NAYGN

NORTH AMERICAN YOUNG GENERATION IN NUCLEAR

Preserving the Safety and Security at the Backend of the Fuel Cycle

Marcus Nichol

PD Committee Member

NAYGN

NORTH AMERICAN YOUNG GENERATION IN NUCLEAR

Used Nuclear Fuel Storage: Safety and Security

Mike McMahon
President and CEO
Transnuclear, Inc.

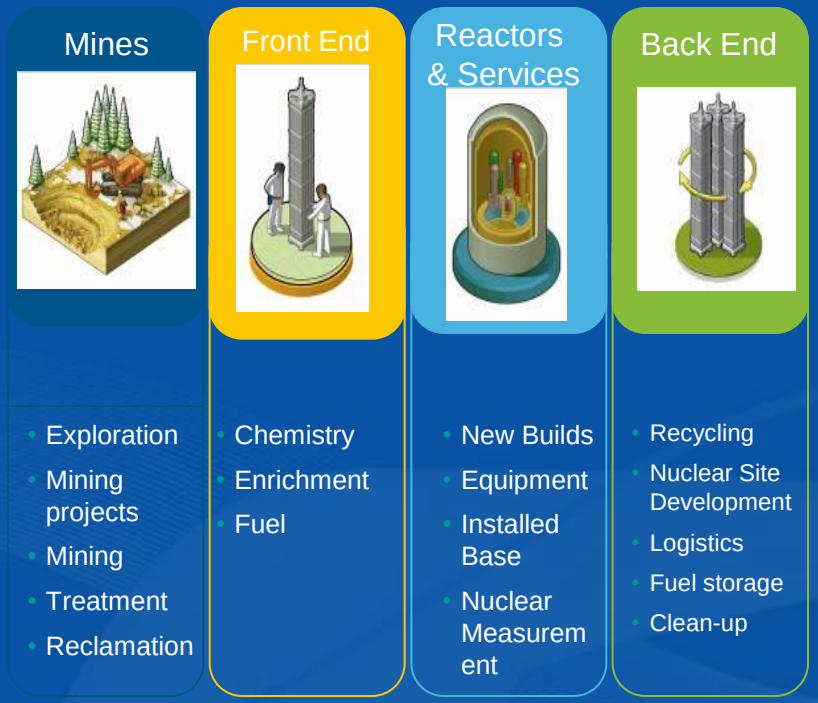
Outline

- Safety and Security of Current Dry Cask Storage Systems
- Safety and Security of Transportation
- Future Challenges
  - Centralized Interim Storage
  - Used Fuel Recycling

NAYGN

TRANSNUCLEAR
Legacy of Performance

- Established in 1965 to transport nuclear materials in the US
- Dry storage since 1985
- Acquired NUHOMS® in 1998
- The AREVA advantage…a global network of excellence!
  - Back End Division
  - Logistics Business Unit (BUL)



