Beyond Nuclear Fact Sheet
A Mountain of Radioactive Waste 70 Years High: The Lethal Legacy of the Atomic Age, 1942-2012

INTRODUCTION
An Ongoing Radioactive Wreck: The Still Unfolding Disasters of U.S. High-Level Radioactive Waste Policy

Electricity is but the fleeting byproduct from atomic reactors. The actual product is forever deadly radioactive waste. Uranium fuel is a radioactive, toxic heavy metal to begin with. But once it passes through an atomic reactor, where it undergoes fission, it comes out a million times more radioactive. Even decades after removal from a reactor core, in the absence of shielding and at close range, irradiated nuclear fuel can deliver a fatal dose of radiation within just minutes. High-level radioactive waste will remain hazardous for more than a million years, so must be isolated from the living environment "forevermore," lest it wreak havoc in the biosphere.

Despite such risks, highly radioactive wastes have been accumulating for nearly 70 years, and we don't even know what to do with the first cupful. On Dec. 2, 1942, Enrico Fermi first split the atom in a self-sustaining nuclear chain reaction at a prototype reactor at the University of Chicago, as part of the Manhattan Project that led to the atomic bombings of Hiroshima and Nagasaki. Fermi's wastes were eventually buried in a simple mound of earth, located in a forest preserve in the southwestern suburbs of Chicago, now adjacent to a bicycle path.

Since commercial nuclear power began in 1957, over 65,000 metric tons of irradiated nuclear fuel has piled up with nowhere to go. Although around two dozen atomic reactors have been permanently shutdown, 104 still operating reactors add more than 2,000 tons per year. In addition, since World War Two, the U.S. has generated around 15,000 tons of high-level radioactive wastes from the nuclear weapons complex, as well as irradiated fuel from research reactors and the Nuclear Navy. Despite decades of effort, dominated by decision makers from within the nuclear establishment in government, industry, and academia who often ignore objections from the environmental movement and concerned citizens, no scientifically safe and sound, socially just and acceptable, permanent solution has been found for the ever mounting problem of radioactive wastes.

Danger Lurks Below: The Perils of Pools

- Even though pool storage was first envisioned as a short term interim measure, 75% of the commercial irradiated nuclear fuel generated since 1957 is still stuck at its original reactor site, stored indoors, underwater in deep pools that provide cooling to the thermally hot -- and shielding against the radioactive -- rods.
- Although originally designed for "low density, open configuration" storage, most pools are now so tightly packed with waste – approaching the density of operating reactor cores -- that extraordinary precautions must be taken to prevent inadvertent nuclear chain reactions. Although often regarded as "out of sight and out of mind," pools actually represent potentially catastrophic accidents waiting to happen.
- Certain pools, including at atomic reactors such as Fermi 2 in Michigan and Pilgrim in Massachusetts (of the identical same design as Fukushima Daiichi Units 1 to 4 in Japan) contain all the waste ever generated there since they began operations. Other General Electric Mark 1s, such as Vermont Yankee, and Oyster Creek in New Jersey, have more waste in their individual pools than all the waste put together in Fukushima Daiichi Units 1, 2, 3, and 4 combined.
- Incredibly, pools are located outside of radiological containment. In addition, emergency back-up power to run cooling systems, make-up water, and even such basic safety measures as water level, temperature, and radiation gauges, are not required on pools by the U.S. Nuclear Regulatory Commission (NRC).
- Loss of enough pool water, as through gradual boiling or sudden drain down (whether due to accident, or intentional attack), would create fatal radiation dose rates in the vicinity of the pool, greatly complicating or entirely preventing emergency response. Once the wastes reach ignition temperature, a radioactive "wildfire" could spread throughout the entire pool's inventory. Up to 100% of such volatile, highly hazardous radioactive isotopes as Cesium-137 would be released directly into the environment in the escaping smoke. As shown by the explosions and loss of cooling at Fukushima Daiichi, this could result in multiple cores of irradiated nuclear fuel, decades-worth of accumulated radioactive risk, exposed to the open sky, at risk of catastrophic release to the environment.
- An NRC study has revealed that such a Ce-137 release from a pool could cause 143,000 cancer deaths downwind, condemnation of 2,700 square miles of agricultural land, and more than $500 billion in economic damages.
- A growing number of pools have sprung leaks, releasing radioactivity into soil, groundwater, and/or surface waters, as at: Indian Point and Brookhaven National Lab, NY; Hatch, GA; Haddam Neck, CT; and Salem, NJ.
- Near-miss drops of heavy loads at Palisades, MI, Prairie Island, MN; seal failures at Haddam Neck, and Hatch, GA; a "turbine missile" at Fermi 2; and a frozen pipe at Dresden, IL have shown that risks of sudden pool drain downs are all

