

New Nuclear Waste Resolutions



Defense (Legacy) Waste

- DOE Testimony before Congress
 - DOE Nuclear complex
 - 8 sites ca. size of Rhode Island
 - 40 years to clean up
 - Estimated \$447 billion cost

SRS “The Bomb Plant”

Defense (Legacy) Waste

5 Reactors for WW II & Cold War support

33,000 tons from decommissioned SRS reactors



■ \$ 4.7 billion for liquid radioactive waste in 51 tanks



■ Hanford, WA = most nuclear waste by volume



■ SRS= highest level of radioactivity

Hanford WA

- Catholic University in Washington, DC
- - 177 aging underground tanks holding 56 million gallons of liquid and semi-solid nuclear and chemical waste.
 - Research
 - Lock liquid radioactive waste in solid glass
- Collaboration with Department of Energy (DOE) and project stakeholders
 - Find material and method for improving vitrification

U.S. Commercial Nuclear Waste

2024, U.S. Nuclear Energy Plants

54 commercially operating nuclear power plants in 28 states

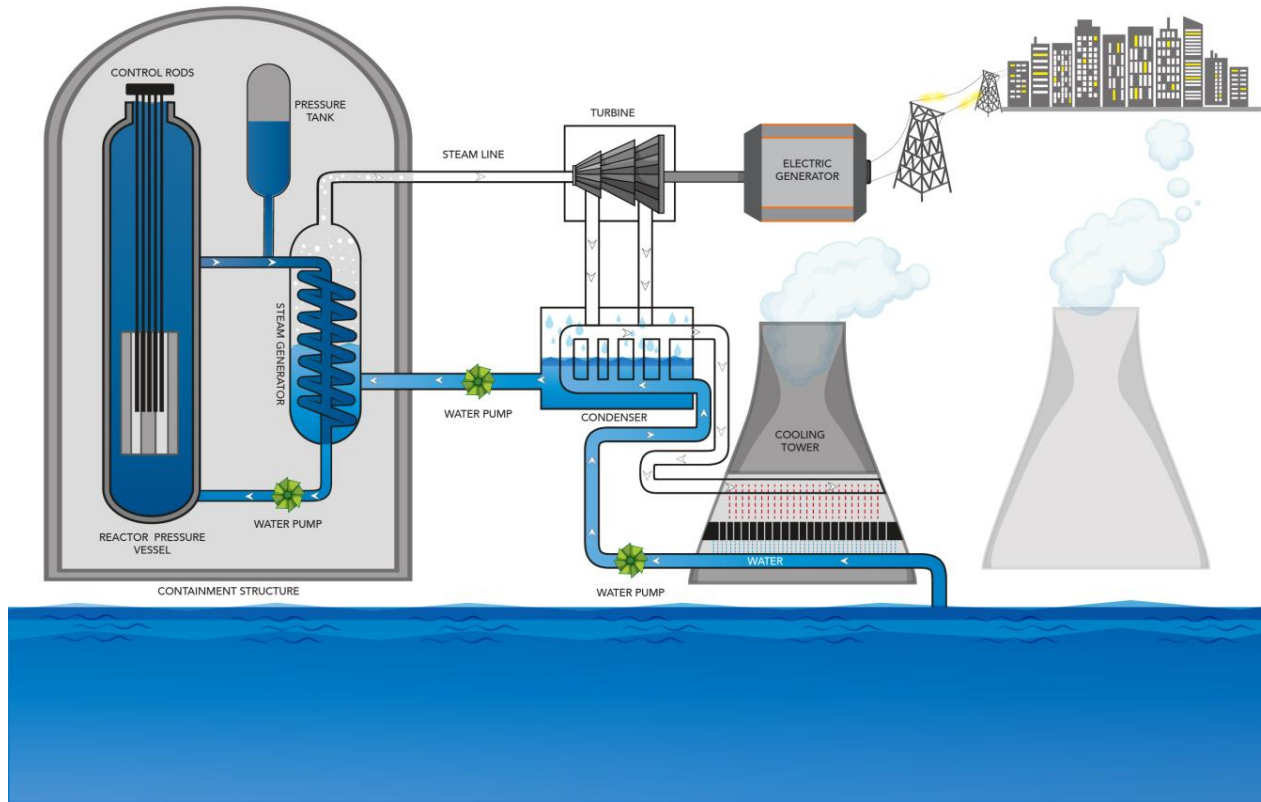
94 nuclear reactors

90,000 tons

Growing 2,000 tons/year

How Reactors Work 101

PRESSURIZED WATER REACTOR (PWR)



- Typical reactor may contain:
 - , **157 fuel assemblies** composed of over **45,000 fuel rods (120-190)**
 - common fuel assembly contains energy for approximately **4 years of operation at full power.**
 - about **one-quarter of the core** is removed annually
 - to **spent fuel pool** (i.e., about 40 fuel assemblies).
 - remainder is rearranged to a location in the core better suited to its remaining level of enrichment).
 - **100 tonnes of enriched uranium**
 - removed fuel (**spent nuclear fuel**) still contains about **96% of reusable material**

Nuclear fuel rods



U.S. Congress

“One of the most hazardous substances on Earth”.,

- Freshly pulled assembly lethal
 - Death = minutes
 - Where does waste start?
 - How much is there ?
 - How do we get rid of it?
-
- **What should U.S. Congress do about it?**
 - **Resolutions (authorize, fund & implement)**

Storage

Nuclear waste belongs to U.S. Govt

No federal repository

Stored at power plants where generated

- Pools

- Dry steel-and-concrete casks

Nuclear Industry Mantra

- Nuclear Energy Is:
- Safe????????
- Cheap??????
- Clean?????

Is It???

- Narrow definition of nuclear industry:
 - No carbon footprint
 - Doesn't consume fossil fuels
 - carbon dioxide
 - Global warming
- Broad definition.
 - Other emissions

Nuclear waste.