More than 820 Systems Loaded as of April 2013

NAYGN

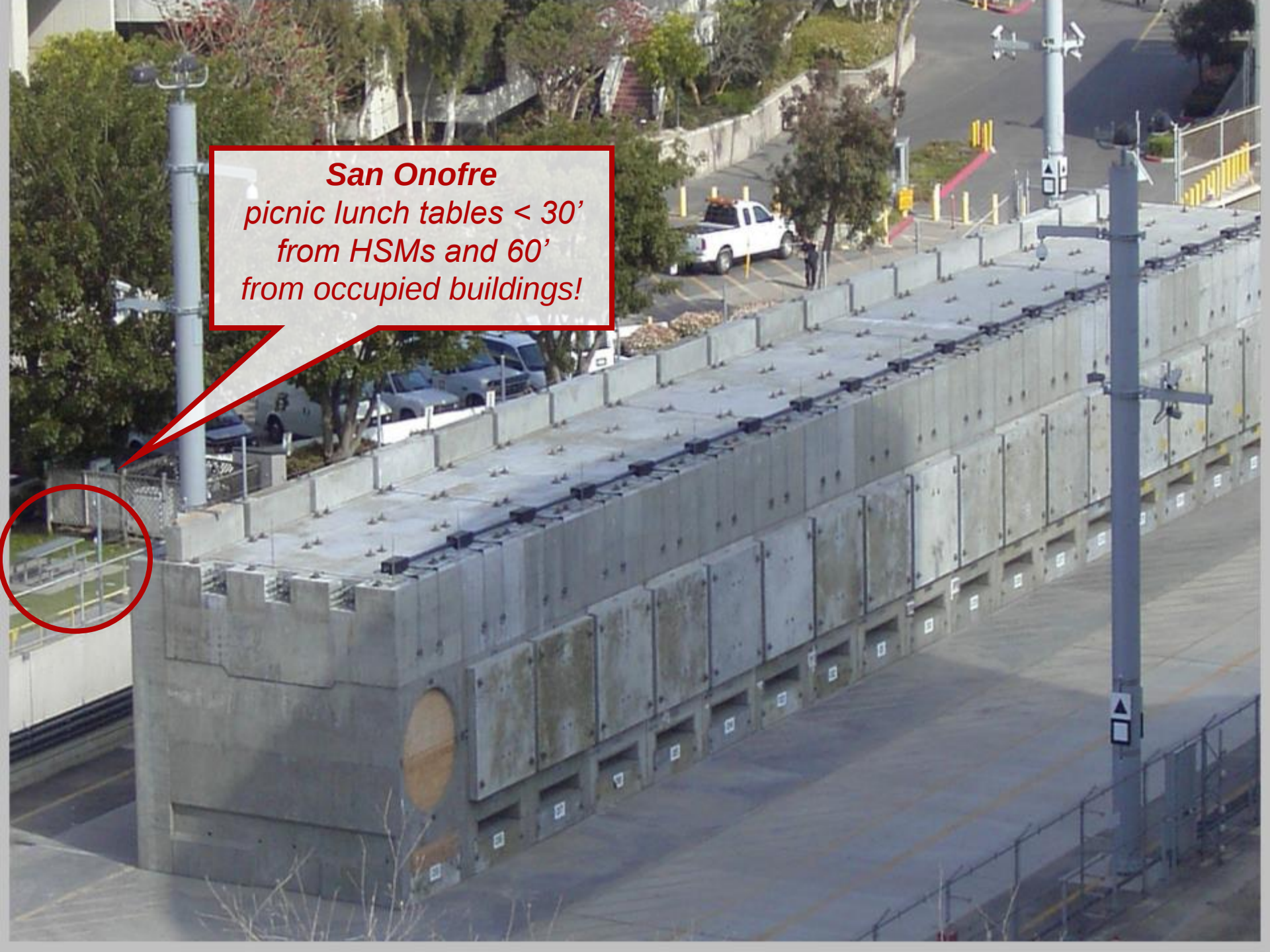
Safety and Security of Current Systems

- Safe to Public and Plant Personnel
- Proven Performance in Accidents
  - Earthquakes
  - Tornadoes
  - Tsunamis
- Aircraft Impact Testing
  - TN NOVA System

NAYGN

Dry Shielded Canister (DSC)

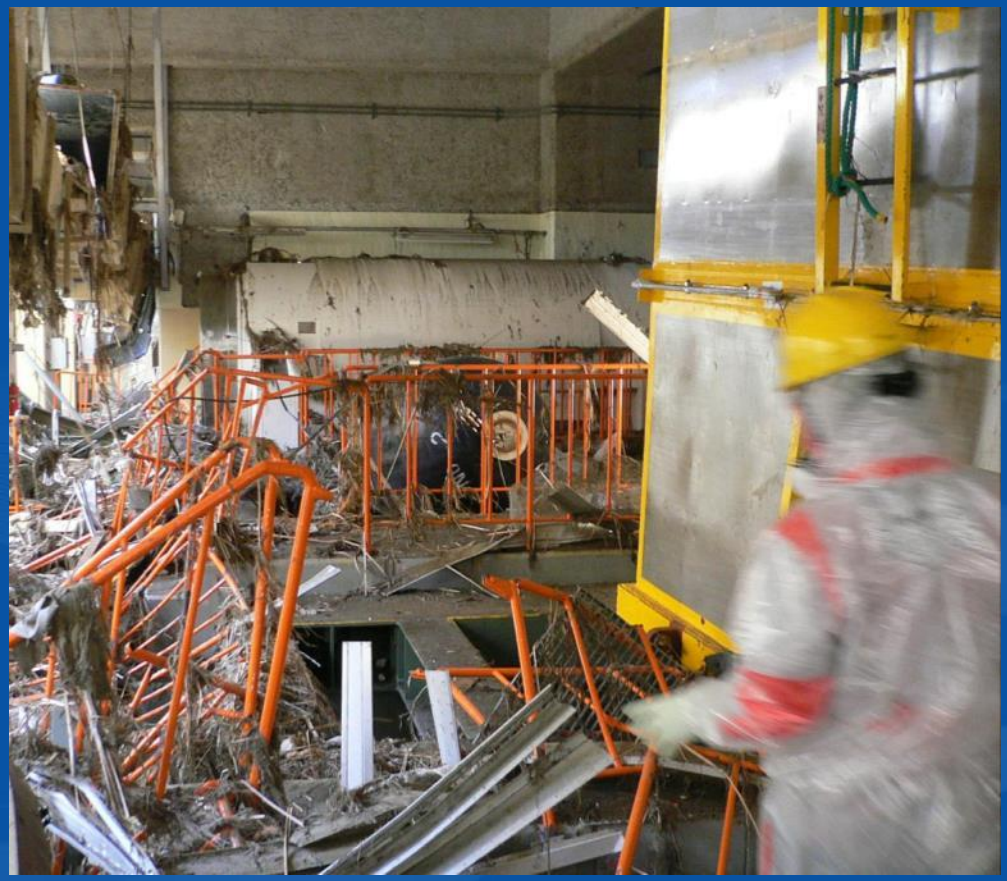
NAYGN


San Onofre
picnic lunch tables < 30’
from HSMs and 60’
from occupied buildings!

North Anna Earthquake

NAYGN

Fukushima Earthquake and Tsunami



NAYGN

Fukushima Earthquake and Tsunami

NAYGN

TN NOVA Aircraft Impact

NAYGN

AREVA Recycling Platforms in France

La Hague

- Used fuel treatment
  - Extraction of valuable materials
  - Ultimate waste conditioning

- RepU fuel fabrication

FBFC Romans

Tricastin
(conversion, enrichment

MELOX

- MOX fuel fabrication

NAYGN

Used Nuclear Fuel Transportation



- >200 transports of used fuel and vitrified, compacted waste each year
- Used fuel delivered to AREVA's La Hague
- Incorporate physical protection systems

