Future of Nuclear Power:

"Too Cheap to Meter?"

John Wargo
Professor, Yale University
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Environmental Politics and Law
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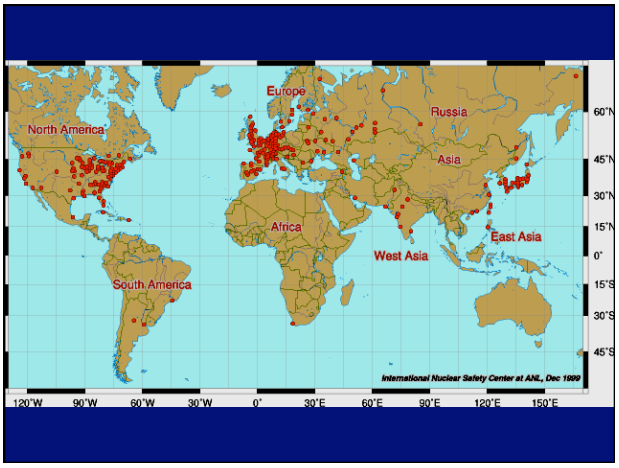


75% of Nation's Electricity From Nuclear Power

U.S.: 19%

By the Numbers:

- *436 Nuclear Reactors Operating in 30 nations.*
- *50 Reactors Now Under Construction- Most Asian*
- *US: Proposals for 20 New Reactors*
- *Of These 4-8 May be Online by 2020*
- *China: 11 Online; 22 Under Construction*
- *US: 60 Plants Granted Operating Extensions > 40 Yrs*

MIT Faculty Conclusions:

After five years, no new plants are under construction in the United States and insufficient progress has been made on waste management.

The sober warning is that if more is not done, nuclear power will diminish as a practical and timely option for climate change risk mitigation.

Capital Costs: Interest Premiums For Risk

If this risk premium can be eliminated, nuclear life cycle cost decreases from 8.4¢ /kWe-h to 6.6 ¢/kWe-h and becomes competitive with coal and natural gas, even in the absence of carbon emission charge.

Atomic Energy Act of 1954

- Defines federal and state authority concerning nuclear energy
- Ends the federal government's monopoly of nuclear technology
- Gave the private sector a role in nuclear power development
- Excluded states from any role in "transfer, delivery, receipt, acquisition, possession, and use of nuclear materials."
- Gave AEC exclusive authority to manage these issues.
- States retained authority over electric power generation, sale, and transmission.

1957 Price Anderson Nuclear Industries Indemnity Act

Protects the Nuclear Industry From Damage Claims

Provides Process for Compensation

1. Show Damage
2. Monetary Loss
3. Loss Caused by Radioactivity

Nuclear Regulatory Commission (NRC)

Created by the Energy Reorganization Act of 1974

- Charged with licensing and regulating civilian use of nuclear energy to protect the public and the environment.
- All licensing and regulatory powers of the former Atomic Energy Commission were transferred to the NRC.
- The NRC establishes rules for the construction and operation of nuclear reactors; regulates the use, possession, handling, and disposal of nuclear materials; imposes civil penalties for violations; and is authorized to shut down nuclear facilities until violations have been rectified.

Pacific Gas & Electric Co. v. State Energy Resources Conservation & Development Commission

In 1976 California established a Moritorium on Nuclear Power Plant Construction…

Until federal government approved of methods to dispose of high level waste.

Pacific Gas & Electric Co. argued Congressional intent to preempt state regulation of the nuclear power industry was implicit in the Atomic Energy Act.

U.S. Supreme Court:

- Federal government possesses exclusive regulatory power over the construction and operation of nuclear facilities, and over radiological safety.
- The states hold authority over decisions concerning the need for additional generating facilities, licensing, ratemaking, and land-use planning.
- *Federal law would preempt the moratorium if related to safety concerns.*
- *Federal law would not preempt the moratorium if based on the economics of nuclear energy.*
- California's assertion that the legislature had enacted the moratorium based on economic concerns.
- Conclusion: CA statute was not preempted by federal law.

Nuclear Waste Policy Act of 1982

DOE was given more than 15 years to begin taking highly radioactive spent fuel from commercial nuclear power plants.

DOE was unable to open a waste facility by the NWPA deadline of 1998.

