Nuclear Plant Decommissioning Challenges and Opportunities

OR:

How to spend a health physics career transitioning from operations through decommissioning

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Disclaimer: all the opinions expressed are mine and do not reflect any views of the HPS, SCE, BHI or anyone else.

If it sounds sarcastic, don't take it seriously. If it sounds dangerous, do not try this at home or at all. And if it offends you, just don't listen to it.
Dexter Holland, the Offspring © 1997

Outline

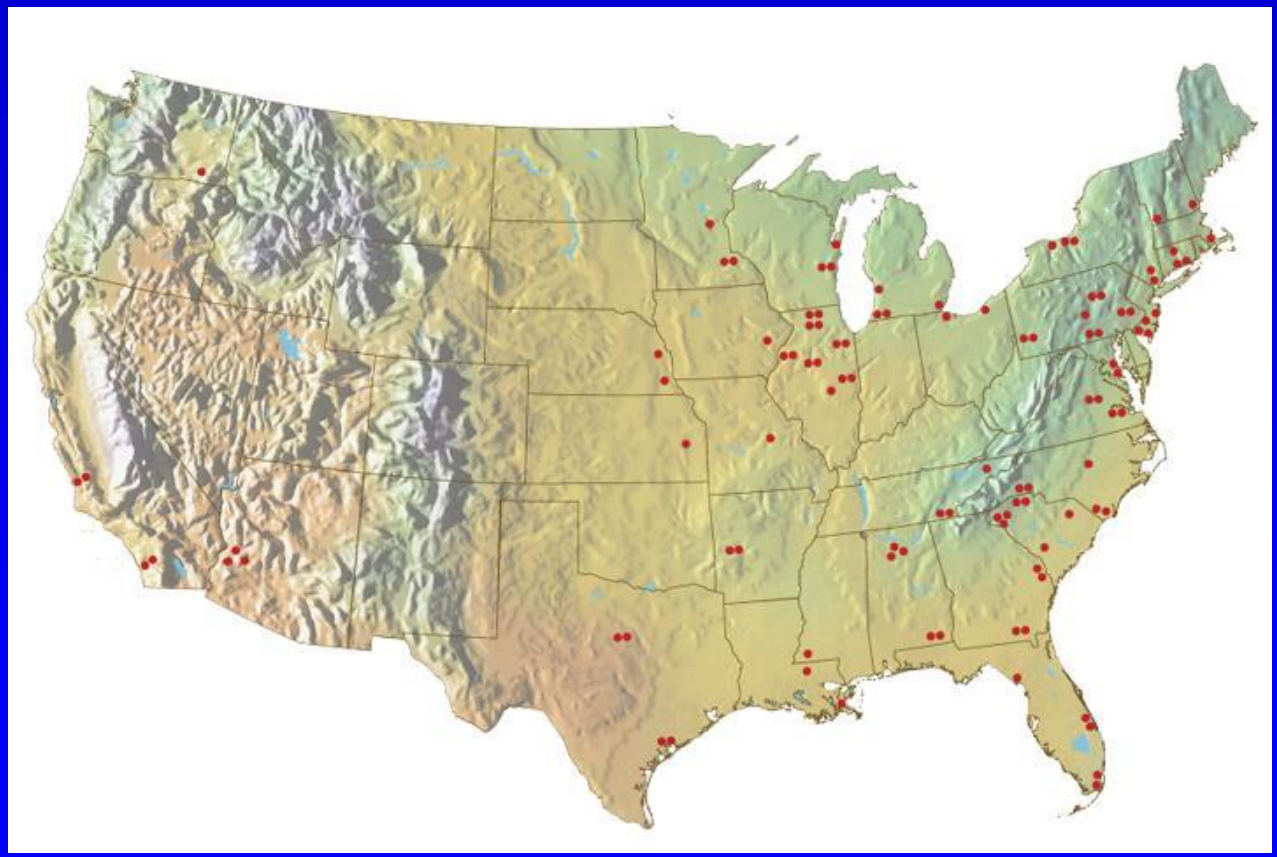
- Commercial Nuclear Power Operations
- Decommissioning
- Dismantlement
- Site Restoration
- License Termination & Final Status Survey
- Storage of Used Nuclear Fuel
- Health Physics Society