1972 DOE SSAB

- Federal Advisory Committee Act
 - One Site Specific Advisory Board over eight local boards
 - provide DOE with information, advice and recommendations concerning issues affecting the EM program at various sites.
 - Meetings open for public comment and questions.
 - clean-up activities
 - future land use
 - environmental restoration
 - waste and nuclear materials management
 - disposition
 - characterize excess facilities (235 F)
 - long-term stewardship
 - risk assessment; and communications (long term).
 - [Hanford Advisory Board](#), [Idaho Cleanup Project Citizens Advisory Board](#), [Northern New Mexico Citizens' Advisory Board](#), [Nevada SSAB](#), [Oak Ridge](#), [Portsmouth \(Ohio\) SSAB](#) and [Paducah Citizens Advisory Board](#) (KY). **SSAB, Savannah River Site Citizens Advisory Board** -- **CAB**

Politics Trumps Nuclear Science Book Cover

- Hayes
- 2014



Politics Trumps Nuclear Science

- Not against nuclear energy
- Against nuclear waste produced by nuclear energy production
- Against consistent **government failure** to plan and fund needed research and development.
- Based on:
 - Federal Public Health Programs Manager 20 years
 - DOE SRS Site Specific Advisory Board , Nuclear Materials Committee Chair 2009-2015
 - Research in seven Presidential Libraries (White House Central Files)
 - Field research (Rossing Mine)
 - NRC files
- Advocate R&D **Transmutation** technology

Nuclear Energy Waste

Half Life Yrs

- Tritium 12.5
- Strontium 90 29
- Cesium 137 30
- Iodine 131 8.02
- Plutonium 239 24,000 (created in nuclear reactors, most for weaponry & energy,)
- Uranium 235 720,000,000 (Alpha Emitter)
 - only poses a radiation hazard if it is breathed in, eaten or drunk, or enters part of the body exposed by injury.

-ALL Transform when they decay

-Shorter half-lives decay more quickly & emit more energetic radio activity.

-All transform when they decay (transmute)

- stable state (like lead)

Resolution?

- Ed Lyman, MIT Union of Concerned Scientists
- "many different radioactive isotopes
- -different decay rates
-no one-size-fits-all solution to convert waste into less hazardous materials,"
- **Plutonium-239**
 - carcinogenic ingested or breathed in
 - **Breathed in** = one pound oxide(dust) could give cancer to two million people
 - ingested far less dangerous
 - Half life = Dangerous 24,000 yrs
 - Public Health **SWAG** = $10 \times 24,000$ = 240,000 years

1954, Atomic Energy Act

Disposal of highly radioactive waste to be responsibility of federal government

- **Reprocessing:**
- hazardous,
- expensive and
- time-consuming—
- takes thousands of years to fully recycle the waste.
-

Federal repository should be developed.

Additional Waste Risks

- Transportation from 54 power plants
- Terrorism
- Human Error
- Mismanagement
- Contractor Fraud
- Reactor Malfunctions (melt downs)
- Natural Disasters

History: Starts in Nuclear Reactors

- 1932 Splitting of the atom in England
 - Early nuclear physicists
 - **Chain reaction** of split atoms
- 1945 U.S. Atomic bomb
 - Legacy waste)
 - 1946-75 Atomic Energy Commission
- 1947-1991 Cold War with USSR
 - Each have massive nuclear arsenals with thousands of nuclear warheads
 - (MAD)
 - Thermodynamic = 5,000 times stronger than A-Bomb blast in Hiroshima

Department of Energy (DOE)

-

Commercial Waste

-

Energy Production Plants

- 1990 = 112 plants
- 2023 = 93 plants

90,000 tons Spent Nuclear Fuel (SNF)

Spent Nuclear Fuel

How dangerous is it???

Reactor Core

- emit extremely high radiation levels

- assembly = **10,000+ rems** per hour shortly after removal from a reactor

EPA human exposure recommendation =100 rems/yr

Reactors World Wide

- **400+ active commercial nuclear reactors**
- **31 countries +**
 - **U.S.** **90+**
 - **France** **58**
 - **Japan** **54**
 - **Russia** **36 +4**
- **Nuclear power plants=**
Like building buildings without toilets.

U.S.

- **No federal repository for at least 50 years**
 - **Targeting 2048**

Safe ??????

SRS Storage/Processing Areas

1950s HLW:

5 reactors brought on line

252 million curies (unit of [radioactivity](#))

L Basin Cooling Pool

1997 Brookhaven National Laboratory Report for NRC

“A severe pool fire could render about 188 square miles around the nuclear reactor uninhabitable, cause as many as 28,000 cancer fatalities, and spur \$59 billion in damage”

“Uninhabitable” = approximately 4 million years

Permissible Exposure Limits

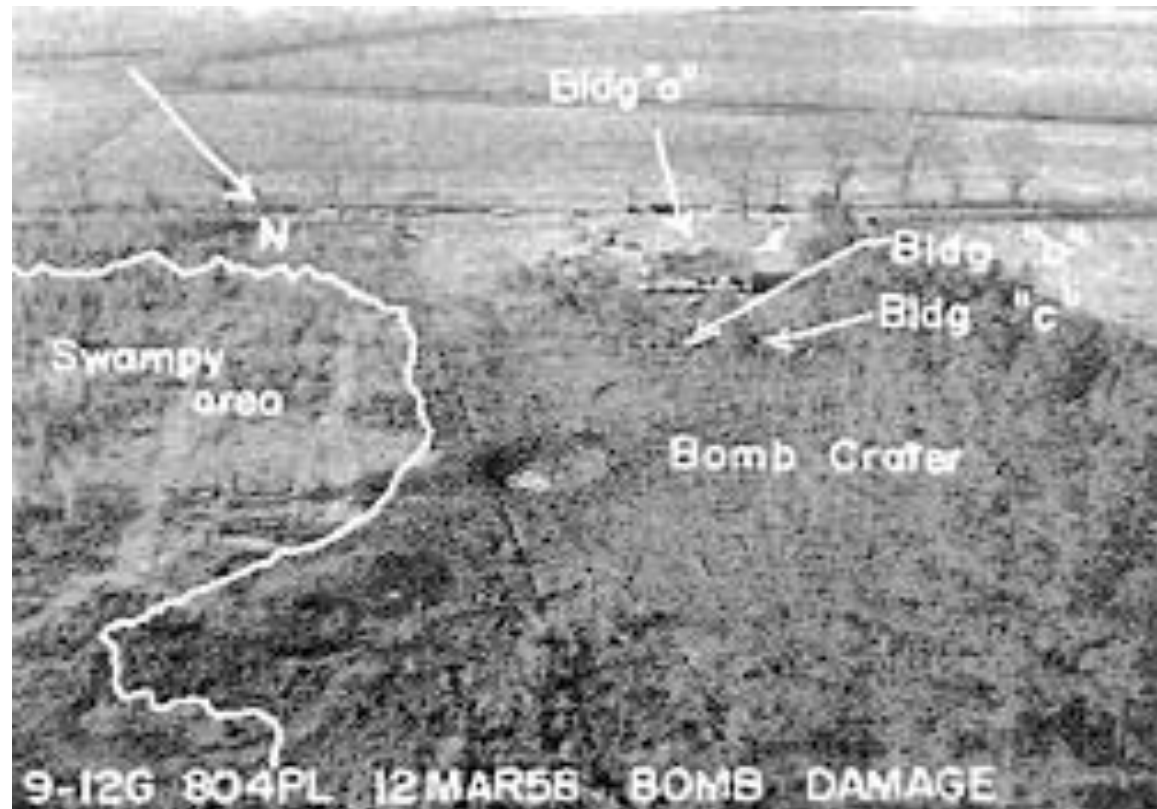
- OSHA PELs
 - Permissible exposure to radioisotopes in an 8-hour work shift without adverse effects
 - (based on animal testing)
- DOE
- NRC
 - In the United States, the maximum amount of radiation exposure that is considered safe for the general public is 100 millirem (mrem) per year. This limit applies to non-medical or dental X-ray sources, including airport X-ray machines.