Repeated delays have pushed back the scheduled opening of a permanent underground nuclear waste repository to 2018.

CRS http://www.ncseonline.org/NLE/CRSreports/Waste/waste-20.cfm

EVACUATION REQUIREMENTS

Before Three Mile Island, Pennsylvania 1979

.. Emergency response plans by nuclear plants in the United States were voluntary.

…Now plans cover a 10 mile radius.

INDIAN POINT NUCLEAR POWER PLANT NY

- Pataki commissioned report of evacuation plan Jan. 2003
- Former FEMA head chaired the commission
- Criticized:
  - Communications between local agencies
  - Size of the area that affected by a release
  - Plans' premises:
    - Orderly evacuation rather than mass panic
    - Parents would leave their children in schools to be rescued by volunteer bus drivers
    - No Terrorist Attack

Pataki Commission Report 2003:

"Any plant adjacent to high population areas should have different requirements than plants otherwise situated, because protective actions are more difficult and the consequences of failure or delay are higher."

• "These planning problems are more serious because of the large population concentrations near the Indian Point plant, and when the effectiveness of the plan requires a degree of public and responder confidence that is largely absent."

106 reactors -31GW in all- have been closed…..

US: "The industry wide obligation for decommissioning U.S. nuclear units approaches $40 billion, according to the NRC. To date, nuclear operating companies have collected approximately $22.5 billion from ratepayers."

The Plutonium Problem: Radioactive Half-Life

Reprocessing chemically separates plutonium from irradiated fuel; the resulting plutonium is readily usable in weapons.

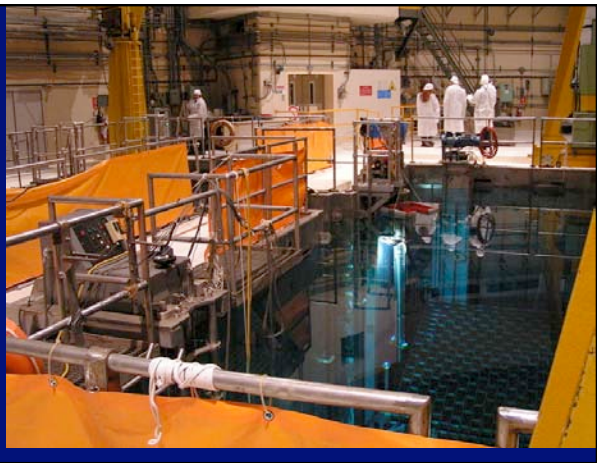
--270 tonnes of separated plutonium from reprocessing of commercial nuclear fuel around the world.

Pu-239: 24,000 years

Without Yucca: Spent Fuels Stored At Plants…

- Spent reactor fuel is is highly radioactive.
- It is cooled in pools of water or dry casks near reactors
- Currently stored at 66 sites in U.S.
  - Year 2000: 2,000 metric tons
  - Year 2010: 10,000 metric tons

Congressional Research Service



Washington State Lawsuit vs. DOE: 2010 Keep Yucca Mountain Repository Viable

"Attorney General McKenna made the right decision to file his lawsuit today to try to stop the Obama administration from closing down Yucca Mountain, the site that remains the statutory nuclear waste repository for the United States," Rep. Doc Hastings, R-Wash., said in a statement.

http://www.thenewstribune.com/2010/04/14/1147203/washington-sues-doe-over-yucca.html#ixzz0l5PpWObl

G-8 Controlled Nuclear Fuel Bank?

International Atomic Energy Agency, supported by private organizations such as the Nuclear Threat Initiative and then by several countries (including the United States and the Persian Gulf states), to establish a nuclear fuel bank.

Intent? Provide security of nuclear fuel supply, so that countries have less reason to pursue enrichment or reprocessing facilities.

G-8= France, Germany, Italy, Japan, Russia, the United Kingdom, and the United States. (Nuclear Supplier States).

MIT Faculty: Safety

"Parallel with the improved operations has been an excellent safety record."

"Nuclear power displays by far the highest capacity factor among all generation technologies, providing about 20% of U.S. electricity supply."

"The judgment of the 2003 study that new light water reactor plants, properly operated, meet strenuous safety standards discussed in the 2003 report is unchanged."