Commercial Nuclear Power

No Free Lunch

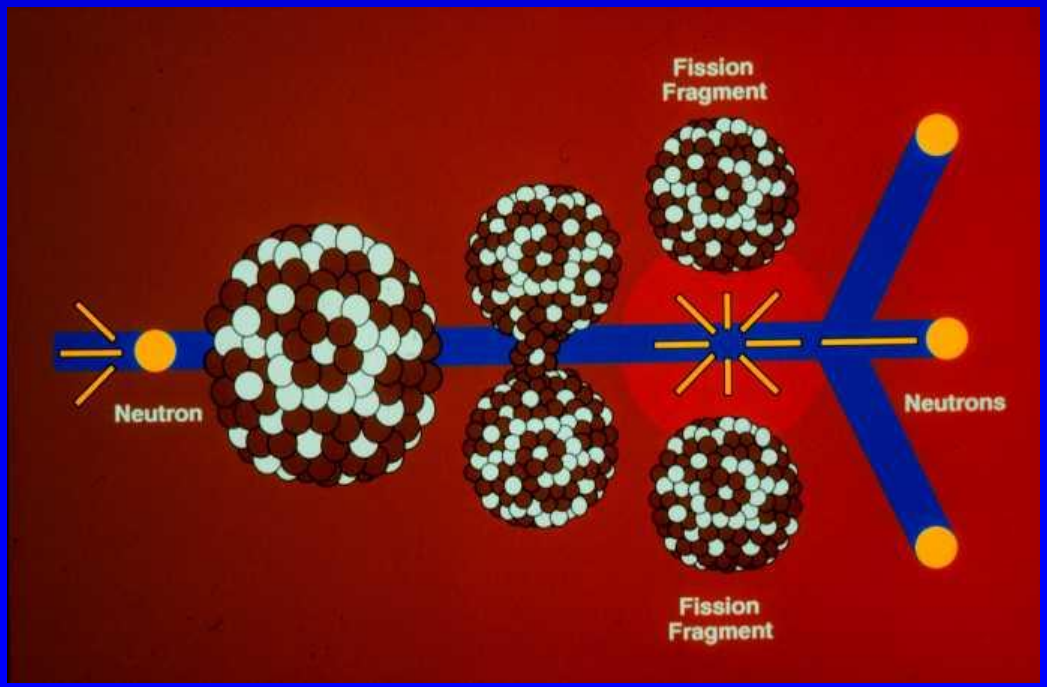
- Every form of electricity generation has pros and cons:
  - Wind – raptor kills, construction, noise, visual, intermittent generation
  - Solar PV – hazardous materials, intermittent generation
  - Hydroelectric – environment, siting
  - Coal – CO_2 generation, particulates, mercury, mining
  - Natural Gas – volatile pricing, hydrofracturing production, CO_2 generation
  - Nuclear – accident scenarios, waste disposal or reprocessing
  - Conservation – is this realistic? Global issues