Sources

- 1958 SAC B47 Dropped Nuclear Weapon on SC Town



Bomb Crater



Aerial view

Tybee Island, 1958

- **Mid-air collision**
 - [United States Air Force](#) Night practice exercise, an [F-86](#) fighter plane collided with the [B-47](#)
 - bomber carrying 7,600-pound [Mark 15 nuclear bomb](#)
 - near [Savannah](#), [Georgia](#)
 -
- The bomb was jettisoned off [Tybeelsland](#) near [Savannah](#), [Georgia](#)
- to help prevent a crash and explosion.
- Unsuccessful searches
- , -declared lost in [Wassaw Sound](#)

Marker documenting [1961 Goldsboro B-52 crash](#), when a stricken B-52 dropped two nuclear bombs near [Faro](#), in January 1961. Marker doesn't mention that one of the two atomic bombs is still **there...**



Savannah River Site Building 235-F Safety

A Notice by the [Defense Nuclear Facilities Safety Board](#) on [05/21/2012](#)

Published Document: 2012-12179 (77 FR 29986)

This document has been published in the *Federal Register*. Use the PDF linked in the document sidebar for the official electronic format.

Published Document: 2012-12179 (77 FR 29986)

- Document Details

Published Content - Document Details

Agency

[Defense Nuclear Facilities Safety Board](#)

Agency/Docket Number

Recommendation 2012-1

Document Citation

77 FR 29986

Document Number

2012-12179

Document Type

Notice

Pages

29986-29988 (3 pages)

Publication Date

[05/21/2012](#)

Published Content - Document Details

The responsible SRS contractor, Savannah River Nuclear Solutions (SRNS), has determined that the unmitigated consequences of a seismically-induced full-facility fire are greater than 10 rem offsite and 27,000 rem to the collocated worker at 100 meters. F-Area routinely has more than a thousand site workers who are normally in the facilities, construction sites, and trailers located adjacent to Building 235-F. Some of the trailers that house workers are located within the Building 235-F fence line.

Contractor MOX Fraud

- 2016
- Federal government and unnamed whistleblower jointly sued a contractor over MOX construction materials issue.
 - Suit alleges contractor failed to ensure that steel rebar being used to reinforce MOX walls met required standards
 - rebar found to be defective (it broke)
 - Suit also alleges contractor lied to government about materials provided.

1979, THREE MILE ISLAND

- UNIT 2 Mechanical FAILURE:

- Valve stuck open
- Reactor coolant escaped
- Core overheated

Human Error:

Plant operators failed to recognize release

Inadequate training

Designer-User/Equipment Design Interface

Ambiguous control room indicators

- hidden indicator light caused operator to manually override automatic emergency cooling system believing too much coolant was present

Plant released radioactive material

Public backlash closed plant

1985, Three Mile Rebirth

- One undamaged reactor down for refueling during accident
 - Off line six years
 - Resumed over objections by residents and activists
 - Provided energy for some 34 years
 - 2019, again shut down
 - Utility plant customers opted for cheaper electricity from natural gas plants

1986, Chernobyl

Causes

- flawed reactor design
- inadequately trained personnel.
 - steam explosion and fires
 - 5% of the radioactivity in core released

Plume spread radioactive materials across Europe.

Natural Disasters

- Earthquakes
 - Richter Scale magnitude
 - None 10 or larger known
 - Would be felt around the world
- 1960 Largest earthquake ever recorded:
Megathrust
Chile
Fault: almost 1,000 miles long

Magnitude 9.5

Chilean Megathrust

- Tremor caused localised tsunamis
-
- Chilean waves up to 82 ft
 - main tsunami traveled across Pacific Ocean devastated [Hilo, Hawaii](#),
 - waves as high as 35 ft
 - recorded over 6,200 mi from the epicenter.

Predictable?

- USGS geophysicists
- Can't predict a major earthquake.
 - not expected in foreseeable future.
 - USGS scientists can only calculate the probability that a significant earthquake will occur in an area.

1964, Alaska tsunami

- March 27
- PRINCE EDWARD SOUND
- Earthquake
 - 9.2 magnitude
 - TSUNAMI WAVE TRAIN
 - W/7 TO 10 WAVES
 - Highest 220 ft
 - 11 HOURS
- Widespread damage and loss of life;
 - Alaska, Canada, the United States, Antarctica and Hawaii:

JAPAN, FUKUSHIMA DAI ICHI

- March 2011

Magnitude 9.1 earthquake

Tsunami wall ca. 40 ft

Flooded all turbine and reactor buildings

Damaged electrical components and connections located on the ground or basement levels

Damaged power supply & cooling systems of three reactors

- Meltdown in three days
- Severe radiation release
- SNF pool 4 overheated

Damage

- Estimated \$2.3 billion in property losses.
- Global Implications
 - disposal of treated wastewater used to cool melting reactors
 - -radioactive elements dumped into sea
 - Cesium-137 on sea floor

• .