Proliferation: Enrichment

"Fuel enriched from natural abundance 0.7% U-235 to the commercial level of 4 to 5% must undergo further isotope separation to reach the "highly enriched level," normally taken to be >20% for U-235, necessary for nuclear devices."

1979
Three Mile Island:
60% Meltdown

Chernobyl Plant in Pripyat

CHERNOBYL-4

April 26, 1986

- ❖ RECORD YEAR LONG FULL POWER RUN
- ❖ PREPARATION FOR YEARLY MAINTENANCE
- ❖ GRADUAL POWER REDUCTION
- ❖ CONTROL RODS INSERTED: Test was planned to run at 20% power, but when this level was reached, the operators failed to press a switch that would have maintained that level and power fell to 1%.
- ❖ CONTROL RODS REMOVED: Rods were quickly removed to bring power back up to 20%.

- ➢ Operators turned off several safety and emergency warning devices, reducing the cooling capacity of the core to produce additional steam. This they believed was necessary to conduct a series of power reduction tests.
- ➢ Power rapidly dropped to 1%, a level known to produce a highly unstable condition, due rapid buildup of gases such as xenon.
- ➢ For the operators…."It was like trying to balance a baseball on a watermelon"
- ➢ Power surged 1,500 times higher within 5 seconds.
- ➢ The operators recognized the error and raced to drop the control rods into the core. But the rods took 10 seconds to put in place, too late given the explosive power surge.

AFTER 4 DAYS OF SILENCE:

Government Announcement….

"An accident has occurred at the Chernobyl atomic power station; one of the nuclear reactors has been damaged. Measures are being taken to eliminate the consequences of the accident. Aid is being given to the victims. A government commission has been established."

- ❖ *Soviets disclosed "a certain leak of radioactive substances". The following day, a Government bulletin claimed that although nearly 200 were hospitalized, the water and air in Kiev were safe.*

"Good evening, comrades. All of you know that there has been an incredible misfortune -- the accident at the Chernobyl nuclear plant. It has painfully affected the Soviet people, and shocked the international community. For the first time, we confront the real force of nuclear energy, out of control."

President Mikhail Gorbachev

1986

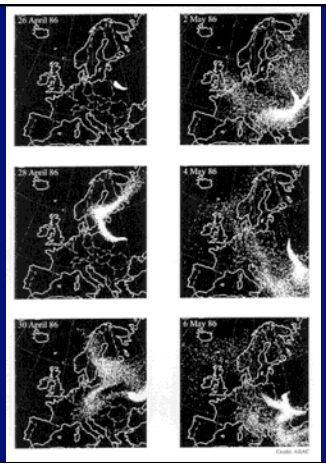
Worker Protection….

- Other than potassium iodide pills available in their first aid kits, the firemen had no special protective equipment other than a normal respirator and heat shielding clothing.

26 Apr

28 Apr

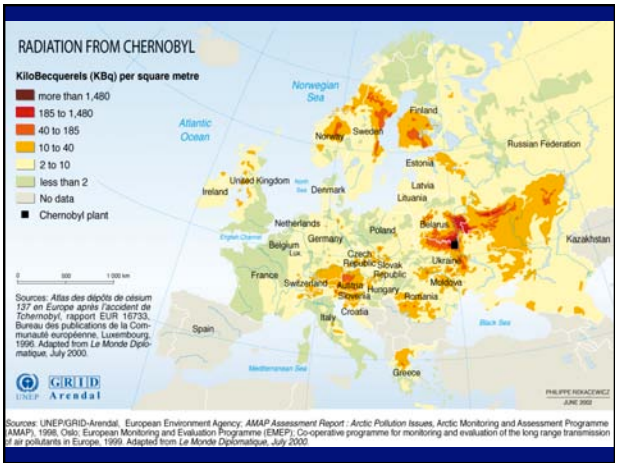
30 Apr



2 May

4 May

6 May



Sources: UNEP/GRID-Arendal, European Environment Agency; *AMAP Assessment Report : Arctic Pollution Issues*, Arctic Monitoring and Assessment Programme (AMAP), 1998, Oslo; European Monitoring and Evaluation Programme (EMEP); Co-operative programme for monitoring and evaluation of the long range transmission of air pollutants in Europe, 1999. Adapted from *Le Monde Diplomatique, July 2000*.