Almost 100 Operating Nuclear Power Reactors

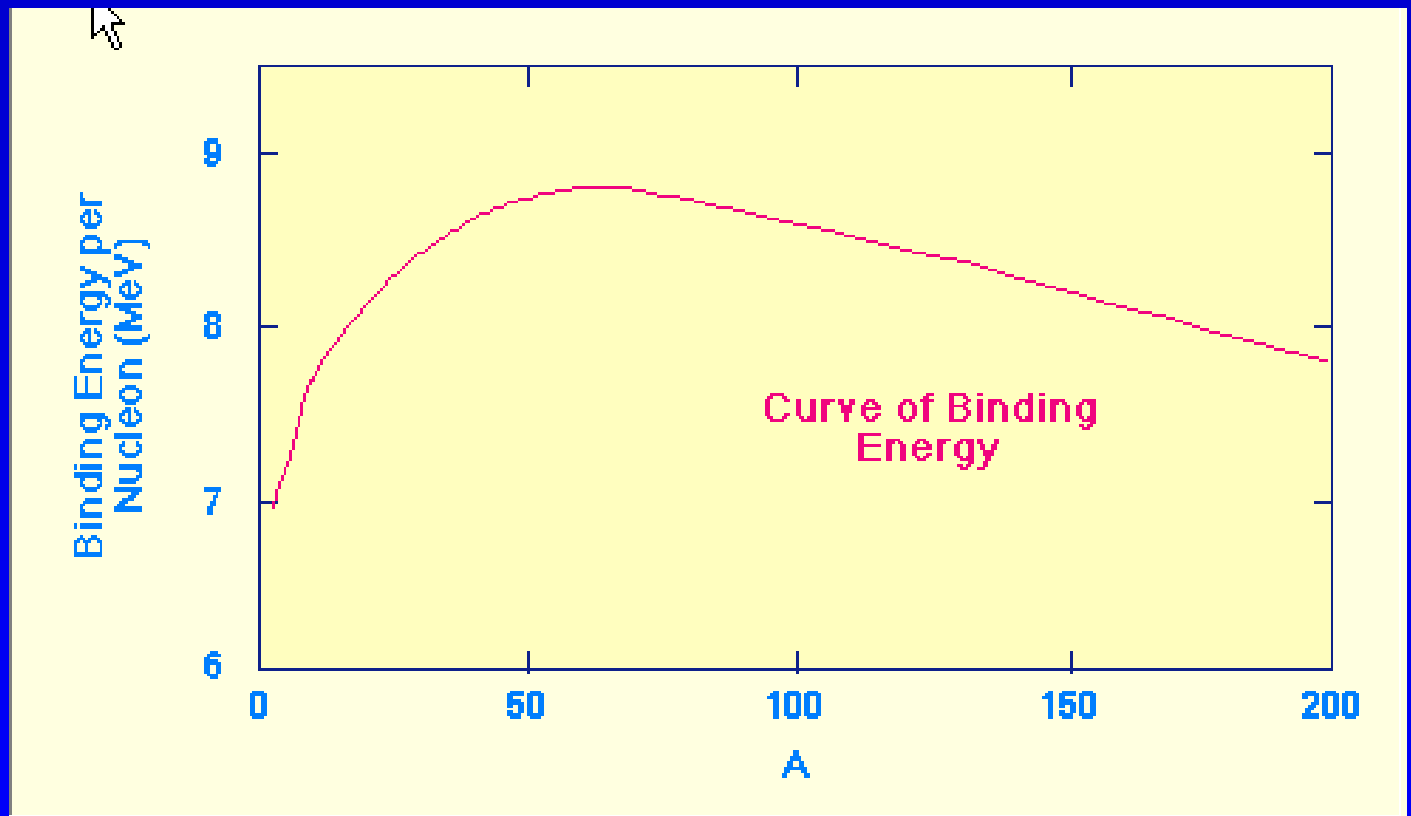


How does a Nuclear Power Plant work?
Fission Process

- Uranium 235
- Atoms split into two or more fission fragments generating heat and additional neutrons.
- Not capable of exploding



Nuclear Engineering



Curve of binding energy.

