduction rules over the next two years.

Proposals to include nuclear power as part of a Clean or Renewable Energy Standard suffer from three fundamental misconceptions: 1) that carbon dioxide is the only pollutant that matters when defining "clean energy;" 2) that because radiation is invisible and odorless, it is not a toxic pollutant; 3) that nuclear power is carbon-free. None of these is true.

Only one of the many technologies that can produce electricity is capable of a catastrophic accident that can kill tens or even hundreds of thousands of people, presents a security threat of unprecedented proportions because of this vulnerability, and creates a lethal byproduct that will be toxic for hundreds of thousands of years: nuclear power. To call nuclear power "clean" is an affront to science and common sense.

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[1] Investigative Reporting Workshop, January 2010. http://investigativereportingworkshop.org/investigations/nuclear-energy-lobbying-push/story/nuclear-energy-working-hard-win-support/

[2] For example, see "Creating a Clean Energy Standard," Third Way, January 2011, http://www.thirdway.org/publications/361

Carbon Dioxide is not the only pollutant on the planet

Carbon dioxide is definitely a pollutant and the leading cause of global climate change. There is no question—except among a few climate deniers who prefer, like the ostrich, to hide their heads in the sand and shun reality—that we must drastically cut our carbon releases to the environment.

To call nuclear power "clean" is an affront to science and common sense.

But that is not the same as saying—as does a "Clean Energy Standard" based entirely on carbon releases—that carbon dioxide is the only pollutant that matters to the health and safety of our people and planet.

By basing a "Clean Energy Standard" on a simplistic carbon formula, its backers ignore the past fifty years of accumulated knowledge of the effects of radiation on the public.

Nuclear power facilities release a variety of cancer-causing radionuclides, including Tritium, Strontium-90, Cesium-137, Plutonium-239 and dozens more. Nuclear reactors also release other toxins into our air and water. While nuclear power qualifies, barely, as a "low-carbon" technology (although it is not carbon-free, see below), the release to the environment of these pollutants, not to mention the radioactive waste every nuclear facility generates, clearly disqualifies nuclear power as being in any sense "clean."

Radiation is a toxic, persistent, and long-lasting pollutant

Nuclear radiation seems "clean" only because you cannot see, feel, touch or smell it. But that doesn't mean it isn't released by nuclear reactors and other facilities. It is. It doesn't take an accident: nuclear reactors emit radiation into our air and water as part of their routine, daily operations. And that it cannot easily be detected or avoided makes radiation even more dangerous.

Indeed, if the toxic radiation emitted routinely from every nuclear reactor and other commercial nuclear facilities were the color and texture of oil, or smelled like natural gas, or was spewed as black smoke, no one would ever again confuse nuclear power with "clean."

A typical nuclear reactor contains a myriad of different types of radionuclides, amounting to some 16 Billion curies of radiation. By comparison, a typical large medical center may hold a total of two curies of radiation and a household smoke detector contains a miniscule fraction of one curie—and even that must be shielded to prevent human exposure.

Since the dawn of the Atomic Age in the 1940s, the U.S. National Academy of Sciences has done periodic reviews of the dangers of radiation to determine acceptable exposure levels for nuclear workers and the general public. Over the years, estimated risks from radiation exposure increased. In their most recent report, released in 2005, the Academy confirmed that there is <u>no</u> safe level of radiation exposure—every exposure to radiation increases the risk of cancer, birth defects, and other disease.[3] While it is impossible to avoid exposure to natural radiation from the sun and earth, it is essential that society not allow unnecessary additional exposures. In practical terms, this means curtailing the use of nuclear power as quickly as feasible—not encouraging new reactor construction or providing subsidies and other incentives to continue operation of uneconomic reactors.

Tritium releases from nuclear reactors

The federal Nuclear Regulatory Commission has acknowledged that, in recent years, there have been releases of radioactive tritium from existing nuclear reactors, exceeding safe drinking water standards, at 37 sites, or more than half of the nation's nuclear sites.[4] The NRC claims that no drinking water supplies other than some wells have been affected and that since the tritium has been released into groundwater, the problem is not so severe. That is

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[3] The National Academies of Science Biological Effects of Ionizing Radiation-VII, "Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII," http://search.nap.edu/nap-cgi/de.cgi?term=BEIR+VII+Phase+II

[4] "*Leaks and Spills of Tritium at U.S. Commercial Nuclear Power Plants*," U.S. Nuclear Regulatory Commission, Rev 6, September 14, 2010. http://www.nrc.gov/reactors/operating/ops-experience/tritium/sites-grndwtr-contam.html

small comfort to the millions of Americans who live near these sites.