Age Factor

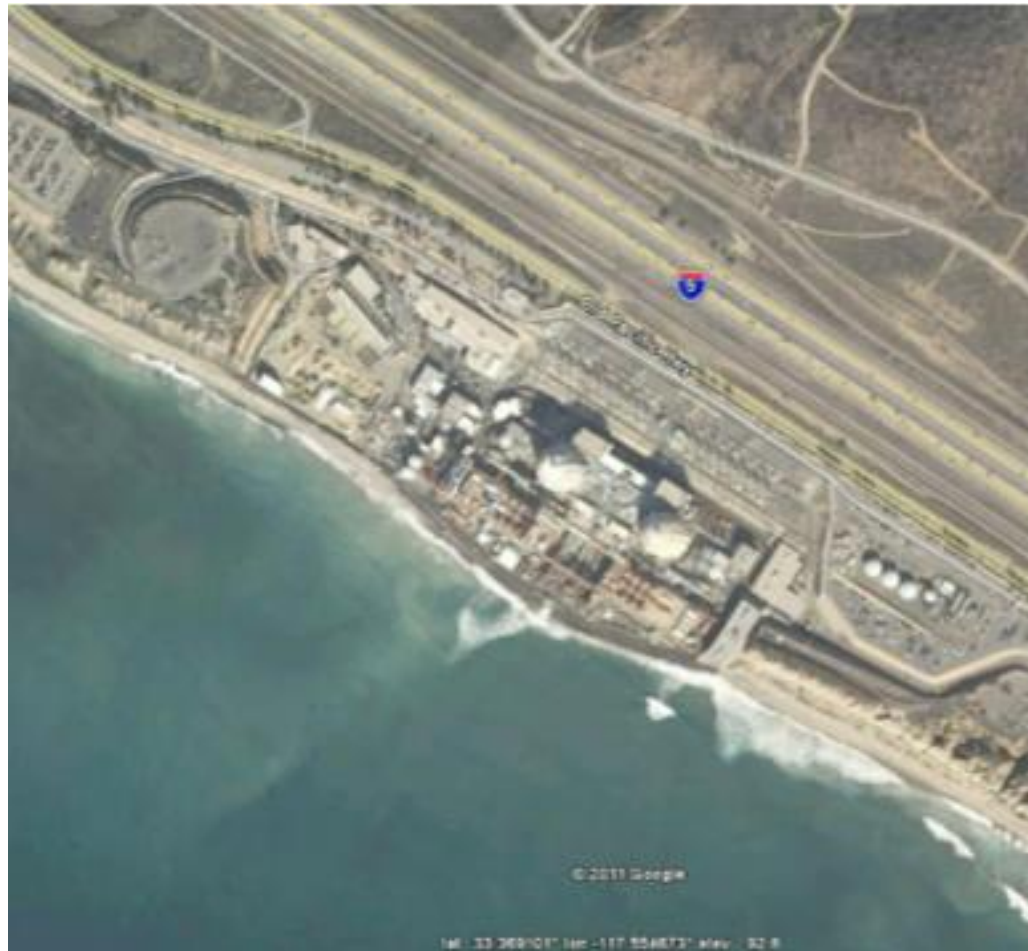
- Extended License Renewals:
- Original NRC license = 40 years
- 87 of 92 commercially operating nuclear reactor units have had license extensions to 60 years
- Subsequent extensions up to 80 years
 - Virginia – Surry units 1 and 2

In process—9 others from Wisconsin to Alabama

San Onofre: Poster Child



San Onofre Proximity to Pacific Ocean



Dangers of Aging

- 3 Reactors --- 1968, 1983, 1984
 - Built for 7.0 earth quake
 - 25 ft wall against tsunami
-
- Inactive Ifault ine 1 mile off shore
 - Active fault line 5 miles off shore
 - **San Andreas Fault = 56 miles east**

Unit 1

- . Off line in 1992
 - now being used as storage for spent fuel.

2009-2010

- Four new steam generators replaced (two in each unit).
- Replaced steam generator
 - 65ft tall,
 - 22ft in diameter
 - weighs 640t.

-

Radioactive Leaks

- January 2012

- 2011 Korean (Mitsubishi) steam generators
 - Cost to rate payers \$671 million
- Faulty computer modeling
- tube degradation (abnormal thinning)
- design flaw: tightly bundled tubes vibrate too much and rubbing together.
- Premature wear in 3,000+ tubes in 15,000 + places
- Radiation leak
- 2012 Units permanently off line

Decommissioning Problems

Nuclear waste (18,000 tons)

Unit 1 cooling pool

Dry Cask System

890,000 SNF rods

Cost \$\$\$\$ billions Shipment leaks

2 Pressurizers:

Skeleton crew

Vessel stored onsite with 400,000 curies

Kittens born on site:

- Radiation levels with 6,000 counts per minute (cesium 137, cesium 135 & cobalt 60)
- -significantly high and potentially dangerous;
- well above normal background radiation levels
- require immediate action

San Onofre Cooling Pool

UNIT 1



San Onofre Dry Cask System



Plates & Volcanoes



2018, Falsified Records: Plant Vogtle Human Factor

Subject: NRC Proposes \$145,000 Civil Penalty for Violations at Vogtle Nuclear Plant
Date: February 21, 2018 at 10:09 AM
To: rosechayes@aol.com

Nuclear Regulatory Commission - Press Release

No: II-18-002 February 21, 2018

Contact: Roger Hannah, 404-997-4417 Joey Ledford, 404-997-4416

NRC Proposes \$145,000 Civil Penalty for Violations at Vogtle Nuclear Plant

The Nuclear Regulatory Commission staff is proposing a \$145,000 civil penalty against Southern Nuclear Operating Co., for violations at the company's Vogtle nuclear power plant involving plant employees who did not complete required rounds to check equipment and plant conditions, but provided inaccurate documentation indicating that they had done so.

The Vogtle plant is located near Waynesboro, Ga., about 26 miles southeast of Augusta. The violations identified during an NRC inspection, occurred from August to

2017 Human Factor: Nuclear Waste on Commercial Airliner:LANL

WWW.AIKENSTANDARD.COM

http://www.aikenstandard.com/news/documents-favor-mox-over-downblending/article_dfd63606-8688-11e7-b3fb-8b717a550b8a.html

Aiken Standard: Lab makes changes in wake of botched nuclear shipments

By SUSAN MONTOYA BRYAN Associated Press

Jul 11, 2017

ALBUQUERQUE, N.M. — Employees have been fired and other personnel actions have been taken at one of the premier nuclear weapons laboratories in the U.S. after small amounts of radioactive material were mistakenly shipped aboard a commercial cargo plane.

Officials at Los Alamos National Laboratory declined to provide any details about the personnel actions, only to say that those who had a role in the mix-up — from individual workers to those in the management chain — have been held accountable.

Los Alamos also has transferred responsibility for the shipment of certain nuclear materials to another division within the lab and has created more controls for making shipping labels in an effort to avoid problems in the future.