Fuel Equivalents

17,000 ft^3 of natural gas

1 ton of coal, 2000 lbs

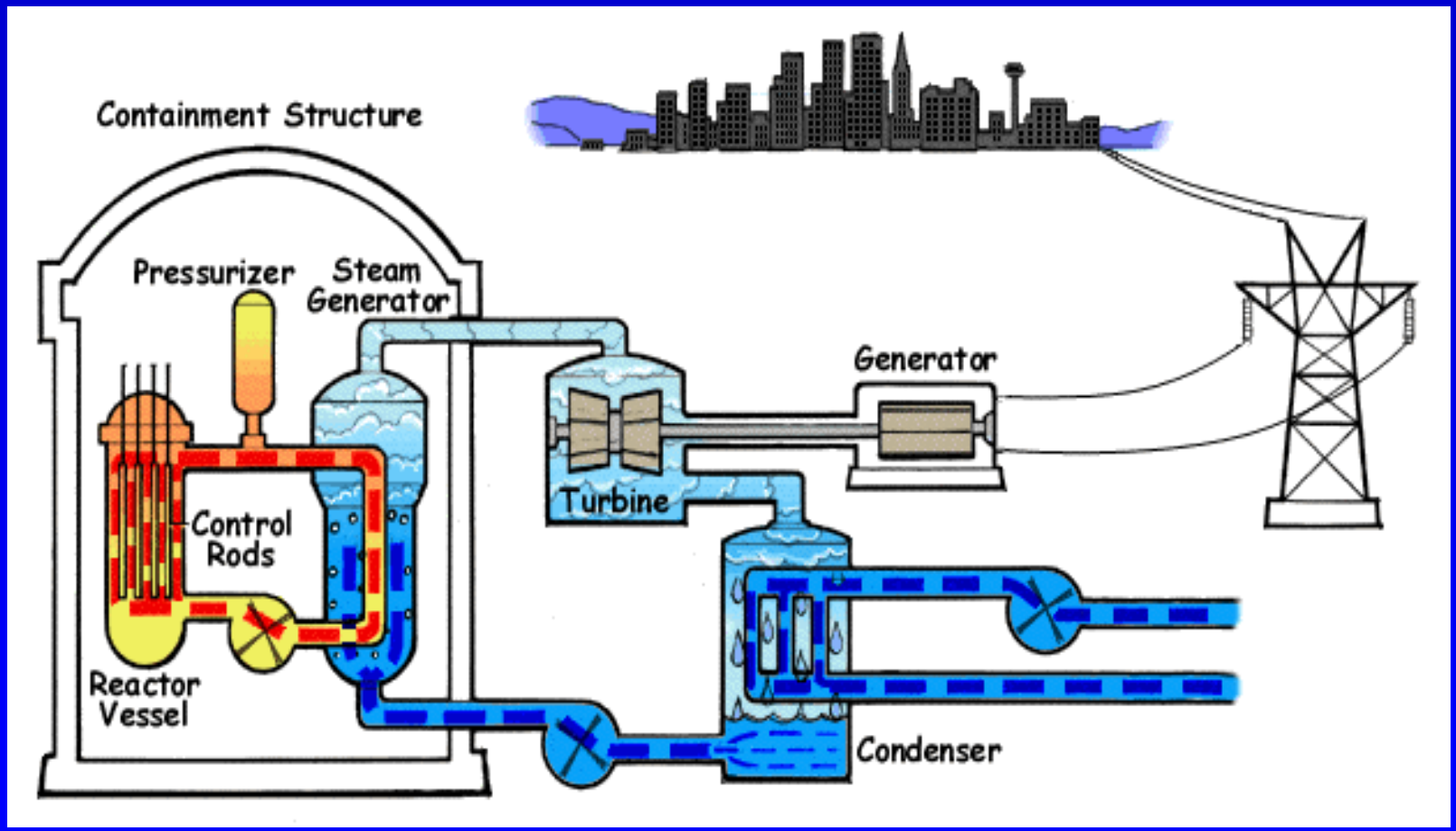
1 Uranium fuel pellet

5000 lbs of wood

3 barrels of oil, 126 gallons

Source: www.cleanenergy4america.org

How the plant works



Decommissioning

- What does it mean?
  - Remove radioactive material or decontaminate
  - Terminate license
- What does this entail?
  - New and revised RP programs
  - Materials and equipment release for unrestricted use, or for radwaste disposal

Decommissioning Process

- Post-Shutdown Decommissioning Activities Report
  - Plans, schedule, finances, end-state, etc.
- Demolition & Dismantlement
- License Termination Plan (Decommissioning Plan for Mat'ls Licensees)
  - Two years before forecast license termination
  - Site Characterization
  - Remaining dismantlement
  - Site remediation
  - End-state of site
  - Final costs
  - Environmental Report supplement
- Final Status Survey (MARSSIM)

Major tasks during decommissioning

Year	Major Activities	Total Personnel with Measurable Doses	Collective Dose (person-rem)	Average Measurable Dose (rem)
1999	Prep and ship spent resin, some RCS component removal, decon containment and cavity	241	15.863	0.07
2000	RCS Severance, RVI preps, remove systems and interferences	416	71.214	0.17
2001	Large Component Removal Preps, RVI Segmentation Preps	338	57.785	0.17
2002	LCR, Reactor Vessel Segmentation, Turbine and Safety Equipment Building Demolition	308	61.214	0.20
2003	Fuel transfer, containment systems removal, Turbine and Safety Equipment Building Demolition	226	35.596	0.16
2004	Fuel transfer, Containment Building Demolition Preps	169	14.899	0.09
2005	Radwaste system and spent fuel removal	198	20.624	0.10
2006	Spent fuel pool liner removal, Containment Building Demolition	183	22.490	0.12
2007	Site Restoration. No major RP activities	20	0.417	0.02
2008	Site Restoration. No major RP activities	2	0.043	0.02
2009	Site Restoration. No major RP activities	0	0.000	---
			300.145 person-rem	