Normal background levels for radioactive tritium in drinking water are 3 to 24 picocuries per liter. By contrast, the Environmental Protection Agency's "allowable" standard (note that "allowable" does not necessarily equal "safe") for radioactive tritium in drinking water is 20,000 picocuries per liter of water. According to the NRC, since January 2009, that level has been met or exceeded by releases into groundwater (not necessarily drinking water) at 37 reactor sites (out of 65). Radiation levels have ranged from 20,000 picocuries/liter to an astonishing 15,000,000 picocuries/liter (at New Jersey's Salem reactor complex). Radioactive tritium levels above 1,000,000 picocuries/liter were measured at nine nuclear sites covering 18 reactors.[5]

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Like all radionuclides, radioactive tritium causes cancer. With a half-life of more than 12 years, the tritium released by these reactors will remain hazardous in the environment—and likely be added to by new tritium releases—for the next century (hazardous life of a radionuclide is generally considered to be ten to twenty half-lives).

Nuclear Accidents and Security

Nuclear power holds the potential for a catastrophic accident that is unique among all energy sources and particularly consequential compared to renewable energy sources. Solar power installations cannot explode because of too much sun. Failure of a wind turbine simply means a little less electricity is produced—not permanent evacuation of hundreds of square miles.

Major reactor accidents are occurring at a rate of one every eleven years—far more frequently than reactor safety studies projected. And accidents have occurred at all types of reactors: Three Mile Island was a U.S. Pressurized Water Reactor, Chernobyl was a Soviet graphite-moderated design not used in the West. The multiple meltdowns at Fukushima occurred in U.S.-designed Boiling Water Reactors. The Chernobyl accident has caused anywhere from 4,000 to 1,000,000 deaths, depending on which es-

Exelon had to buy at least 9 homes, at a cost of $6.1 million, so some residents could leave after tritium contamination was discovered in offsite drinking wells near its Braidwood reactors. [6]

timates one finds most compelling.[7] By any assessment, it was the most devastating industrial accident in history. Economically, the accident caused damages in excess of $300 Billion—in a region where average wages are a fraction of those in the U.S.--and made significant sections of Ukraine and Belarus uninhabitable while perhaps permanently ending agricultural in the most highly contaminated zones.

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[5] Ibid.

[6] Associated Press investigation, *Tritium leaks found at many nuke sites*, http://www.ap.org/company/awards/part-ii-aging-nukes

[7] The United Nations' World Health Organization continues to cling to estimates on the low end, about 4,000 fatal cancers caused by Chernobyl. Other studies have calculated much higher fatalities. For example the TORCH study of 2006 estimates 30,000-60,000 deaths (http://www.nirs.org/c20/torch.pdf) and was largely responsible for WHO updating its previous estimate of several dozen deaths. A Greenpeace study in 2006 conducted largely by scientists from the former Soviet Union estimated 90,000-200,000 deaths (http://www.nirs.org/c20/chernobylhealthreportgp.pdf). More recently, the New York Academy of Sciences published a study by three Russian/Belorussian scientists, including Russia's former Environment Minister, that estimates as many as 1,000,000 deaths from Chernobyl ("Chernobyl: Consequences of the Catastrophe for People and the Environment"). http://www.nyas.org/publications/annals/Detail.aspx?cid=f3f3bd16-51ba-4d7b-a086-753f44b3bfc1

Some 150,000 people were evacuated from the area around Fukushima; for most the "evacuation" will be permanent. Homes were lost, careers and businesses ruined and lives destroyed. Official studies predict thousands of cancers from radiation exposure from the Fukushima reactors (where favorable wind currents sent 80% of the airborne radiation over the Pacific Ocean rather than over land and people); critiques of the studies suggest the casualty toll will be higher.[8]

While nuclear manufacturers and operating utilities take pains to prevent nuclear accidents, all major accidents so far share one attribute: at their root is some form of component failure (in Fukushima's case largely caused by natural disaster) compounded by human error. And human error is one thing impossible to design around. The odds are that the longer reactors operate and the more reactors there are, the more likely another catastrophic accident will occur.