too real.

- All of these risks undermine NRC's Dec. 2010 "Nuclear Waste Confidence" claim that pool storage is currently safe and secure, and will remain so for decades to come – a false assertion maintained by President Obama's and Energy Secretary Chu's Blue Ribbon Commission on America's Nuclear Future as well.

"Overflow Parking": The Risks of Dry Cask Storage

- Beginning in the mid-1980s at Surry, VA pools began reaching absolute capacity. Older, more thermally-cooled and radioactively-decayed rods were then transferred into outdoor silos of concrete and/or steel called dry casks, as they lack cooling water, relying instead on convection currents of air to cool the still-hot wastes sealed within.
- Currently, a full 25% of U.S. irradiated nuclear fuel is stored in many hundreds of dry casks located at most nuclear power plant sites. NRC predicts that by the end of this decade, almost all atomic reactors will have installed at least some dry cask storage.
- Almost from the very start, dry cask storage has been plagued by problems. Inner seal failures at some of the oldest casks in the country revealed that eventual loss of air-tightness and inerting gases needed for heat transfer can lead to oxidation of the rod cladding, deterioration of the rods' structural integrity, and release of radioactive gases and particles from casks to the environment.
- The rush to dry cask storage resulted in a bare-bones NRC regulation requiring only notification by nuclear utilites of their intention to install dry cask storage, and use of NRC-certified casks. However, major flaws in such casks were soon to be revealed.
- NRC allowed Palisades to install dry cask storage on a sand dune just 100 yards from Lake Michigan, drinking water supply for many millions downstream. The cask pad has "floating" atop 55 feet of loose sand, in violation of NRC earthquake safety regulations, since 1993, despite warnings by NRC whistleblower Dr. Ross Landsman that an earthquake could plunge casks to the bottom of Lake Michigan.
- Palisades' VSC-24 casks are so badly designed, manufactured, and maintained that such an underwater submersion could result in an accidental nuclear chain reaction, if neutron-moderating Lake Michigan water infiltrated into the still-fissile Uranium-235 and Plutonium-239 within the waste.
- A fully loaded Palisades cask with defective welds has remained deployed since 1994, despite utility and NRC assurances under oath in federal court that wastes from any problem casks would be quickly and easily unloaded back into the storage pool.
- NRC allowed Davis-Besse, OH to deploy dry casks which had inner canisters ground thinner than design specifications.
- Unforeseen hydrogen gas generation, an explosion at Point Beach, WI in 1996, and additional "hydrogen ignitions" at Palisades in 1999 revealed quality assurance failures and violations not only within the cask industry and at nuclear utilities, but also at the regulatory agency itself.
- Such early failings were never fixed. Industry whistleblower Oscar Shirani revealed major quality assurances with Holtec dry casks, deployed at 33 U.S. reactors.
- As with pool storage, NRC also does not require that dry casks have direct monitoring to guard against overheating, radiological releases, or loss of anti-corrosion/heat transfer inerting atmospheres.
- Although dry casks are inherently less at risk of terrorism or sabotage than pools, in that pool inventories are divided up into dozens or hundreds of self-contained silos with no moving parts or cooling water systems, dry casks are not designed to withstand attacks and hence remain vulnerable. A 1998 test at the U.S. Army's Aberdeen Proving Ground showed that even German CASTORS – the Cadillac of dry casks – could be breached by a TOW anti-tank missile, creating a pathway for disastrous radioactivity releases.
- The August 23, 2011 earthquake at North Anna, VA shifted 26 of 28 vertical dry casks, weighing 115 tons each, up to 5.5 inches on their storage pad, while damaging surface concrete on horizontal dry casks.
- A 2009 Government Accountability Office report revealed that dry casks will likely have to be replaced, at huge expense, once per century or so, as they wear down from the impacts of the elements, as well as the intense heat and radioactivity they contain. This contradicts NRC's assertion, in the Nuclear Waste Confidence Decision of Dec. 2010, that on-site dry cask storage is safe and secure for at least 120 years, if not 300 years.
- More mishaps with dry cask storage are documented in "Get the Facts on High-Level Atomic Waste Storage Casks," posted online at: http://www.nirs.org/radwaste/atreactorstorage/drycaskfactsheet07152004.pdf.