Reactor Vessel Internals Segmentation

Large Component Removal

Large Component Lifts

Heavy Haul Shipments for Disposal

Burial at Energy Solutions Clive Facility

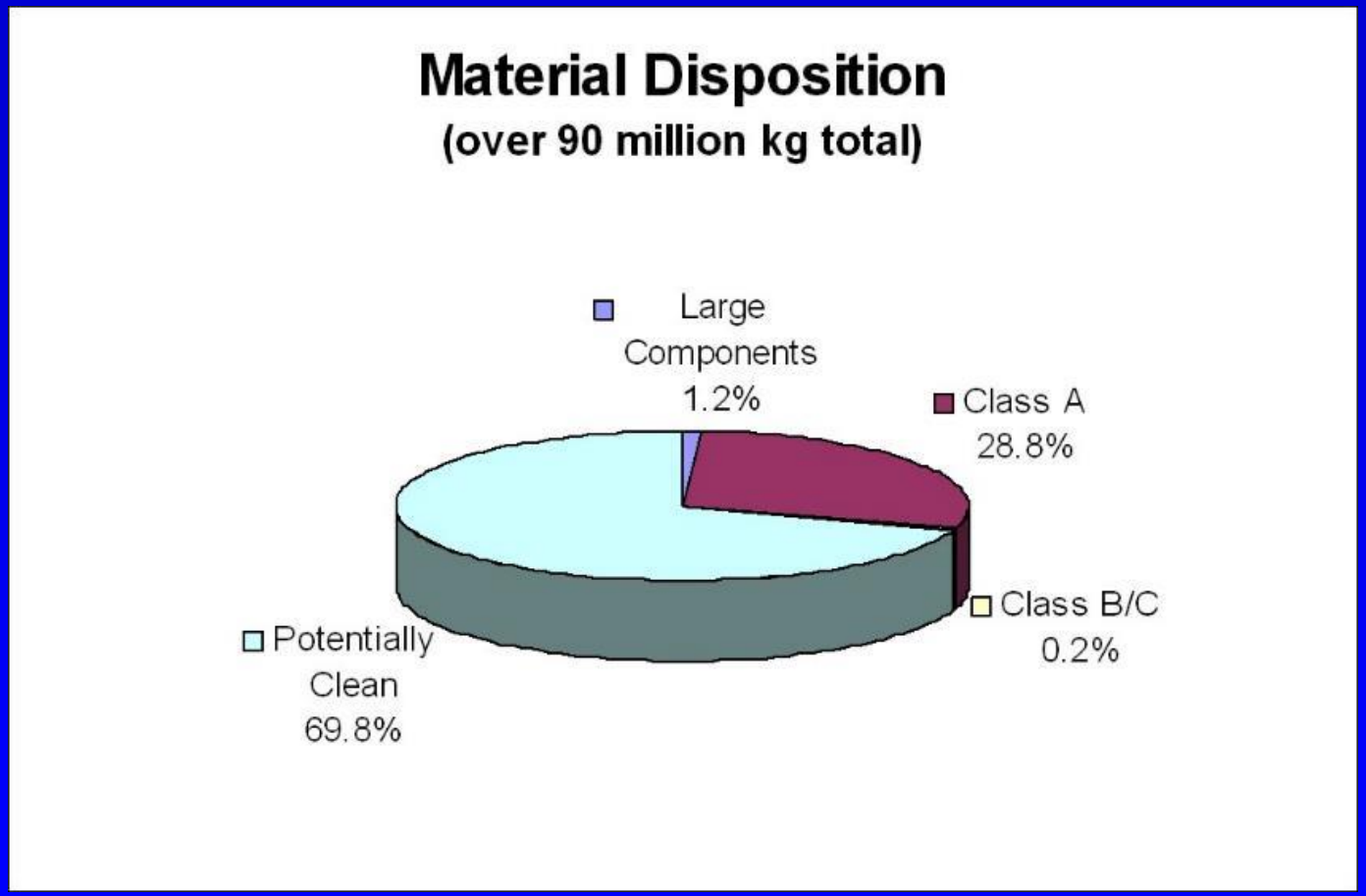
Unit 1 RPV

Building Demolition

Maine Yankee Containment Demolition

- https://www.youtube.com/watch?v=6kToZfbKbd4

Materials Disposition



Materials Management

- Airborne contamination without confinement, controls
- Very large quantities of barely detectable contamination
- Surveys for release

Excavations for foundations

Time after shutdown implications

- What does this mean?
  - Aged unit high on activation products
  - Aged unit high on fission products
  - Note that beta decay intensity may be important
    - i.e. Cs-137 (95%), Cs-134 (70%), Co-58 (15%)
- Really old facility
  - Alpha contribution builds in due to decay rates of beta-gamma emitters
- During decommissioning
  - Instrument selection for Final Status Survey

