The Beginning of “Forevermore”
High-Level Radioactive Waste Management Risks:
Pools & Dry Cask Storage

Kevin Kamps, Beyond Nuclear
Stony Point, NY
May 3, 2015
“Electricity is but the fleeting byproduct from atomic reactors. The actual product is forever deadly radioactive waste.”

---Michael Keegan, Coalition for a Nuclear-Free Great Lakes and Don’t Waste Michigan (Dr. Judith H. Johnsrud Unsung Hero Award Winner 2015)
And we don’t even know what to do with the first cupful…
Risks of long-term irradiated MOX fuel storage in pools on-site at nuclear power plants

Kevin Kamps
Radioactive Waste Watchdog
Beyond Nuclear
August, 2010 [Saga City, Japan]
Peekskill, NY, Sept. 2011
(Photo by David M. Grossman)
Irradiated nuclear fuel pool storage in the U.S.

- Pools not within radiological containment
- By 2015, almost all pools full
- Pools vulnerable to accidents, attacks, sabotage, leakage
- No away-from-reactor waste plans in sight
Pools outside containment
By 2015, most pools full

Note: All operating nuclear power reactors are storing used fuel under NRC license in spent fuel pools. Some operating nuclear reactors are using dry cask storage. Information is based on loss of full-core reserve in the spent fuel pools.

Source: Energy Resources International and DOE/RW-0431 – Revision 1
Safety risks: accidents

- Loss of off-site power
- Natural disasters
- Pool drain downs
- Heavy load drops
- Inadvertent nuclear criticality
Loss of Off-Site Power

- Continuous electricity supply is needed to continuously run pool circulation pumps.
- In the event of loss of off-site power, emergency diesel generators must be connected to pools, and must work, or pool boiling could begin within hours.
Tornadoes
Hurricanes
Earthquakes
Tsunamis
Flooding
“Port” Calhoun: 2011
Pool Drain Downs

I can fix anything

Where's the duct tape?
Heavy Load Drops

- Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants (NRC, NUREG-1738, 2001)
- Cask drops, dangles, explosions
Security risks: attacks/sabotage

Security Risks: Attacks/Sabotage

- 1997 Brookhaven National Lab: pool fire could cause 1,500 to 143,000 cancer deaths, and $800 million to $566 billion in property damage, and render up to 2,790 sq. miles uninhabitable

- Institute for Resource and Security Studies has reported that a pool fire at either of Indian Point’s reactors could render 75,000 to 95,000 sq. km uninhabitable (the area of New York State is 127,000 sq. km)
Large waste inventories in pools

- Dresden nuclear power plant has 2,146 metric tons of irradiated nuclear fuel in storage pools
- The amount of nuclear fuel that exploded and burned at Chernobyl was “only” 200 tons
BWR pools especially vulnerable
Environmental risks: leakage from pools
Pool Leaks: Haddam Neck, CT
Pool Leaks: Indian Point, NY
Pool Leaks: Salem Unit 1, NJ
Pool Leaks: BWX Technologies, VA
Pool Leaks: Brookhaven National Lab, NY
Add’l SNF pool leaks, from NRC Nuke Waste Con Game EIS, App. E

**Internal leak to plant:**
- Crystal River 3, FL, 2009
- Davis-Besse, OH, 2000
- Diablo Canyon 1 & 2, CA, 2010
- Duane Arnold, IA, 1994
- Hope Creek (Salem), NJ, 2009
- Kewaunee, WI, 2007
- Salem 2, NJ, 2010

**Leaked to environment:**
- Hatch, GA, 1986
- Turkey Pt., FL, 1988
- Palo Verde 1, AZ, 2005
- Seabrook, NH, 1999
- Watts Bar 1, TN, 2001
- San Onofre 1, CA, 1986
- Yankee Rowe, MA, 1979 and 1999
GAO, April 2005

- “NRC Needs to Do More to Ensure that Power Plants Are Effectively Controlling Spent Nuclear Fuel”
- Lost irradiated nuclear fuel at Vermont Yankee, Humboldt Bay, CA, and Millstone, CT in past decade
Other Pool Risks
Leaks from pools or pipes
Leakage of radioactive pool water from Salem Unit 1, Artificial Island, NJ on the bank of the Delaware River
Other leaks at nuclear power plants