Transport risks: "Mobile Chernobyls, Dirty Bombs on Rails, Floating Fukushimas"

- While U.S. industry brags of a "perfect" shipping record for high-level radioactive waste, the 2,500 to 3,000 shipments almost entirely took place decades ago, in the 1960s and 1970s. In fact, a full-scale away-from-reactor transport campaign – as to the now-cancelled Yucca Mountain, Nevada dumpsite – would involve as many shipments in a single year as have occurred in the U.S. over the past 70 years. Such Yucca annual shipment rates would have gone on for 24 to 48 years, greatly multiplying transport risks.
- Robert Halstead, now director of the State of Nevada Agency for Nuclear Projects, has documented 72 incidents involving irradiated nuclear fuel shipments between 1948 and 1996. Of these, 4 involved radioactivity release beyond

the vehicle and transport container. Around 50 involved exterior surface contamination of the shipping container.

- In the late 1990s, watchdogs and journalists revealed that a quarter to a third of all irradiated nuclear fuel shipments to the French reprocessing facility involved shipping containers contaminated to radiation levels 500 to 3,000 times permissible doses, representing a hazards to workers as well as innocent public passersby.
- Even "routine, accident-free" shipments represent "mobile x-ray machines that cannot be turned off." NRC allows a chest x-ray per hour worth of gamma radiation to emanate from a shipping cask to a distance of 6 feet away. At the cask surface, dose rates equivalent to 20 chest x-rays per hour are allowed. This represents radiological risk to workers, as well as unsuspecting public bystanders.
- Risks of severe accidents, such as high-speed crashes into immovable objects like bridge abutments or rock surfaces, high-temperature/long duration fires, or deep/long lasting underwater submersions could turn radioactive waste truck, train, and barge shipments into "Mobile Chernobyls" or "Floating Fukushimas."
- Transport casks are not designed to withstand terrorist attacks, as by anti-tank missiles, high explosives or shaped charges, risking "dirty bombs" on the roads, rails, and waterways.
- Apart from at a handful of urban research reactors, high-level radioactive waste is not located in metropolitan centers. However, the thousands or tens of thousands of irradiated nuclear fuel shipments envisioned by the atomic establishment in the years and decades to come would move this deadly material directly through such population centers, as well as past vital water supplies and the agricultural heartland.
- Hundreds to thousands of barge shipments -- on rivers and the Great Lakes, or along sea coasts and bays -- threaten vital fresh water drinking water supplies and fishing grounds, not to mention areas essential to tourism, recreation, and ecological biodiversity.

Risky Relapse into Reprocessing

- Although the BRC has reported that a full-scale commercial deployment of reprocessing is not likely for decades in the U.S., it still advocates for full taxpayer funding for reprocessing research, development, and demonstration – costing tens to hundreds of millions of dollars annually.
- An in depth look at the many risks of reprocessing, from nuclear weapons proliferation, to environmental ruination, to a price tag for taxpayers into the tens or even hundreds of billions of dollars, can be found in Beyond Nuclear's pamphlet posted on-line at: http://www.beyondnuclear.org/storage/Reprocessingwebview.pdf.