"Although these shipments arrived safely at their destinations and no one was hurt, this mistake, taken together with other mistakes in the past, is unacceptable and is in the process of being addressed promptly and thoroughly," the lab said in a statement. "Our response

Uranium Worker Diseases

- NIOSH/CDC STUDIES, 1950-PRESENT

• Disease	White	Non-White
Lung cancer	6.0X	3.0X
Pneumoconiosis	24.0X	2.5X
Tuberculosis	4.0X	2.5X
Emphysema	2.5X	---

Conclusions:

Causes: radon gas & airborne particles of invisible radioactive elements

Lower non-white rates due to smaller samples

2024/2012, National Institute for Occupational Safety and Health, Cincinnati, OH, US (17 pages)

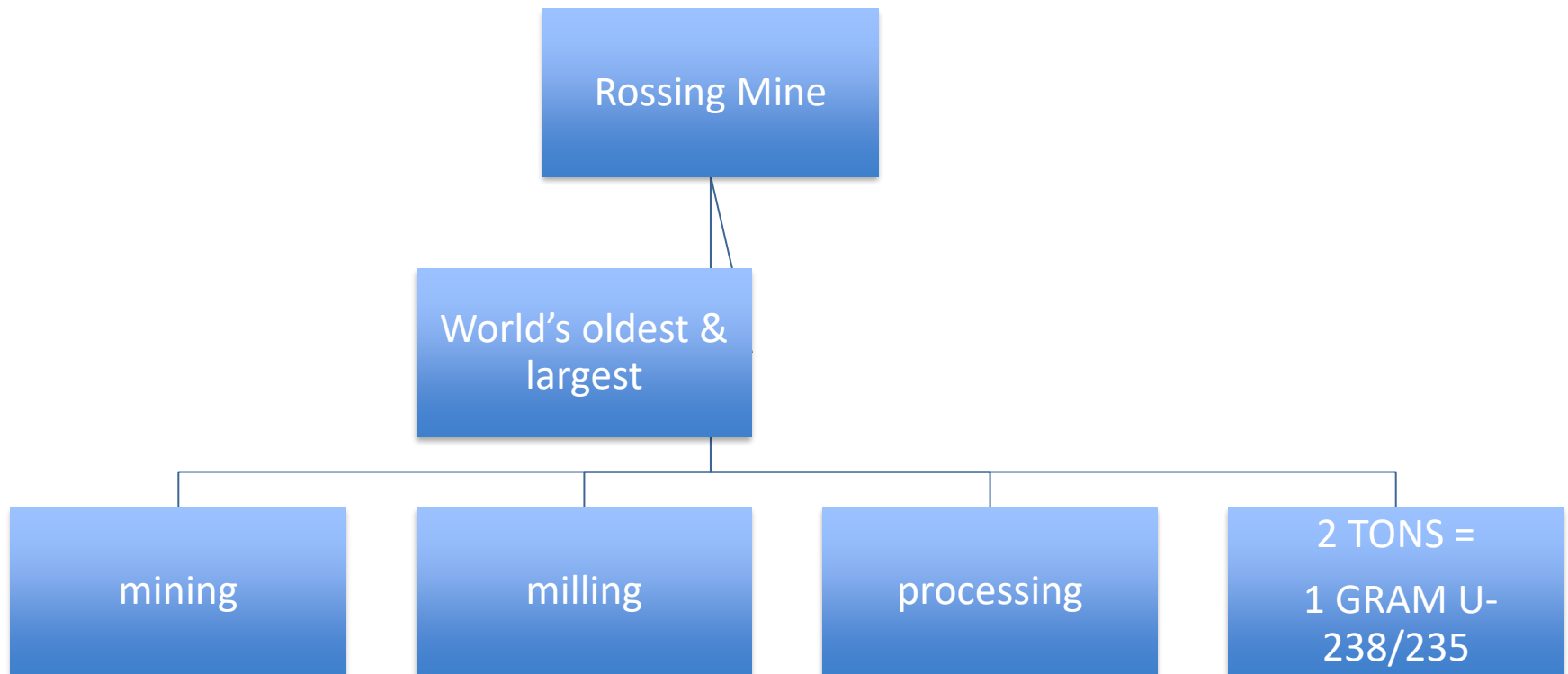
Radon and Lung Cancer in the Pooled Uranium Miners Analysis (PUMA): Highly-exposed Early Miners and All Miners

- largest and most up-to-date
- three times as many lung cancer deaths than last National Academies of Science pooled analysis.
- 119,709 male miners from four North American cohorts
- 1990. Radiation Exposure Compensation Act (“RECA”
apology and monetary compensation to individuals and their families for diseases associated with radiation exposure resulting from efforts to protect the national security of the United States during the Cold War.
- RECA paid \$2.5 billion

- In 1987, the National Institute for Occupational Safety and Health (NIOSH)
- current occupational standards for radon exposure in the United States do not provide adequate protection for workers at risk of lung cancer from protracted radon decay exposure
- recommended occupational exposure limit for radon decay products should be reduced substantially.
- To date, no enforceable standard by the DOL Mine Safety and Health Administration or OSHA .

Uranium Ore: Open pit mining

Safe, Cheap, Clean???



Rössing Mine



Map of the Erongo Region indicating the location of the Rössing Uranium mine.



Skeleton Coast



4th Rock Crusher



The Pit



Hydrochloric Acid



U.S. DOE Office of Environment, Health, Safety & Security Deficiencies

- **ALARA**
 - As low as reasonably achievable. ‘
-
-
- Low dose levels of radiation = **dose/risk association** not well understood
- Cancers cannot be **DISTINGUISHED** from other causes:
 - environmental, chemical or biological factors.
-
- Cancers from a radiation exposure usually have a latency period
-
- Delay up to 2-10 years after exposure.
- **OBSCURES As low as reasonably achievable (ALARA)**
-
- **Is it SAFE?**

Is It Cheap????: Follow the money

- Commercial nuclear power plants have produced more than 90,000 metric tons
 - Require isolation in deep-mined geologic repositories for hundreds of thousands of years.
 - U.S. has no program to develop a geologic repository
 - Yucca Mountain = decades and \$9 billion dollars
 - SNF currently stored in pools or in dry casks at reactor sites
- Accumulating at a rate of about 2,000 metric tons per year.