Sources: *Atlas des dépôts de césium 137 en Europe après l'accident de Tchernobyl*, rapport EUR 16733, Bureau des publications de la Communauté européenne, Luxembourg, 1996. Adapted from *Le Monde Diplomatique*, July 2000.

HOTSPOTS OF RADIATION:

- Confiscated
- Permanent Control
- Period Control
- Unregulated

Decontamination

AREA CONTAMINATED

3200 sq km
40 Ci/sq km

76,000 sq km
1-5 Ci/sq km

3 million people
1-5 Ci /sq mi

500 Million Tons of Highly Radioactive Waste Entombed

❖ *Sweden…*

❖A Swedish worker arrived at a nuclear plant, on the morning of April 28th, and radioactive particles on his shoes set off an alarm.

❖ The plant was immediately evacuated and soon other plants in Sweden reported similar alarms.

❖ When all operations seemed normal, they checked weather patterns over the past several days and suspected a problem originating in the Soviet Union.

❖Radiation in Sweden reached 1000 times normal background levels several days later.

❖Winds then shifted toward the south, and blew the radiation toward Romania and Yugoslavia.

❖Within 5 days, both Polish and Swedish governments issued a warning about radionuclides in their milk supplies, and farmers were cautioned against grazing their cattle on pastures.

❖By the end of the first week, the fallout was detected in Great Britain, and most other Western European nations.

❖ Within two weeks, the U.S. EPA announced that the fallout had reached the U.S. driven by the jet stream moving at 100 to 150 miles per hour across Siberia and the Pacific.

❖ By May 12th, rainfall in Sante Fe, New Mexico measured 360 picocuries of radiation.

❖ Soviets: If one liter of the contaminated water were ingested per day, it would be the equivalent of receiving approximately one-quarter of a chest X-ray.

Germany….

❖West Germany reported radiation levels that were 60 times normal, causing widespread fear of contamination of their food and water supplies.

❖ Germans were warned against allowing children to play on playgrounds due to fallout in sandboxes, play equipment and fields.

❖Early in 1987 the German government decided to destroy 3,000 tons of powdered milk containing nearly 10 times the level of radiation allowable for human consumption.

❖ Bavarian officials suggested that the contaminated milk be diluted by adding it to animal feed, and then sold to Angola and Egypt. They argued that the European Community standard could be met.

❖Their suggestion created an international uproar.

International Atomic Energy Agency International Agreements

❖ Only months after the accident, 49 member nations including the Soviet Union, approved two international conventions.

❖ One required immediate notification of accidents, and the other pledges international aid to contain damage in the nation where an accident occurs.

❖ The U.S. and Soviets successfully excluded leaks from weapons and underground tests from the notification requirement.

❖ *The Soviet Union signed both agreements.*

❖ *At the time nearly 270 nuclear power plants existed in the world, with 100 others under construction.*

❖ *The Soviets agreed that they had a moral but not legal responsibility for the damages caused by the Chernobyl disaster.*

Evacuation

➢ Civil defense officials were finally able to convince government and plant officials of the need to evacuate the Pripyat and Chernobyl communities, but not until 36 crucial hours had passed following the initial explosion, a period of intense release of radiation.

➢More than 1,000 buses lined up to pick up nearby residents

➢*Defining the Evacuation Zone….*

➢10 days following the release, 49,000 people were reported to be evacuated from areas at risk, defined initially as an 18 mile radius known as the "zone".

➢The zone was defined quickly as a rough boundary including the most contaminated lands.

➢Yet its definition depended both upon the environmental testing and predictions of possible future releases from a reactor, still burning.

EVACUATION HISTORY:

On 2-3 May, some 45,000 residents were evacuated from within a 10 km radius of the plant, notably from the plant operators' town of Pripyat.

In the years following the accident a further 210 000 people were resettled into less contaminated areas.

The initial 30 km radius exclusion zone (2800 km²) was modified and extended to cover 4300 square kilometres.

HOTSPOTS OF RADIATION: Cesium 137/ km²

Chernobyl

10 mile radius

- Confiscated 40 C/km²
- Permanent Control (15-40)
- Periodic Control (5-15)
- Unregulated (1-5)

➢By 1990, 4 million residents of Byelorussia, the Ukraine and western Russia were living on seriously contaminated soils, including 5 million agricultural acres in Ukraine alone.