"Parking Lot Dumps": The Senseless Risk of "Centralized" or "Consolidated Interim Storage"

- BRC has advocated for "consolidated interim storage" as its foremost near term policy recommendation. But this would simply create a radioactive waste shell game, first on the roads, rails, and waterways, then at one or more "parking lot dumps" across the U.S.
- "Centralized interim storage" would significantly increase transport risks, as wastes would move long distances from reactors to parking lot dumps, only to have to be moved again to permanent repositories, which could well be back where the wastes came from in the first place.
- Parking lot dumps have very often been targeted at Native American communities. Scores of tribal councils have been approached, first by the U.S. Dept. of Energy's (DOE) "Nuclear Waste Negotiator," then by nuclear industry consortium "Private Fuel Storage, Limited Liability Corporation" (PFS, LLC).
- Ojibwe environmental activist Winona "No Nukes" LaDuke has quipped that the greatest minds in the nuclear industry have been hard at work for over 50 years seeking a solution to the radioactive waste problem, and they've finally found it: haul it down a dirt road and dump it on an Indian reservation."
- Traditional Native American women environmental activists, often at great personal risk and self-sacrifice, have led the resistance to parking lot dumps targeted at their own or other indigenous communities, including Grace Thorpe (Sauk and Fox, OK), Rufina Marie Laws (Mescalero Apache, NM), and Margene Bullcreek (Skull Valley Goshutes, UT).
- "Interim storage" could easily become de facto permanent storage if national repositories remain elusive. In fact, the George W. Bush Bureau of Indian Affairs cited such a risk as its reason for blocking the Private Fuel Storage, LLC lease agreement with the disputed, pro-dump Skull Valley Goshutes tribal government executive committee.

A Burial Site Targeted at Every State in the Lower 48?! The Failures of "Permanent Disposal"

- President Obama and Energy Secretary Chu have stood strong by their wise decision to cancel the Yucca Mountain, Nevada national repository project. Yucca is sacred and belongs to the Western Shoshone Indian Nation by treaty rights. It is also a very active earthquake and volcanic zone, with fissured and fractured geology that would allow large amounts of radioactive gases to escape into the atmosphere, and radioactive liquids to leak into the drinking water supply, putting a farming community, National Wildlife Refuge for endangered species, Death Valley National Park, and the Timbisha Band of Shoshone Indians at perilous radioactive risk over time.
- Dr. Arjun Makhijani of Institute for Energy and Environmental Research, a proponent of geologic disposal but arch opponent of the proposed Yucca dump, has cited multiple "double standard standards" used over decades to keep the geologically unsuitable Nevada project on life support. Dr. Makhijani refers to Yucca as the worst site yet studied for a geologic repository.

- Despite its cancellation, Michael Keegan of Don't Waste Michigan points out that the Yucca dump has been a "huge success" for the nuclear power industry, keeping alive the "illusion of a solution" to the radioactive waste problem for decades, allowing it to generate tens of thousands of tons if irradiated nuclear fuel.
- Although "deep geologic disposal" continues to be touted as a supposed solution for high-level radioactive waste, no country in the world has yet opened such a repository, as scientific flaws in studied sites continue to vex efforts to safely isolate irradiated nuclear fuel for the hundreds of thousands and even millions of years it remains hazardous to human beings and all life forms. Multiple proposed repository sites in numerous countries, including Australia, Canada, Germany, Japan, the U.K., and the U.S., to name a few, have been cancelled, forcing site search efforts to return to square one.
- BRC has advocated re-launching a national "site search" for the first U.S. repository. In Dec. 2008, George W. Bush's DOE reported that a second national dumpsite would be needed, even though a first had yet to be opened. Under the Nuclear Waste Policy Act of 1983, as Amended, the first repository is limited to accepting 63,000 metric tons of commercial irradiated nuclear fuel, at least until a second repository was opened. That much waste already existed in the U.S. by spring 2010.
- In its Dec. 2008 report on the need for a second repository, DOE indicated that each and every state in the "Lower 48" has "suitable" geology making it eligible for a permanent repository.
- DOE's Office of Nuclear Energy, charged with promoting atomic power (and, ironically, host to BRC despite its mandate to find a solution to the radioactive waste dilemma) is currently exploring the concept of "deep borehole disposal" at reactor sites. Around six deep boreholes would be drilled at "suitable" nuclear power plant sites, and high-level radioactive wastes lowered into them for permanent burial. DOE has also "floated" deep borehole disposal as a proposal for "Greater Than Class C low-level" radioactive waste, so radioactive that it is treated the same as high-level radioactive waste, that is, requiring deep geologic disposal. GTCC is currently stored on-site at the reactors that generated it in the first place, just as is irradiated nuclear fuel.