DOE cost estimate

- In 2024, estimated its overall liability for failing to dispose of commercial spent nuclear fuel to be between \$37.6 billion and \$44.5 billion.
- Estimated \$500 million per year
- Department of Labor, Office of Workers' Compensation Programs, *EEOICP Program Statistics*, January 30, 2022,
 - Medical Bills Paid, Parts B and E Combined
 - Over \$7.5 billion
-

2013, Georgia,

NEW Plant Vogtle Units

2 additional units on line; 3 & 4

Slipped schedule by 7 years

Cost overrun \$20 billion

\$36.8 billion,

2017, South Carolina

“Nukegate”

Virgil C. Summer Nuclear Generating Station,

2 UNITS

-DELAYS

-COST OVER RUNS

-FRAUD

Abandoned after spending \$9 billion

\$2 billion to rate payers

Never generated energy

Nuclear Energy Rebirth with Techno-Industrial Data Control

- Microsoft
 - Three Mile Island,
 - Paying Constellation Energy to bring bring TMI back on line
 - New Name (Crane Clean Energy Center)
 - \$1.6 billion to restart two reactors
 - Reduce Microsoft energy costs
 - Federal & State Tax credits
 - Also explore adding new reactors to existing nuclear sites

Google and Amazon Data/Industrial/Nuclear Control

- Plans to develop startups with SMRs:
 - Savannah River Site (2009-2015)
 - Replace maintenance/repair costs of existing nukes
 - Data Center Needs Driven

Data Center Driven

- recent data center energy crisis driving huge growth potential for SMR players
- SMRs can provide economical decarbonized solution”

\$72.4 billion by 2033

NuScale SMR

- 76 ft tall (Westinghouse 81 ft)
- 15 ft in diameter (Westinghouse 12 ft)
- 77 -300 mw (Westinghouse 1100 MW)
- SMRs Factory built
- Located where needed
- Transported (along highways)
- Cost \$5.3 billion
- LEU (Low enriched fuel)
 - Simiar to conventional reactors
 - Some advanced SMR designs require up to 20% (HEU)
 - Weapons Grade = 90%

Coolant

- SMRs may use water, [liquid metal](#), [gas](#) and [molten salt](#) as coolants. [\[31\]](#)[\[32\]](#)
- Expands the number of sites where a SMR could be built, including **remote areas**

MIT Conclusions

- Delays and cost hikes.
- Years before built quickly and efficiently.
- NuScale
 - U.S. Government [final approval](#) for its reactor design
 - first to reach this stage
 - Kairos Power + Resolution
 - GE Hitachi Nuclear Energy

Nuclear Waste:Proceedings of the National Academy of Sciences (NAS)

- SMRS WILL EXACERBATE CHALLENGE OF HIGHLY RADIOACTIVE NUCLEAR WASTE
 - generate more radioactive waste than conventional nuclear power plants
 - increase need of management and disposal of waste by factors of 2 to 30

NAS Conclusions

- SMRs inferior to conventional reactors with respect to radioactive waste generation, management requirements, and disposal options.
- The research team estimate:
 - radiotoxicity of plutonium in spent fuels discharged from SMRs
 - = 10,000 years
 - waste at least 50 percent higher than the plutonium in conventional spent fuel per unit energy extracted.

-

Proliferation Planning: planning study on international collaboration-- Advanced Nuclear Technology Development Project

Korea and U.S.

- Focus: development of future nuclear energy systems
- **Goals:** broaden cooperation between advanced countries for acquisition of the advanced technologies
- Export domestic nuclear energy systems to **developing countries**
 - **1970s International Technology Transfer**
 - **Third World Countries**

SMR Critics

- many more^[2] small nuclear reactors pose a higher risk, requiring more **transportation** of nuclear fuel to factories
- increasing production of radioactive waste.^[24]
- require new designs with new technology,
- Safety yet to be proven.

Thresholds

- Known PELs: NRC recommends 100 mrem/year of
- High Level radiation
 - Computer generated models
- Excess of 100 mrem likely to cause:
 - Cell death
 - Genetic mutations
 - Cancers
 - Leukemia
 - Birth defects

Unknown PELs: Low Level radiation

DEFENSE NUCLEAR FACILITIES

SAFETY BOARD

Washington, DC 20004-2901

November 2, 2021

- The Honorable Jennifer Granholm
- Secretary of Energy
- US Department of Energy
- Dear Secretary Granholm:
- The Defense Nuclear Facilities Safety Board (Board) considered your office's
- February 25, 2021, response and the briefing your staff provided on April 28, 2021, regarding
- Recommendation 2012-1, *Savannah River Site Building 235-F Safety*. The Board is encouraged
- by the progress made toward improving the safety posture at Building 235-F, including removal
- of combustibles, ignition sources, and some material-at-risk. However, the Building 235-F
- safety basis still contains deficiencies that make it inconsistent with Department of Energy
- (DOE) standards.

On Feb 11, 2025, at
8:22 AM, James.Tanner@srs.gov wrote

- Good morning Rose,
-
- The most recent presentation solely dedicated to 235-F is [this one from November 2021](#). That said, updates to the deactivation project have been embedded into other presentations and the manager's updates at each meeting. Progress on the work is continuing and the state and EPA have both expressed (verbal) support for the deactivation and decommissioning work on 235-F.
-
- Thank you,
- James
-
-

COMPLETION DATE

- Hi Rose, It's currently set to be completed FY30.
-
-
- 18 YEARS AFTER CITATION

Clean?

- Nuclear industry:
- NO CARBON FOOTPRINT BUT USING THE BROAD DEFINITION OF CLEAN.....
- SEE ALL OF THE ABOVE and
 - 400,000 tons SNF
 - 10,500+ per year

Early Suggested Resolutions for U.S. Waste (AEC)

- Shoot into space toward sun (space trash)
- Bury under Ice Cap (**Cold War Missile Site**)
- Bury under sea floor (**tectonic upheaval along fault lines**)
 - Earthquakes and tsunamis
- Gulf of Mexico
 - Dump ½ **way between Mexican & U.S. shores**
 - U.S. State Department objections

1946-1970, Pacific Ocean Dump Site,

27 miles off San Francisco

Hunters Point Naval Radiological Defense Laboratory
Contractor Fraud (cost cutting)

47,500 barrels of nuclear waste

Radioactivity in fish, 90-5,000 times over
“allowable”

1974, Farallon Islands National Maritime Preserve

1974, Farallon Islands National Maritime Preserve



1956

- National Academy of Sciences (NAS) Report
- Recommended repository:
 - Deep Geological Repository
 - Suggested salt deposits and other rock types be investigated for permanent repositories
 - Research in ancient salt domes and beds

WHERE THE BUFFALO ROAM



Under The Kansas Prairie, 1970-1972

AEC & Morton/Carey Salt Mines

- Hutchinson
- Lyons
 - Laced till fatal to humans
 - STATE'S RIGHTS VS FEDERAL GOVT
 - Aquifers (Senator Dole, Cary CEO, KS Gov)
 - Swallow & carry away thousands of gallons to unknown destinations.
 - President Dwight D. Eisenhower

OLD CAREY MINE CAP



Recent Resolutions?