➢Many of these people faced the reality that they had spent the past 3-4 years living in areas contaminated areas they believed were safe.

➢They now worried about relocation, as well as the health consequences of their former radiation exposures.

- By 1989, 10,000 new homes were constructed for those originally displaced, and now 37 additional villages would need to be constructed.
- In 1990, 13,000 people lived in Polesskoye, with radiation levels of 40 curies per square kilometer.
- In 1991, 5 years following the accident, residents of the town of Narodichi, 50 miles west of Chernobyl were still being relocated from areas found to be more heavily contaminated than earlier believed.

ACCEPTABLE CONTAMINATION LEVELS?

- The Ukrainian Supreme Soviet appointed a commission in 1991, and reported that 5 million people in Ukraine lived on lands so contaminated that evacuation should be unconditional.
- Although the Soviet law set a standard of allowable exposure at 35 rems, the Ukraininan commission recommended a maximum lifetime exposure of 7 rems.
- They argued that the standard for allowable soil contamination should be lowered from 15 to 5 curies per square kilometer.

Soviet manipulation of environmental and health surveillance and standards served to limit their legal liability, need for evacuation of millions living in contaminated areas, their medical care, compensation, new village construction costs and clean up.

Food Safety Regulations Vary Among Nations

- Many of the European nations had different standards for the acceptability of radionuclides in different foods.
- This led to a chaotic set of national bans on specific products such as milk and fresh produce.
- Finally, the Europeans decided to ban meat, live animals and produce from all areas within 1,000 kilometers (630 miles) of the site.

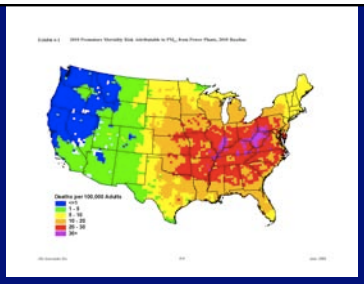
FOREIGN ECONOMIC CONSEQUENCES

- The Austrian government banned the import of East Bloc milk, fruit and vegetables.
- The Dutch Agriculture ministry prohibited cattle grazing.
- The Swiss warned against providing fresh milk to young children, and against drinking rainwater from cisterns.
- Italy banned the sale of its own leafy vegetables—resulting in the waste of nearly 10 million pounds of produce. Carrots were exempted, with the logic that they grow underground.

- Sweden's detection of cesium 137 with a half life of more than 30 years means the problem is virtually irreversible in the Laps' lifetime.

Comparison of Radioactive Releases

Event (number)	*Location*	*Year(s)*	*Curies Released (Total)*	*Isotopes*	*Risk (fatal cancers)*
First Atomic Bombs	*Hiroshima & Nagasaki, Japan*	*1945*	*~250,000,000*	*Short-lived fission products[f]*	*300 estimated/76,000 tracked*
Early Hanford operations	*Hanford, Washington*	*1945-1947*	*700,000*	*I-131[h]*	*~1.6 cases of thyroid cancer expected/ 3,200*
Green Run	*Hanford, Washington*	*1949*	*8,000*	*I-131*	*0.04expected/30,000 exposed[m]*
Atomic weapons testing	*Worldwide*	*1945-1980*	*~26 million(Cs-137); ~18 million(Sr-90); ~19 billion(I-131); ~6.5 billion (H-3); ~6 million(C-14)*	*Cs-137; Sr-90; I-131; H-3; C-14*	*12,000 expected/5 billion[e]*
Chernobyl	*Ukraine, Soviet Union*	*1986*	*950,000 1,900,000 17,000,000*	*Cs-134; Cs-137; I-131[b];*	*17,400 expected/2.9 billion exposed[c]*
Three Mile Island	*Harrisburg, Pennsylvania*	*1979*	*15 10,000,000*	*I-131 noble gases[j]*	*0.7/2 million exposed[k]*
Household radon	*United States*	*Lifetime*	*N/A*	*Ra-222*	*14,000 per year expected/240 million[d]*



20,000-60,000 Premature Deaths from Coal Fired Power Plants in US
Abt Associates: 2004