The Future: Alternatives and Solutions?

- Past lessons learned from the "Mountain of Radioactive Waste 70 Years High" should have taught us by now that the only real safe, sound solution for irradiated nuclear fuel is to STOP MAKING IT IN THE FIRST PLACE! Once generated, the long term management of forever deadly radioactive waste poses many dilemmas, offering only choices between "greater and lesser evils."
- Nearly 200 environmental groups have been advocating HOSS (hardened on-site storage) for nearly a decade now. HOSS, albeit a near-term "solution," not a permanent one, calls for pools to be emptied into dry cask storage that is well designed and manufactured to last for the many decades that irradiated nuclear fuel will inevitably remain stored on-site at reactors. Even BRC and DOE have acknowledged that any away-from-reactor scheme, such as a parking lot dump, reprocessing facility, or permanent burial dump, will take many years or even decades to open, with additional years or decades required to transport the wastes there from the over 100 reactor sites across the U.S.
- HOSS would require irradiated nuclear fuel to be much better safeguarded against accidents, secured against attacks, and protected against leakage into the environment, even over decades of on-site storage.
- However, certain sites may very well be so risky they are not even appropriate for HOSS, let alone current risky pool and dry cask storage. Prairie Island, MN, for example, is on an island subject to regular severe flooding by the Mississippi River which surrounds it. Its dry cask storage is located just a several hundred yards from the nearest residents and a day care center of the Prairie Island Indian Community, which has opposed the twin atomic reactors and stored radioactive wastes since before it was built. Besides the risks of on-site storage on river banks and lake shores to vital fresh drinking water supplies, there is also the risk of rising sea levels to the many reactors located along our ocean coasts.
- Given the cleaner, safer, and cheaper electricity alternatives provided by energy efficiency and renewable sources such as wind, solar, and so many more, continuing to worsen the radioactive waste burden inevitably to be faced by future generations is unnecessary, inexcusable and increasingly immoral and unjustifiable.

Conclusion

We can no longer sweep the problem of high-level radioactive waste under the rug, by pretending, as NRC, BRC, DOE, the nuclear power industry, and its friends in Congress and the White House do, that pool and dry cask storage, as currently practiced in the U.S., is risk-free. "Illusions of solutions" have never sufficed to protect public health, safety, national security, the environment, and the common defense from the very real, dire risks of forever deadly high-level radioactive waste. While HOSS may serve as a common sense interim improvement, we still lack a permanent solution for our Mountain of Radioactive Waste 70 Years High. Molly Ivins' East Texas aphorism for the radioactive waste dilemma is most appropriate: the first rule of holes is, when you're in one, stop digging.

For more information, visit the Radioactive Waste section of Beyond Nuclear's website at www.beyondnuclear.org, or contact Beyond Nuclear's Radioactive Waste Watchdog, Kevin Kamps, at kevin@beyondnuclear.org or (301) 270-2209 extension 1.

Prepared by Kevin Kamps, Beyond Nuclear, 10/17/2011.