NAYGN

Recycled MOX Fuel Transportation

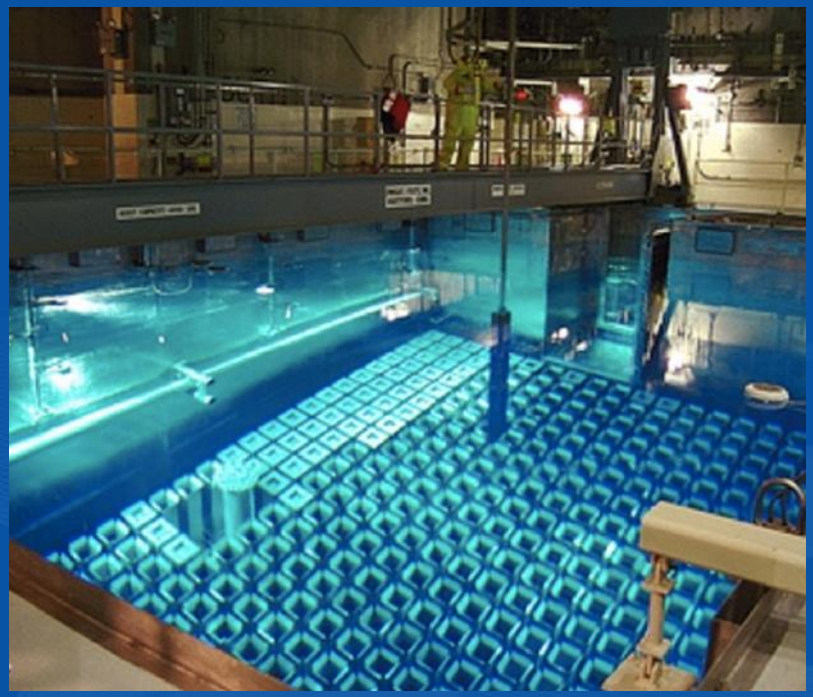


- >150 MOX fuel transports each year
- Fresh MOX assemblies transported from MELOX
- Transported in specially designed vehicles w/ physical protection systems

NAYGN

Centralized Interim Storage

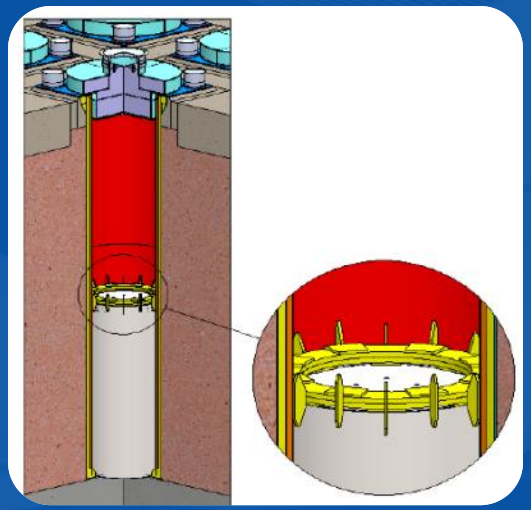
- Top Priorities:
  - Safety
  - Security
- Wet or Dry?
- Standard Package, or Current Designs?



NAYGN

Centralized Interim Storage

- Vertical or Horizontal?
- At grade, below, or above?
- Transportation?

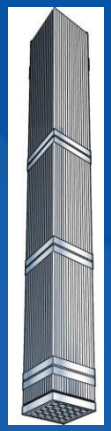


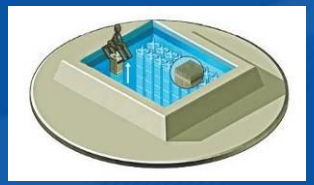
NAYGN

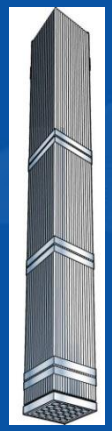
The Main Stages in Recycling

Used fuel

Unloading and Interim storage







Treatment operations
(shearing - dissolution - separation - purification)

Uranium

Plutonium

Fission products

Hulls and end-pieces

Universal Canister of vitrified waste **(UC-V)**

Universal canister of compacted waste **(UC-C)**

Interim storage

Recycled fuel

Transported back to the customer's country

A few years | *A few days* | *A few years*

At each stage, nuclear material is accounted for in accordance with EURATOM and IAEA safeguards

NAYGN

Types of Final (Repository-bound) Waste

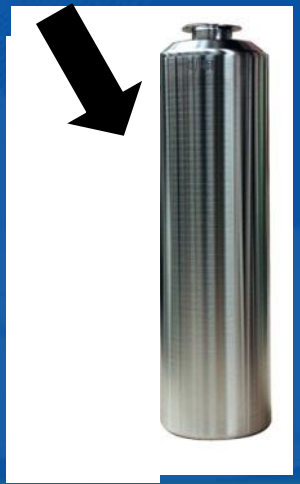
The non-reusable materials are conditioned into a stable and compact form suitable for simplified transport, storage and final disposal

- Encapsulation of Fission Products in a stable, homogeneous, and durable glass matrix with a long-term predictable behaviour


vitrification

- Compaction of structural pieces (hulls and end-pieces)


compaction



- Both the glass matrix and compacted waste are encased in a standard “Universal Canister”

Final (Repository-bound) Waste Interim Storage: French Example

The vitrified waste canisters corresponding to 40 years of French nuclear electricity production lined up side by side would occupy only one soccer field

One of the three interim storage units on the site for vitrified canisters : EEVSE

NAYGN

Summary & Conclusions

- Current storage systems are robust with demonstrated excellent performance against natural and man-made hazards
- Future challenges include
  - Effects of very long storage times (~300 years)
  - Concentration of large amounts of UNF in a single location
  - Transortation of large quantities of UNF (~3000 MTU/year)

NAYGN

Your Generation Holds the Answer to These Challenges!

NAYGN

Questions?