- International Atomic Energy Agency (IAEA) : SNF
- dose rate 10 years after removal from reactor = 10,000 rem/hour vs PEL 100 mrems /year
- 400,000 metric tons globally + 10,500/year
- U.S. = 90,000 metric tons + 2 tons/year
- SRS = <> 30 tons
- Hanford = 34 tons

Country	Current Operating Capacity (GW)
US United States	102
FR France	64
CN China	58
RU Russia	29
KR South Korea	27
CA Canada	15
UA Ukraine	14
IN India	8
GB United Kingdom	7
TR Türkiye	0
Global total	396

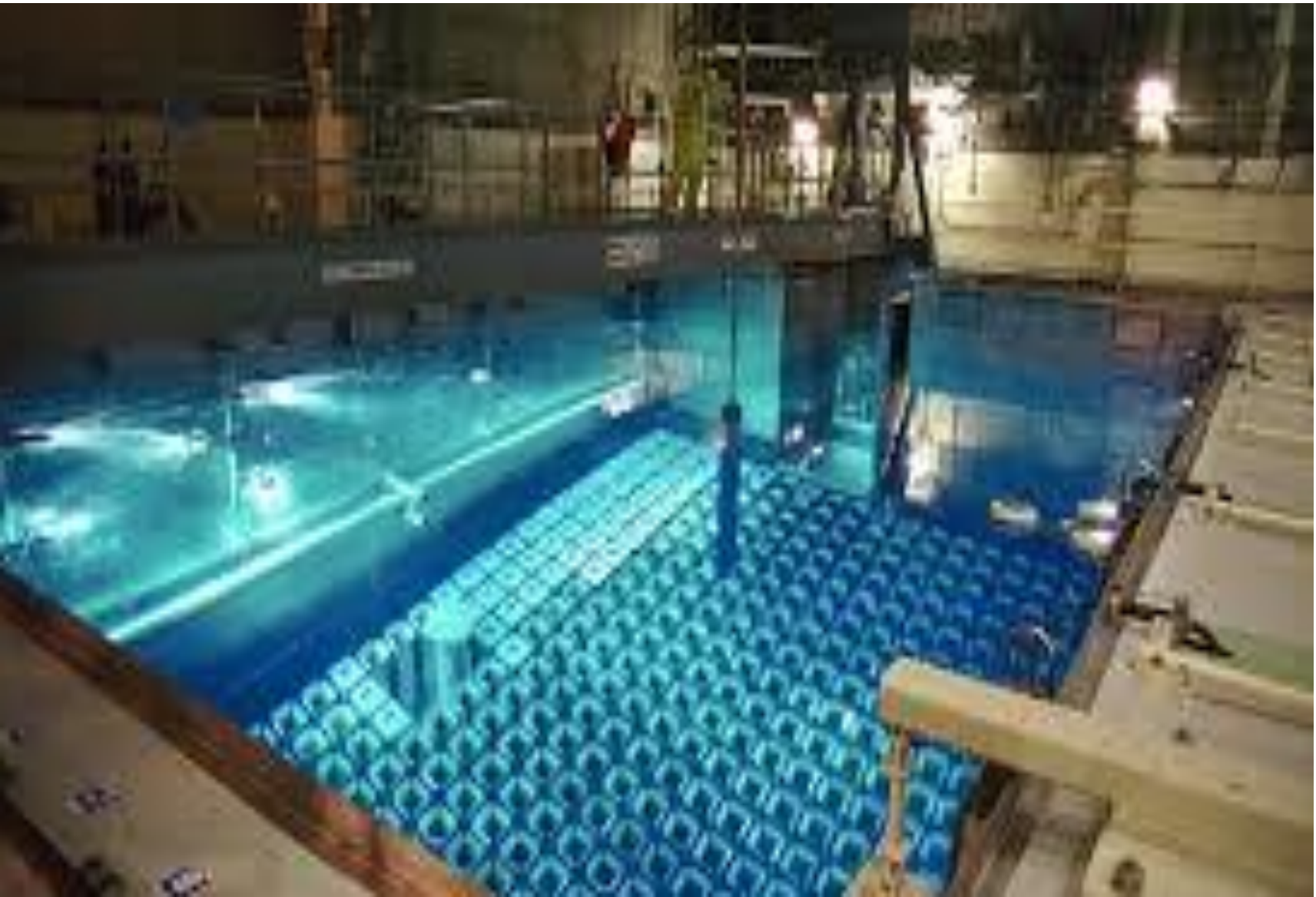
Considering plants

- in construction
- pre-construction
- have been announced

-- global nuclear capacity = **695 GW.**

Jump of 75%

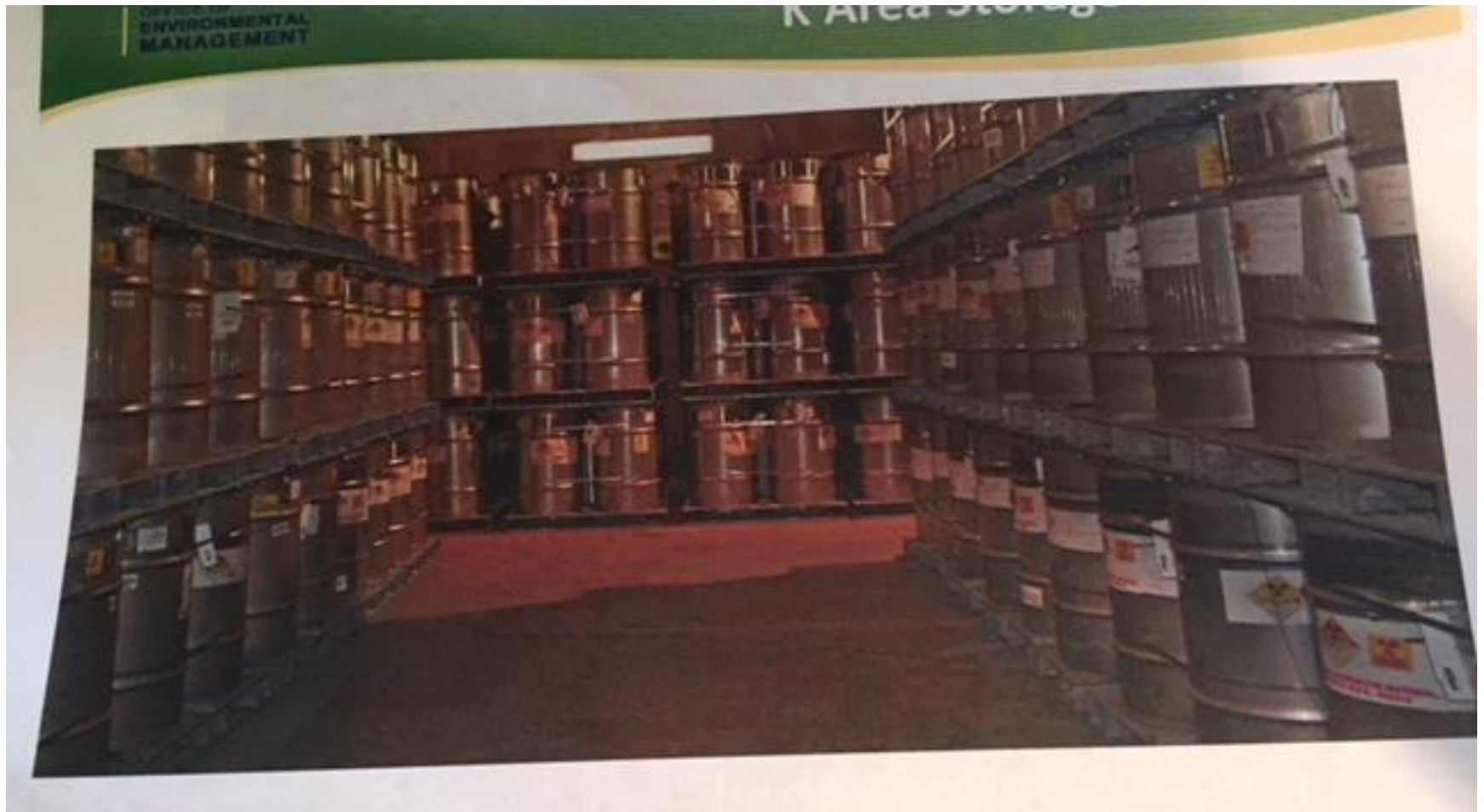
SNF Assemblies in Cooling Pool



DRY CASK SYSTEM



K Area in 2009



Are these resolutions?

- Deep Geologic Repository (2048)
- Government Managed Interim Storage
- Reprocess SNF (Mixed oxide fuel MOX)
- SMRs
- Non-governmental management

Interim Storage

- 2025
- NRC licensed 2 private “Consolidated Interim Storage Facilities” (TX & NM)
 - DOE – design, construct, operate
 - DOT – package & carriage
 - DOI – collaborate with DOE on earth science issues & may withdraw public lands for limited use by DOE in support of radioactive waste disposal actions.

STANFORD UNIVERSITY

- Dec 10, 2018
- Study: U.S. reset nuclear waste program
- Move responsibility for commercially generated used nuclear fuel away from federal government
- Move to independent, nonprofit, utility-owned and –funded nuclear waste management organization.

PEW Research Center

- Surveys show 56% adults favor new nuclear plants
 - Narrow Definition: Safe, Cheap and Clean
 - No Carbon Footprint
- Unaware of Broad Definition:
 - Amount & Dangers of SNF

- Future Energy Requirements
- Clean???

DATA CENTER FUNCTION

- Brains of the Internet—
 - process, store, and communicate all data behind social media & scientific computing.

Servers

- provide logic to respond to information requests
- perform computations
- store data and files

Network devices

- enable the incoming and outgoing flows of data
- connecting the entire data center to the internet.

IT Devices

- No Carbon footprint
 - Use electricity
 - Processing = heat
 - Heat removed by cooling equipment
 - Cooling equipment consumes energy
 - (energy consumption black holes)

Data Center Requirements

Estimates:

Data centers account for

-3.5% of US electricity consumption today,

-2027= 5.5%

AIKEN POWER DRAIN

- Meta data centers= 22 in U.S.
- Meta's data center in Aiken County =
- Meta owner/Operator (Mark Zuckerberg)
 - Facebook, Instagram, Threads, WhatsApp
 - 16 acres
 - will require 200 megawatts of electricity
- -"To be powered by 100% renewable energy".
 - ?????? hydro, wind, solar????

Small Nuclear Reactors (SMRs)

- Back End Costs:
 - Stanford & University of British Columbia:
 - SMRs will produce higher levels of waste radiotoxicity
 - (up to >50%)