MARSSIM – EPA, NRC, DOE, DOD

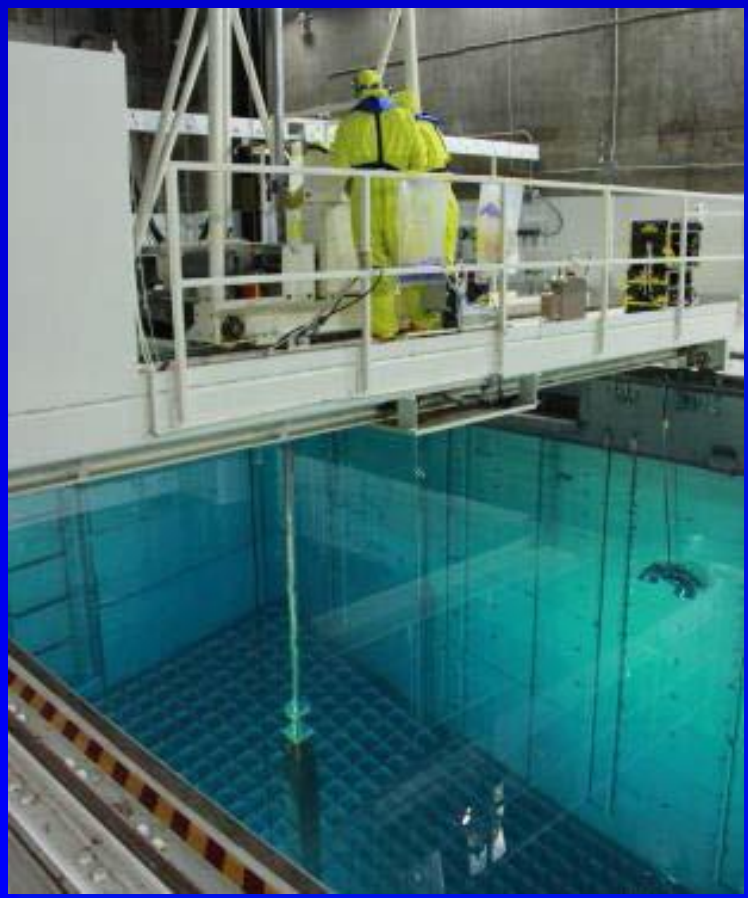
- Multi-Agency Radiation Survey and Site Investigation Manual
- Statistical approach to demonstrating that a site/area has been sufficiently decontaminated to meet Derived Concentration Guideline Levels or the equivalent of the license termination criterion
- Very rigorous process
- Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)
- Surveys for license termination – after remediation
  - Planning – area classification, Final Status Survey design, MDCs
  - Conducting – instrumentation requirements, samples
  - Evaluating – review DQOs, statistical tests, elevated measurements
  - Documenting – did survey unit demonstrate compliance with regulations?

And then there's the "regulatory gap"

- Surface Contamination Guidance
  - 5000 dpm/100 cm^2 total
- License Termination Criterion
  - 25 mrem per year
  - 10,000 – 20,000 dpm/100 cm^2 (based on radionuclide mix)
    - Residual radioactivity left behind
    - What to do with rad material and no license?

Spent Fuel Pools

- Enclosed, steel-lined concrete pools are filled with water
- Fuel assemblies are submerged with 23 feet of water above top
- Pool water is recirculated to ensure cooling, remove residual heat and provide radiation protection
- Designed to withstand seismic and other external events



Dry Cask Storage

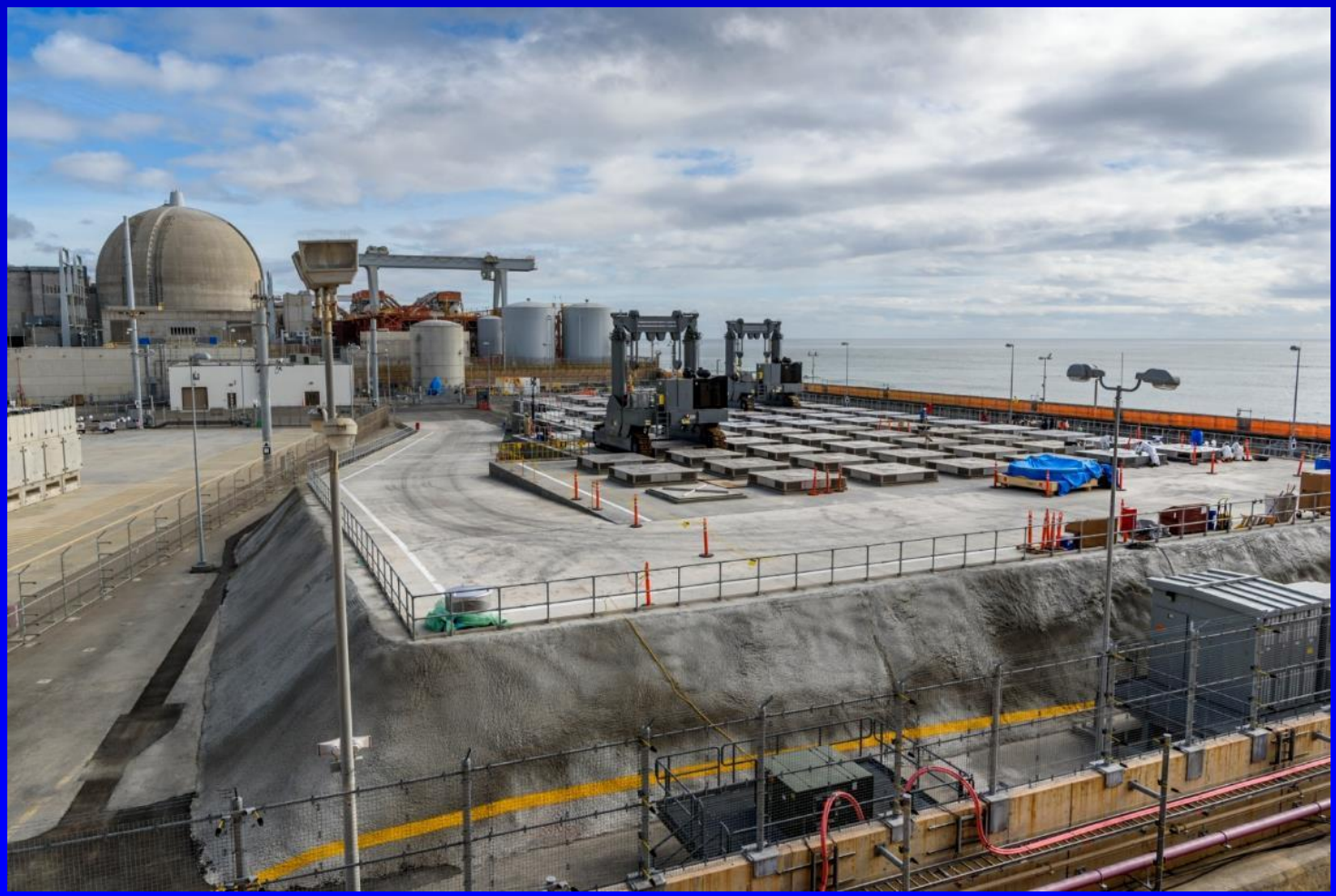
- Used nuclear fuel sealed in airtight stainless steel canisters
- Used nuclear fuel can be transferred from spent fuel pools to dry cask storage after it has cooled in a pool for approximately 5 to 7 years
- Designed to withstand natural phenomena including floods, projectiles from a tornado, temperature extremes, seismic events and lightning strikes
- Certified by the NRC as meeting strict design and performance specifications