NAYGN

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Preserving the Safety and Security at the Backend of the Fuel Cycle

Mark Lombard
Director, Division of Spent Fuel Storage and Transportation
Office of Nuclear Materials Safety and Safeguards
U.S. Nuclear Regulatory Commission

North America Young Generation Nuclear Conference
May 12, 2013

Overview

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- NRC Mission and Role
- SFST Role
- Waste Confidence
- National High Level Waste Strategy
- Interim Storage Facility
- Licensing Program Improvements
- Preview of Coming Attractions

NRC Mission

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

To license and regulate the nation's civilian use of byproduct, source and special nuclear materials to ensure adequate protection of public health and safety, promote the common defense and security, and protect the environment

NRC's Role

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Principles of Good Regulation
  - Ensuring safety and security while appropriately balancing the interests of the NRC's stakeholders, including the public and licensees
  - Independence does not imply isolation
    - But collaboration does not imply collusion
  - Open channels of communication
  - Regulations should be coherent, logical, and practical
  - Regulation should be perceived to be reliable

Best Places to Work in Federal Government

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- NRC ranked third out of 22 agencies that participated in the mid-size agency category last year
- In the top 3 agencies for the past several years

SFST Business Line Role

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Provide licensing, oversight, and rulemaking of storage and transportation of spent nuclear fuel and transportation of other nuclear materials (e.g., medical and industrial uses)

Waste Confidence

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Top agency priority
- ISFSI renewal licensing reviews continue
  - Prairie Island
  - Calvert Cliffs
- Draft EIS, Draft Waste Confidence Decision, and Proposed Waste Confidence Rule scheduled to be issued September 2013
- On schedule for final rule by September 2014
- Plan to issue renewals soon after

National High-Level Waste Strategy and Challenges

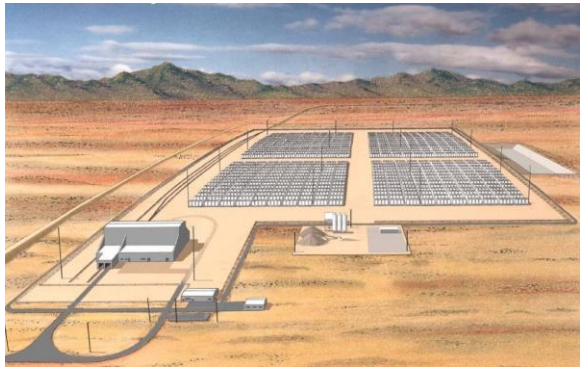
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- National strategy issued in January 2013
- Major elements:
  - Consent based process
  - Pilot interim storage by 2021
  - Full-scale interim storage facility by 2025
  - Geologic repository by 2048
- NRC is supporting the implementation within our role as independent regulator
- Draft Senate legislation

Interim Storage Facility

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Review of NRC regulations complete
- No changes required (caveat)
- At least four entities expressing some level of interest



- NRC prepared to engage in pre-selection as well as pre-application meetings

Interim Storage Facility (cont.)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Application review not part of budget cycles pending degree of assurance regarding timing and number of potential applications
- Length of the review will depend on quality
- Much of spent fuel currently stored is not in transportable casks which may require additional licensing actions and transfer activities
- Need stakeholder input to assist licensing planning efforts

Licensing Program Improvements - Background

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- COMDEK-09-0001(Feb 2010)
  - Undertake a thorough review of spent fuel storage and transport regulatory programs beyond 120 years
- COMSECY-10-0007 (June 2010)
  - Plan for Near-Term Licensing and Inspection Program Improvement Review
  - Plan for Extended Storage and Transportation (EST) Program
  - Potential Policy Issues
- SRM-SECY-09-0900 (Sept 2010)
  - Develop a Plan for a Long-Term Rulemaking to update Waste Confidence (WC) beyond 120 years
  - Integrate Plans and Resources with Staff Plans in COMSECY-10-0007
- SECY-11-0029 (Feb 2011)
  - Plan for Development of WC EIS
  - Strategy and Prioritization for Integrating with EST Activities
  - Separates Near-Term Program Improvement Plans from broader WC/EST challenges

SRM-SECY-09-0900
Extended Storage and Transportation

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Focus on potential degradation phenomena for dry storage systems
- Consider impact on performance of safety functions
- Highest priority technical information needs
  - Stress corrosion cracking of stainless steel canisters and welds
  - Swelling of fuel over time, including fuel fragmentation
  - More realistic thermal models for longer time periods
  - Effects of residual moisture after drying
  - In-service monitoring methods
- Eight areas in next priority level include degradation processes for cladding, hardware, concrete

SRM-SECY-09-0900
Licensing Program Improvements

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Licensing Program Improvements
  - Retrievability and cladding integrity
  - Compatibility of Part 71 and 72
  - General vs. specific license requirements
  - Administration of certificates of compliance

Preview of Coming Attractions

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- High burnup fuel
  - NRC task force
- DOE demonstration project
  - Instrumented cask
- Licensing process changes
  - Internal process changes
  - Potential prioritization of actions