- Other Entergy plants, such as Vermont Yankee & Palisades
- 102 leaking reactors between 1963 and 2009
- From March 2009 to April 2010, 13 nuclear plants reported 15 leaks (including VY)
- Individual leaks of several million gallons
- Some leaks undetected/unannounced for over a decade
- Contamination of groundwater, drinking water, and surface water supplies
- As high as over 10 million picocuries per liter – 500 times EPA SDWA standard (at Dresden, IL, 2004)
“Leak First, Fix Later,” Paul Gunter, April 2010
• Jan. 2006 public health emergency enforcement petition based on NRC regulations limiting radiation doses to members of the public, as well as requirement for control and monitoring of radioactive releases to the environment
No Waste Solution: Yucca Mountain, Nevada
Yucca zombie?!
Shimkus, Upton, etc.
No Waste Solution: Parking Lot Dumps
No Waste Solution:
Reprocessing
MOX fuel higher risk

- Thermally hotter than irradiated uranium fuel
- Larger radioactive source term than U fuel
- Greater risk of accidents
- Worse consequences of accidents
MOX lead test assemblies defective

• In June 2008, after only 3 years of a 4.5 year trial, Duke Energy was forced to discontinue testing Areva MOX fuel in its Catawba reactor due to risky elongation of the fuel rods.

• In November 2009, Duke terminated its MOX partnership with DOE.
What are the risks?

- Health, safety, security, environment
- Property damage
- Loss of property values
- Radioactive stigma impacts on diverse economic sectors, from agriculture to fisheries, tourism to real estate
Updates:
The Beginning of “Forevermore”

High-Level Radioactive Waste Management Risks: Pools & Dry Cask Storage, the Big Picture
Ongoing Fukushima Daiichi Nuclear Catastrophe
HLRW Storage Pool
“Near-Misses” (?)
Unit 4: “Close-Calls” (?!)

[Images of industrial equipment and workers in a facility]
Unit 3: Close-Calls (!?)
Unit 3: Close-Calls (?!)
Debris in Pool!/Status of Fuel?!
Warning to Americans in Japan

NRC Chairman Greg Jaczko

- Evacuation to more than 50 miles from Fukushima Daiichi
- NRC
- State Department
- White House
- U.S. military shelter in place orders at Yokohama (250 miles from Fukushima)
Contingency planning to evacuate 30-50 million people

Worst case scenario:
- Reactor meltdowns and pool fires at Fukushima Daiichi (3 operating reactors, 7 pools), plus:
  - 4 meltdowns and 4 pool fires at Fukushima Daini
  - 1 meltdown and 1 pool fire at Tokai
  - Evacuation of Metro Tokyo region
National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission

Kiyoshi Kurokawa, Chairman

Key Findings

• “Profoundly man-made” catastrophe
• Collusion between so-called safety regulatory agencies, nuclear power industry, and government (elected officials, ministries)
• “They effectively betrayed the nation's right to be safe from nuclear accidents.”
Chernobyl:

Radiation-controlled zone of 6,000 square miles, about 2/3rds the land area of the State of NJ

“...a spent fuel pool fire in the United States could render an area uninhabitable that would be as much as 60 times larger than that created by the Chernobyl accident. If this were to happen at one of the Indian Point nuclear reactors located 25 miles from New York City, it could result in as many as 5,600 cancer deaths and $461 billion in damages.”
Comparison

Fukushima Daiichi Units

• Unit 1: 40 tons
• Unit 2: 97 tons
• Unit 3: 63 tons
• Unit 4: 219 tons; 1,331 SNF assemblies

Indian Pt. 1, 2, and 3

• 1,164 MTHM, more than 2,649 equivalent assemblies (per DOE 2002 figures, as of spring 2010).
• In last 5 years, this has grown by about 40 MTHM/year, so now 1,365 MTHM (3,100 equivalent assemblies)
• Approaching 250 million curies (per Alvarez, 2011)
Obama’s Blue Ribbon Commission on America’s Nuclear Future, 2010-12