Moreover, nuclear reactors pose a massive security threat compared to other energy sources. No terrorist or enemy state would attack a windmill or solar facility, why bother? There is no possibility of mass destruction or even a widespread power outage. But a successful attack on nuclear reactors could cause mass destruction and lead to widespread and prolonged power outages, crippling our nation's ability to function.

Nuclear power is not carbon-free

A common fallacy advanced by those who would declare nuclear power a "clean" energy source is that the technology is "carbon-free."[9] It is not.

Nuclear reactors themselves are low carbon-emitters. But they are carbon-intensive to build, since they require enormous amounts of concrete, steel and carbon-based fuels for transport of materials, workers, etc. And the nuclear fuel chain necessary to support reactor operations, which consists of uranium mining, milling, processing, enrichment and fuel fabrication, then shipment of fuel to reactors, then reactor operation and finally millennia of radioactive waste storage, results in substantial and unavoidable carbon emissions.

More than 100 studies have been done about nuclear power's carbon footprint, and many have come to contradictory conclusions. An analysis of the studies was conducted in 2008 by Virginia Tech and University of Singapore professor Benjamin Sovacool.[10] His conclusion is that nuclear power is responsible for about six times the carbon emissions of wind power, and 2-3 times the carbon emissions of various types of solar power technologies—and the renewables' carbon footprint drops as the technology becomes more efficient. At such a disparity in carbon emissions, nuclear should not qualify as a "clean energy" technology even based only on carbon releases, much less other pollutants.

The nuclear fuel chain is necessary for nuclear reactors, and pollutes our environment

Nuclear reactors cannot, of course, operate without uranium fuel. In that respect, nuclear power is much more like fossil fuels, which are extracted from the earth, than like renewable power, which produces energy from natural and omnipresent phenomena like wind and the sun.

Mining uranium, processing it, milling it, enriching it and producing uranium fuel pellets from gaseous enriched uranium is both carbon-intensive and dirty business at every step of the way. Perhaps the dirtiest part of this lengthy process is the mining, which, like coal mining, leaves massive quantities of "tailings" that are often left either as mountainous piles, or as slag in "empoundments" that pose substantial threats to miners, local communities, and to the larger environment.

Because of the widespread contamination and health effects caused by uranium mining on its land in the Southwest, for example, the Navajo Nation has banned any more uranium mining. But 500 to

[8] See for example, *IPPNW/PSR critique finds UNSCEAR underestimated Fukushima health effects,* GreenWorld, June 10, 2014. http://safeenergy.org/2014/06/10/unscear-underestimated-Fukushima-effects/

[9] For example, see Creating a Clean Energy Standard, Third Way, page 6 "Nuclear energy is entirely carbon-free…." Page 6, January 2011

[10] "Valuing the greenhouse gas emissions from nuclear power: A critical survey," Benjamin Sovacool, University of Singapore and Virginia Tech University, Energy Policy 36, June 2008. http://www.nirs.org/climate/background/sovacool_nuclear_ghg.pdf

1300 abandoned uranium mines from the Cold War era remain on its land awaiting cleanup. At one mine abandoned years ago near Cameron, Arizona, for example, the EPA found in November 2010 that radiation levels were higher than its equipment could measure.[11]

The Ranger uranium mine in Australia—not exactly "clean"

Clean-up estimates for the hundreds of abandoned mines run into the many hundreds of millions of dollars.

Enriching uranium 235 from the mined and milled uranium is enormously energy intensive and creates long lasting and deadly solid, liquid and gaseous wastes. Similarly, at the end of the fuel chain, after nuclear reactors split atoms making them millions of times more radioactive, radioactive waste is generated for which there is no known permanent isolation from the environment.

Most uranium used by U.S. reactors is—like oil—imported. While renewable energy sources are secure as long as the sun shines and the wind blows, nuclear power, like other technologies requiring extraction of fuel, remains an insecure means of power production, dependent on the whims of other nations.