NUHOMS Horizontal Storage Design

NUHOMS Dry Cask Storage Pad

Holtec Above Ground Vertical Storage Pad

Holtec Below Ground Vertical Cask Storage Pad



Dry cask loading

Holtec Vertical Cask Transporter

Spent Fuel Shipment for Offsite Disposal/Storage

- In 2006, The National Research Council's Committee on Transportation of Radioactive Waste found:
  - There is no fundamental technical barrier to the safe transport of spent fuel in the U.S.
  - U.S. regulations are adequate to ensure package containment effectiveness over a wide range of transport conditions
  - The accident fatality risk associated with spent fuel shipments is more than three orders of magnitude less than for some other common hazardous materials
  - https://www.youtube.com/watch?v=Bu1YFshFuI4
  - https://www.youtube.com/watch?v=U1nvRBk4W3o

From this

To this

HPS Specialists in Radiation Protection

Health Physics Society

What can it do for you?

And what can you do for it?

Health Physics Society Strategic Plan

HPS is a professional organization whose mission is excellence in the science and practice of radiation safety. HPS activities include encouraging research in radiation science, developing standards, and disseminating radiation safety information. HPS members are involved in understanding, evaluating, and controlling the potential risks from radiation relative to the benefits.

HPS is the largest radiation protection society in the world with members in many countries and has established numerous chapters in the United States, chapters in non-U.S. countries, student branches, and technical sections.

Our Mission

Excellence in the science and practice of radiation safety

Our Strategies

The strategies we employ to accomplish our mission are simple:

Promote the science and sound practice of radiation safety
Advance member careers
Ensure HPS as the trusted source of expertise in radiation safety

Our Core Services

- For more than 60 years HPS has served its members, the public, and the radiation protection profession. HPS currently serves these stakeholders through the following core activities:

- Advocate for radiation safety and scientifically sound information
- Provide radiation safety information to the public and government
- Support academic programs and students
- Provide continuing education for radiation safety professionals
- Publish *Health Physics/Operational Radiation Safety*
- Publish *Health Physics News* and HPS.org
- Publish HPS standards, positions, and position papers
- Collaborate with international radiation safety organizations
- Host technical meetings, workshops and networking opportunities