Questions

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

CENG SM

a joint venture of

Constellation Energy

EDF

Used Fuel Storage Safety and Security

John Massari
Fleet Nuclear Fuels

NAYGN Washington, DC
May 2013

New Fuel

Fuel Pellet

Uranium Oxide (ceramic)
4-5% U-235 Enriched
0.45” L x 0.38” D
~300 per fuel rod

Fuel Assembly

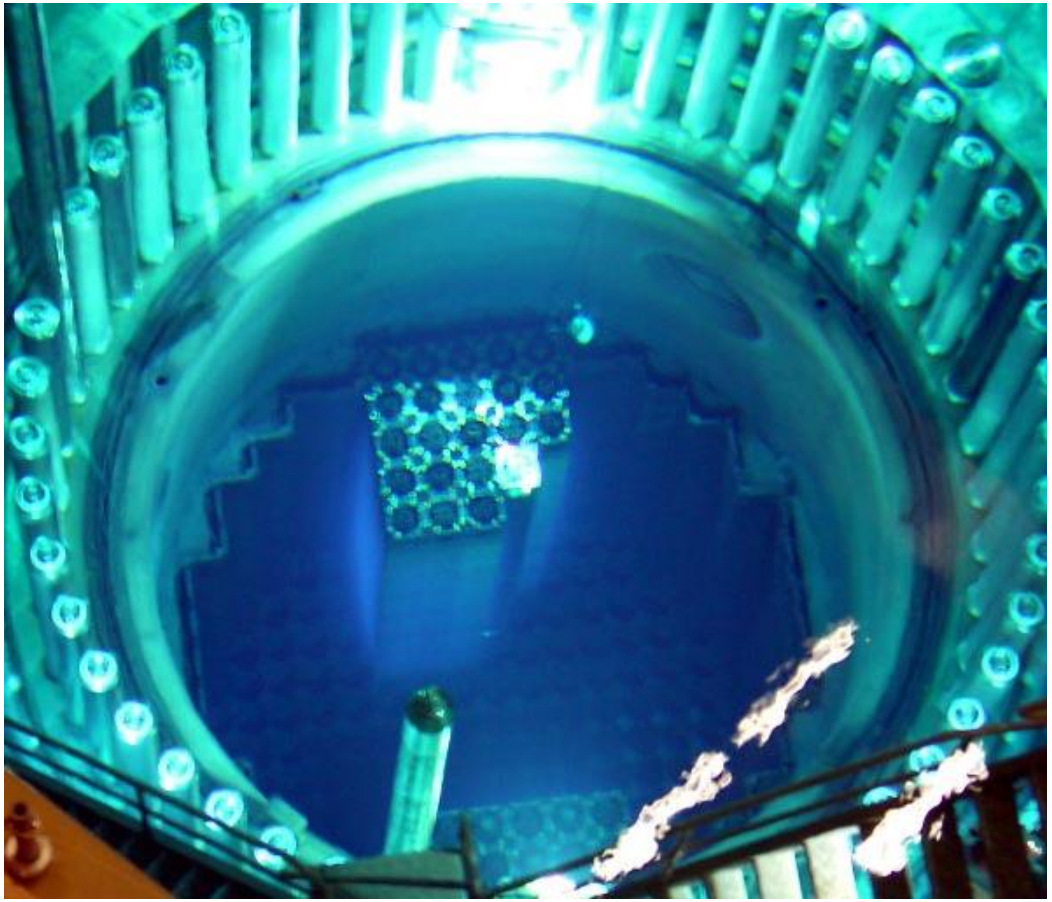
13 feet tall
176 fuel rods
8.4 inches on side
880 lbs uranium
1350 lbs total weight