- Moniz, Macfarlane, Hagel, Rowe, *et al.*
- Ignored thousands of quality public comments
- Go through the motions exercise of public participation
- The ongoing revolving door between industry, government, academia
Nuclear Guardianship Project

- Despair and Personal Power in the Nuclear Age (New Society Publishers, 1984), by Joanna Macy
HOSS

- Hardened On-Site Storage or Robust Storage
- Thin or even empty the pools
- Design and build dry casks well, to last centuries, not decades
- Real time radiation, heat, pressure monitoring
- Safeguard dry casks against leaks
- Secure dry casks against attacks
HOSS/Robust Storage

Arjun Makhijani, IEER

Gordon Thompson, IRSS
Dry casks as

“Rust Buckets of Death”

Mary Sinclair

Deb Katz
No “Nuclear Waste Confidence”

Diane Curran

NY AG Schneiderman
No “Nuclear Waste Confidence”
Nuke Waste Con Game
Public Comment
HOW much?!

- $210-450 billion (yep, with a B!) for the first 200 years of HLRW management (assuming one repository opened)
- This effectively doubles the price of nuclear generated electricity (although it’s not being accounted for)
Beware HOLTECs!

Oscar Shirani, Exelon/ComEd

Dr. Ross Landsman, NRC
Beware CASTORs!
“Accident Testing at Sandia National Lab”

• “Broad sided a container by a 120-ton train locomotive traveling 80-miles per hour.” – J.P. Tarzia, RSCS

• Marvin Resnikoff, RWMA: cask was jacked up above main force of oncoming train (sill), glanced off nose
“NRC Required Licensing Tests”

“30-minute engulfing fire at 1,475 F”

• Other flammable and hazardous substances that share the roads, rails, and waterways burn at much hotter temperatures (diesel burns at 1,800 F).

• The July 2001 Baltimore train tunnel fire burned for more than 3 days, and reached temperatures above 1,500 F.
“NRC Required Licensing Tests”

Damaged cask, submerged under 3-feet of water for 8 hours

- A damaged cask could contaminate water supplies with radioactivity
- A critical mass, moderated by infiltrating water, could spark an inadvertent nuclear criticality, making emergency response extremely dangerous

Undamaged cask, submerged under 656-feet of water for 1 hour

- Casks can weigh well over 100 tons, and would be very difficult to recover in an hour, especially in remote areas
- Water pressure over long periods could cause a radioactive release
S. 854, Nuclear Waste Administration Act of 2015

U.S. Sen. Lisa Murkowski (R-AK), Chair, ENR Ctte

U.S. Sen. Maria Cantwell (D-WA), ENR Ranking Member
S. 854, Nuclear Waste Administration Act of 2015

U.S. Sen. Lamar Alexander (R-TN), Energy & Water Appropriations. Subctte Chairman

U.S. Sen. Dianne Feinstein (D-CA), E&W Appropriations. Subctte Ranking Member
A.K.A. The Mobile Chernobyl Bill
DOE Yucca (etc.) barge routes
DOE Yucca (etc.) barge routes
HLRW Barge Shipments: Up to 211 in this area

- Oyster Creek, NJ along NJ shore, to Newark, NJ: Up to 111 shipments
- Indian Point, NY down Hudson River, to Jersey City, NJ: Up to 58 shipments
- CT Yankee, down CT River & Long Island Sound, to New Haven, CT: Up to 42 shipments
DOE Yucca (etc.) road & rail routes
NYS road & rail casks to Yucca (etc.)

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<tr>
<th>Mostly Rail</th>
<th>Mostly Legal-Weight Truck</th>
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<tr>
<td>Truck</td>
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<td>5,287 total</td>
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<tr>
<td>Rail</td>
<td>From Table J-76, Page J-145</td>
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<tr>
<td>350 originating/861 total</td>
<td>Feb. 2002 DOE Yucca FEIS</td>
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Forevermore begins today