 - SMRs will Increase volume of nuclear waste
 - Cost of conventional unit = tens of billions
 - Cost of factory built SMR = \$5.3
 - 1100 mw vs 300

Stanford Conclusions

- “The study concludes that, overall, small modular designs are inferior to conventional reactors with respect to radioactive waste generation, management requirements, and disposal options.

Carbon Free Experiments:

- **NRC to Issue Construction Permit for Kairos Hermes Test Reactor**
- Build a 35-megawatt thermal reactor using molten salt.
 - TVA in Oak Ridge Tennessee
 - Nevada experiment, 2015
 - Kairos Hermes CURRENT STATUS
 - NON OPERATIVE

Kairos Experiment



Carbon Free SNF Solution?

- Beneficial

Does not eliminate 400,000 tons of spent nuclear fuel + 10,500 per year

- Need R & D for another solution
 - a process that changes radioactive substances into less toxic ones
 - 2015- NEVADA TEST SITE

Solution:Transmutation

- In nature, radioactive elements emit their energy and gradually transition from one element to another of lower energy.
- Eventually, radioactivity ceases as elements transition to stable states, like lead.

Transmutation

- 1970s.
 - House & Senate bills funding study of **transmutation technology.**
 - Lower volume of radioactive waste
 - Lower energy in remaining waste
 - Shorter half life of remaining waste
 - Simplified storage issues

U.S. Transmutation R&D

- NRC discontinued transmutation R&D after NAS recommended deep geologic repository (NWPA 1982).
 - 1982 Nuclear Waste Policy Act recommending two sites
 - 1985 amendment = Yuca Mt. (“Screw Nevada” bill)
- Transmutation R&D dropped as “costing too much & taking too long”

Deep Geologic Repository (Yuca Mountain failed)

- \$\$\$\$\$\$\$\$\$\$ storage costs, court awards, clean ups, Yuca Mtn failure

NO REPOSITORY

**NO CURRENT TECHNOLOGY CAN NEUTRALIZE OR ELIMINATE
NUCLEAR WASTE**

Planning for repository delayed to 2048

EUROPE'S MYRRHA

- **Transmutation:**
 - greatly reduce amount and radiotoxicity of high-level radioactive waste.
 - decreased necessary storage time from several hundred thousand years to less than 1000
 - Demonstration of the accelerator-driven system (ADS)
 - concept will enable the **European** Atomic Energy Community (EURATOM) to evaluate the viability of the **transmutation** approach.
- Will not process nuclear waste on an industrial scale,

Partitioning & Transmutation

- Potential complimentary route to SNF storage
- 2001 IAEA
 - Report analyzing current state of P&T& potential options

2003: Report finalized

advanced fuel cycles incorporating partitioning of actinides along with minor actinides and their subsequent transmutation (P and T) in a fast neutron energy spectrum could be proliferation resistant and at the same time reduce the waste radiotoxicity by many orders of magnitude.

International Atomic Energy Agency has initiated many collaborative research programs in this area as part of