CENG
a joint venture of
Constellation Energy
EDF

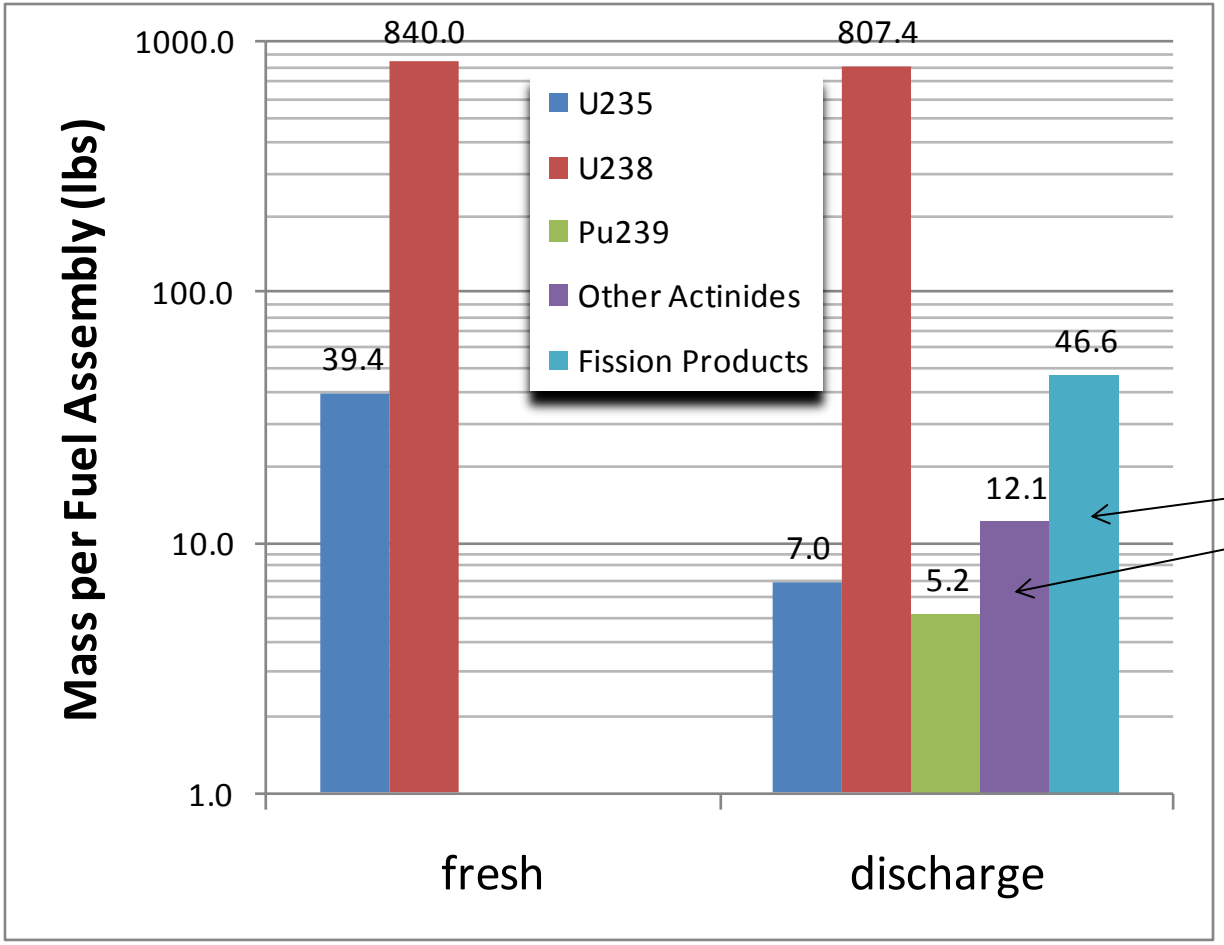
Used Fuel

- 44% of fuel assemblies replaced with new fuel every 2 years
- Fuel assembly spends 4-6 years in reactor
- Each fuel assembly produces 20,000 Megawatt-days of thermal power during time in reactor



CENG
a joint venture of
Constellation Energy
EDF

Used Fuel - Composition

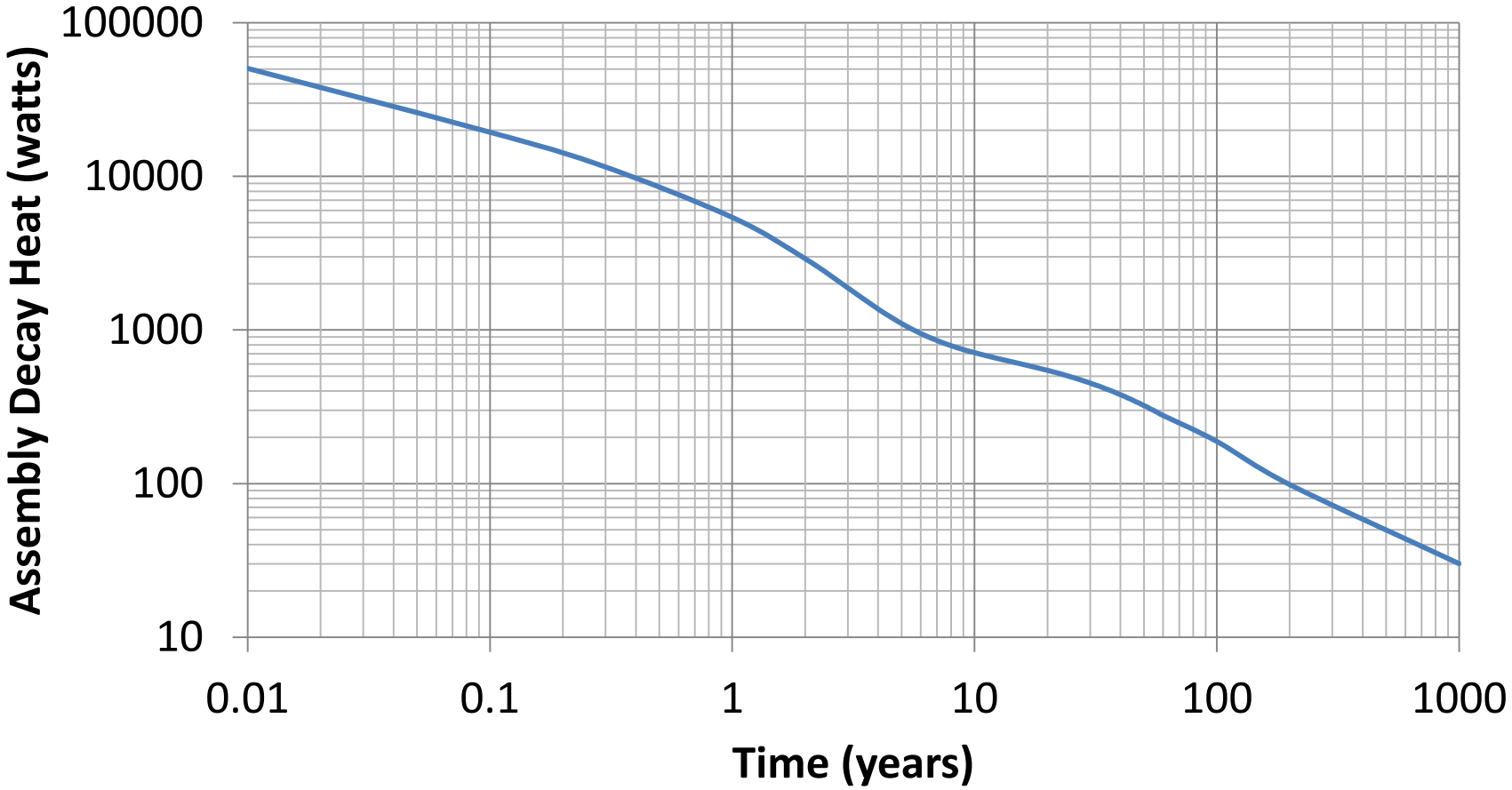


Only 60 lbs of actual waste from 880 lbs of original uranium if fuel assembly recycled