Nuclear Power and Water Pollution

Nuclear power's pollution of our nation is not limited to releases of radioactive materials. Nuclear reactors are also responsible for significant damage to marine environments and diversion of increasingly scarce water supplies.
Nuclear reactors require vast amounts of water for cooling their red-hot nuclear cores as well as simply to produce electricity. Those with cooling towers take in some 20,000 gallons per minute of water from rivers, lakes, or oceans. Reactors without cooling towers, which use "once-through" cooling systems, take up to 500,000 gallons per minute of water before spewing it back out again. When the water comes out and is discharged back to its source, it is five to ten degrees warmer than it was when it went in.[12]

This causes havoc among marine environments. The huge amount of water taken in, and the rate at which it's taken, also results in massive fish kills at reactors that use once-through cooling systems—often numbering in the billions of fish and fish eggs per year at a single reactor.[13]


The "once-through" cooling system at California's Diablo Canyon nuclear complex, as at many other reactors, discharges water (see plume in photo) at a much higher temperature than brought in, killing large amounts of fish and devastating other marine life.

Further, because the water discharged is so much hotter than the water taken in, it can cause problems

[11] *Abandoned Uranium Mines: An Overwhelming Problem in the Navajo Nation*, Scientific American, December 30, 2010.
http://www.scientificamerican.com/article.cfm?id=abandoned-uranium-mines-a&print=true

[12] A more complete discussion of water use by nuclear reactors is found in "*Got Water*," a December 2007 issue brief from Union of Concerned Scientists.
http://www.nirs.org/reactorwatch/water/20071204ucsbriefgotwater.pdf

[13] See, for example, "*Licensed to Kill*," published in 2001 by NIRS, SECC and the Humane Society of the United States, which documents the environmental devastation caused by once-through cooling systems.
http://www.nirs.org/reactorwatch/licensedtokill/licensed2kill.htm

downstream for other industrial uses, and even drinking water uses.
Finally, when evaporated in cooling towers, or made unusable through heating, water use by reactors can use up a significant amount of municipal and regional water supplies. This will become increasingly important as the Department of Energy has predicted droughts in about 2/3 of the U.S. over the next decade.[14] Electricity generation and agriculture are the two predominant consumers of water in the U.S., and nuclear power is by far the largest consumer among electricity producers.[15]

No assessment has yet been conducted as to the effects on water supplies, especially drinking water supplies, of the kind of major reactor construction endeavor including nuclear power in a clean or renewable energy standard would seek to encourage. Nor are the effects on water supplies and marine life evaluated when existing reactors are considered for such standards.

In France, which obtains nearly 80% of its electricity from nuclear power, summer heat waves in recent years—which increased river water temperatures to the point reactors could not legally use the water for cooling—forced reactors to close at the exact time electricity was most needed for residential cooling. But France had no back-up supplies of electricity to provide that cooling. In the summer of 2003, thousands of people died because of the heat and related blackouts.

But it's not just a French problem: in recent years U.S., reactors, such as Browns Ferry in Alabama and Millstone on Long Island Sound, have been forced to close or reduce power because of rising water temperatures.

In an era of global warming, it is folly to encourage new reactor construction without a thorough, scientific assessment of water availability for reactor operation, taking into account drinking water needs.

Conclusion

No source of electricity generation is absolutely "clean." All types require use of resources, some of which are toxic. Every source of electricity results in some level of carbon emissions. The only "clean" electricity is the electricity that is not used. Ensuring the use of energy as efficiently as possible should be the number one goal of any clean energy standard.

Nuclear power, compared to the viable renewable alternatives like wind, solar, geothermal, and coupled with smart grids, distributed generation and other 21st century energy technologies, does not even come close to "clean."

Clean and Renewable Energy Standards exist to support clean energy sources, not nuclear power or fossil fuels.

Nuclear power releases toxic radiation on a routine basis. It is not carbon-free—its carbon footprint is substantially higher than renewables. It uses far more water in an era of water scarcity. It requires a vast and polluting nuclear fuel chain simply to function.

Inclusion of nuclear power in a Clean Energy Standard would make a mockery of the concept. Moreover, although beyond the scope of this paper, nuclear power's enormous costs and typical reactor size would discourage use of genuinely clean, safe and affordable renewable technologies were nuclear chosen as a means of meeting a "clean energy standard."

The United States wants, needs and deserves clean energy. Nuclear power does not fit the bill.

--*Michael Mariotte, Nuclear Information and Resource Service, updated July 2014.*

[14] "*Water Dependency of Energy Production and Power Generation Systems,*" Virginia Water Resources Research Center, Virginia Tech University, July 2009. http://www.nirs.org/reactorwatch/water/sr46waterdependency.pdf
[15] Ibid.