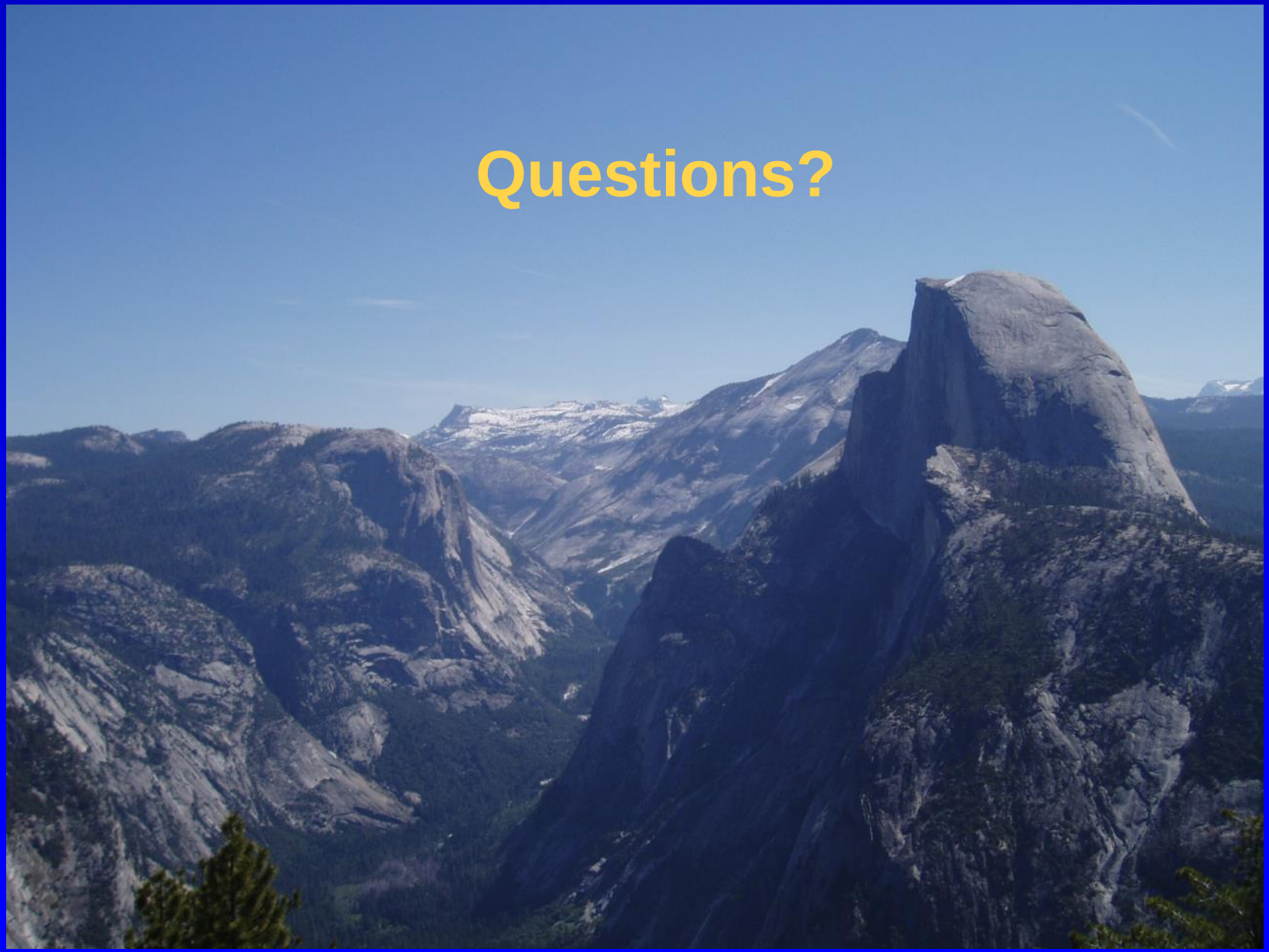
- The core activities of the HPS serve our stakeholders well, but we know that stakeholders' needs are dynamic. The HPS Board of Directors (Board) developed a vision for HPS to remain relevant to its members, the public, and the radiation protection profession.

- **Our Vision**
- *HPS will be the home for radiation safety specialists and the trusted source of radiation safety information that enables the safe use of radiation to improve people's lives.*

Membership Benefits:

- Operational Radiation Safety and Health Physics Journal and HP News
- Full library of previous publications
- Members directory
- Discounted registration fees and hotel reservations for HPS meetings
- Discounts on registration for Radiation Research meetings
- Discounts on NCRP publications, PDFs of older publications are free
- Free ANSI standards developed by HPS
- Discounted subscription available for Physics Today
- Membership in IRPA, access to newsletters of some international societies
- Access to past HPS meeting presentations
- HP Tool Box – online resources (calculators, impact assessment, etc.)
- Employment postings
- Chapter resources
- Specialized Sections such as Medical, Academic/Industrial/Research, Accelerator, ...
- HPS membership is a pre-req for Section membership, local Chapter President

- Dues: free for first year students, then $40. Reduced for early associate or member


Questions?