CENG
a joint venture of
Constellation Energy
EDF

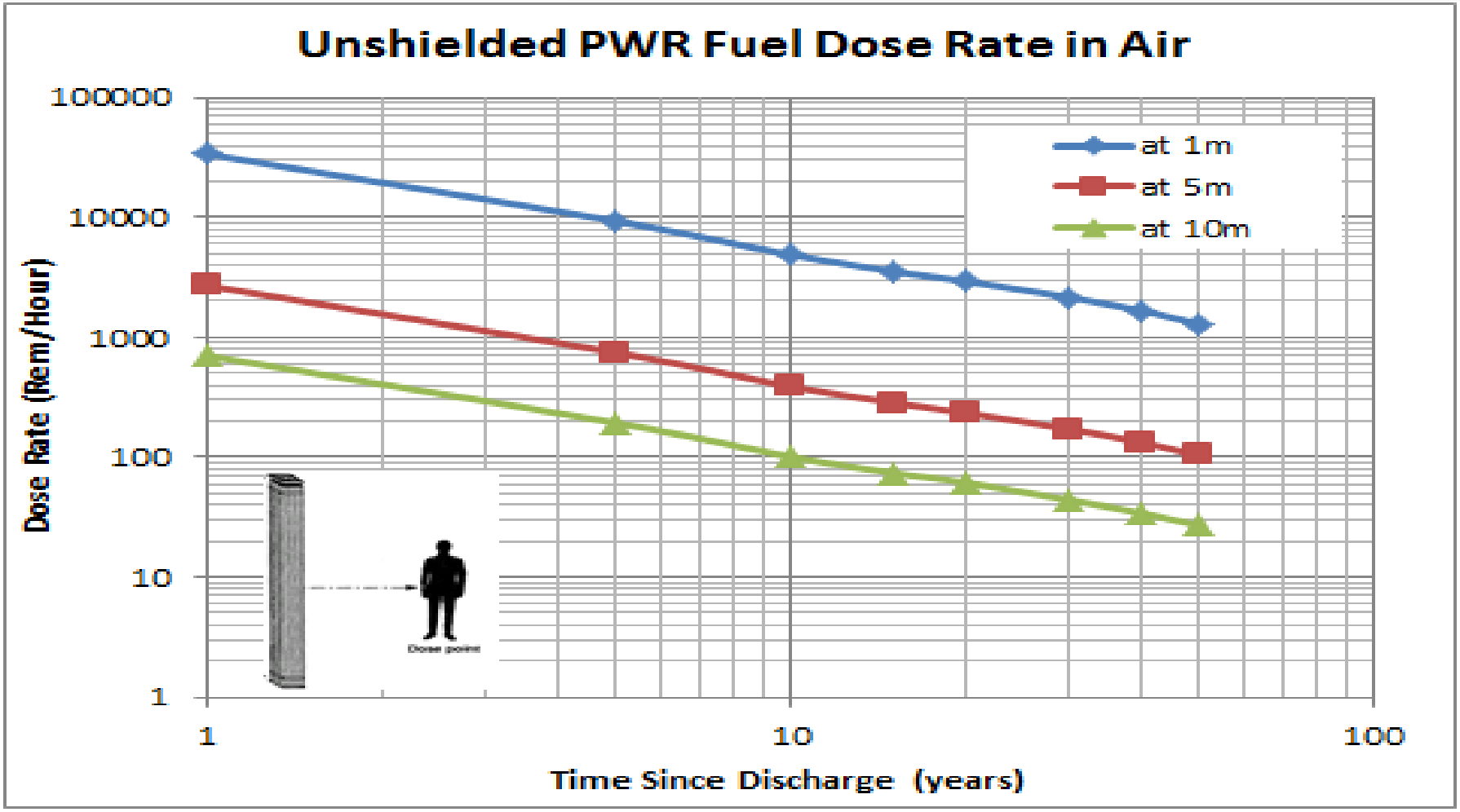
Used Fuel – Decay Heat





CENG
a joint venture of
Constellation Energy
EDF

Used Fuel – Radiation Source

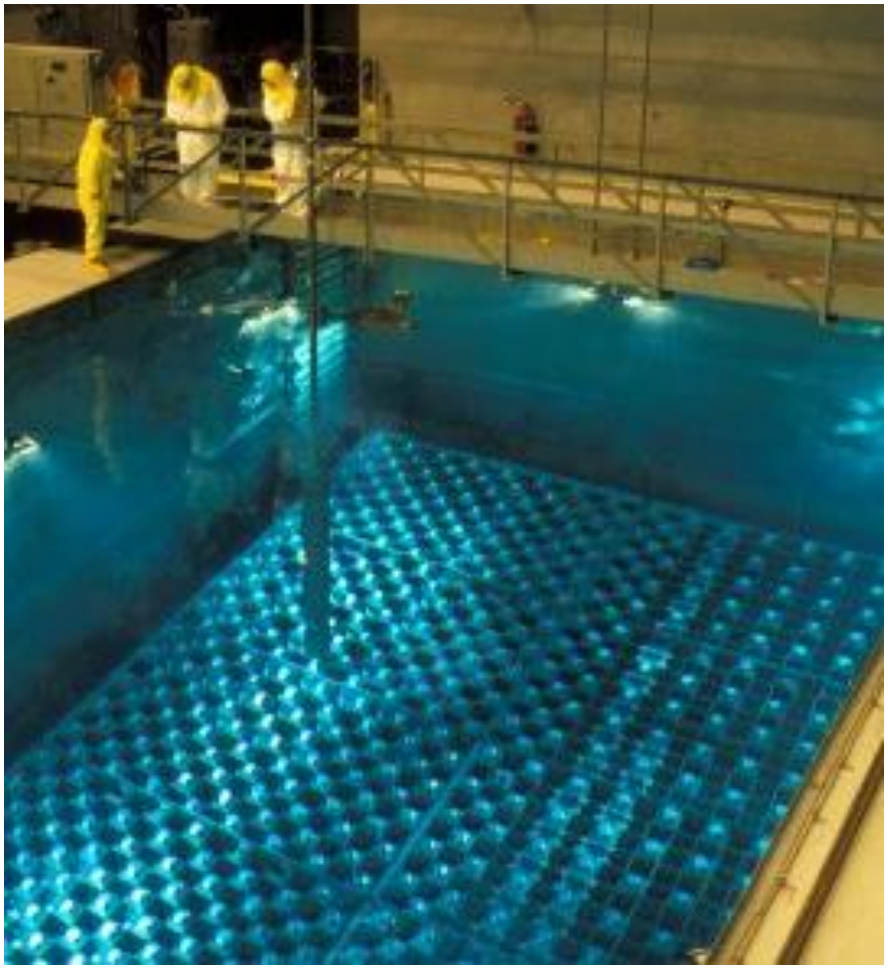




CENG
a joint venture of
Constellation Energy
EDF

Wet Storage

- Used Fuel Pool
  - 6 foot thick Stainless Steel lined concrete walls and floor
  - 590,000 gallons of water
- Room for 15+ years worth of discharged fuel assemblies + full core
- Design Considers:
  - Radiation Shielding
  - Radiological Release
  - Criticality Safety
  - Decay Heat Removal
  - Structural/Seismic



CENG
a joint venture of
Constellation Energy
EDF

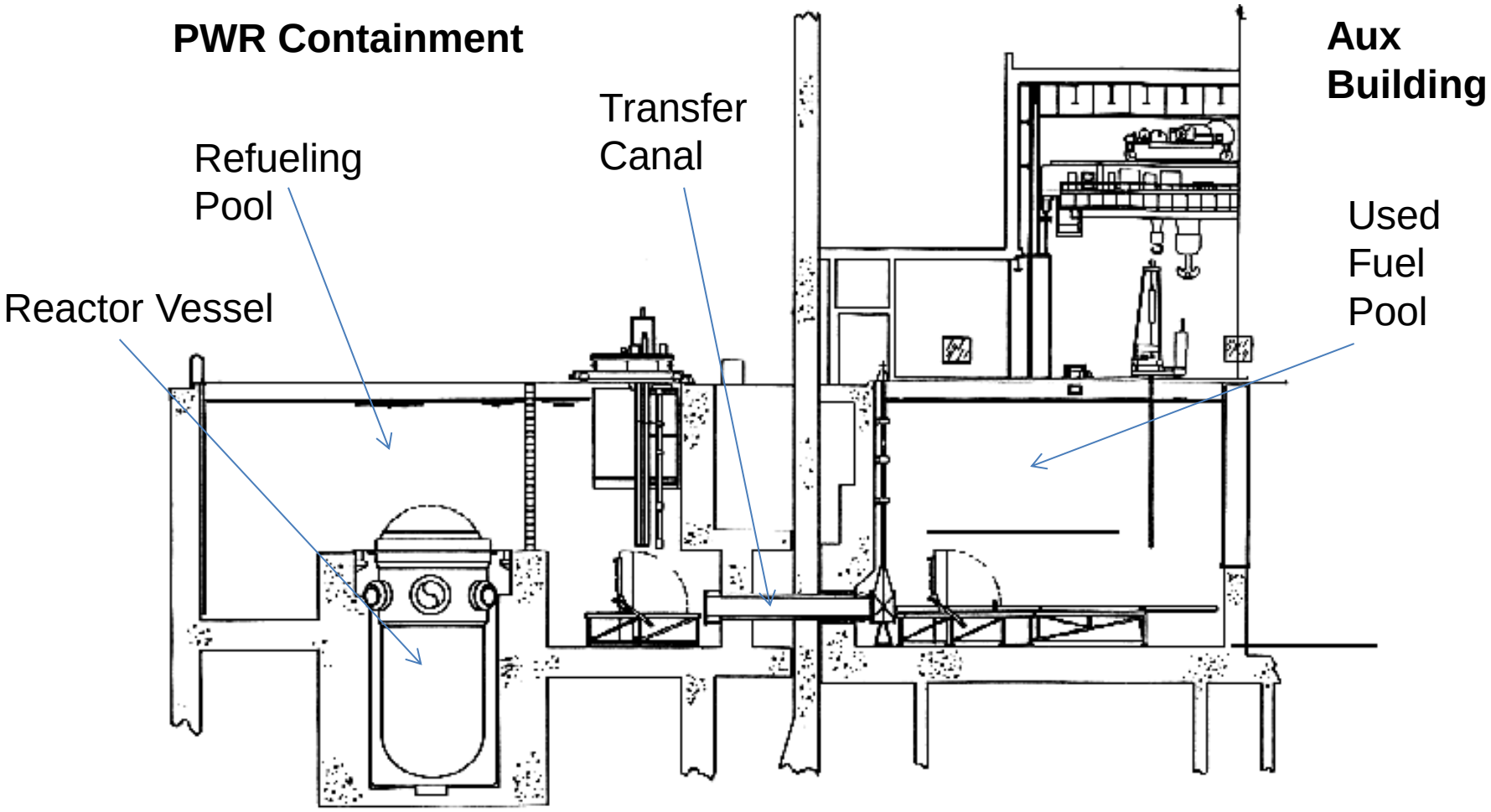
Wet Storage

- Licensed for 1830 fuel assemblies at Calvert Cliffs
- Currently holds 1432 fuel assemblies
- Typically discharge 96 assemblies/year from 1 of 2 reactors
- Typically load 96 assemblies/year into dry storage
- Fuel with less than 5-years cooling time
  - 34% of fuel inventory in pool
  - 63% - 85% of decay heat load in pool (not counting full core discharge during RFO)
  - 57% of Cesium inventory in pool (from EPRI TR-1025206)



CENG
a joint venture of
Constellation Energy
EDF

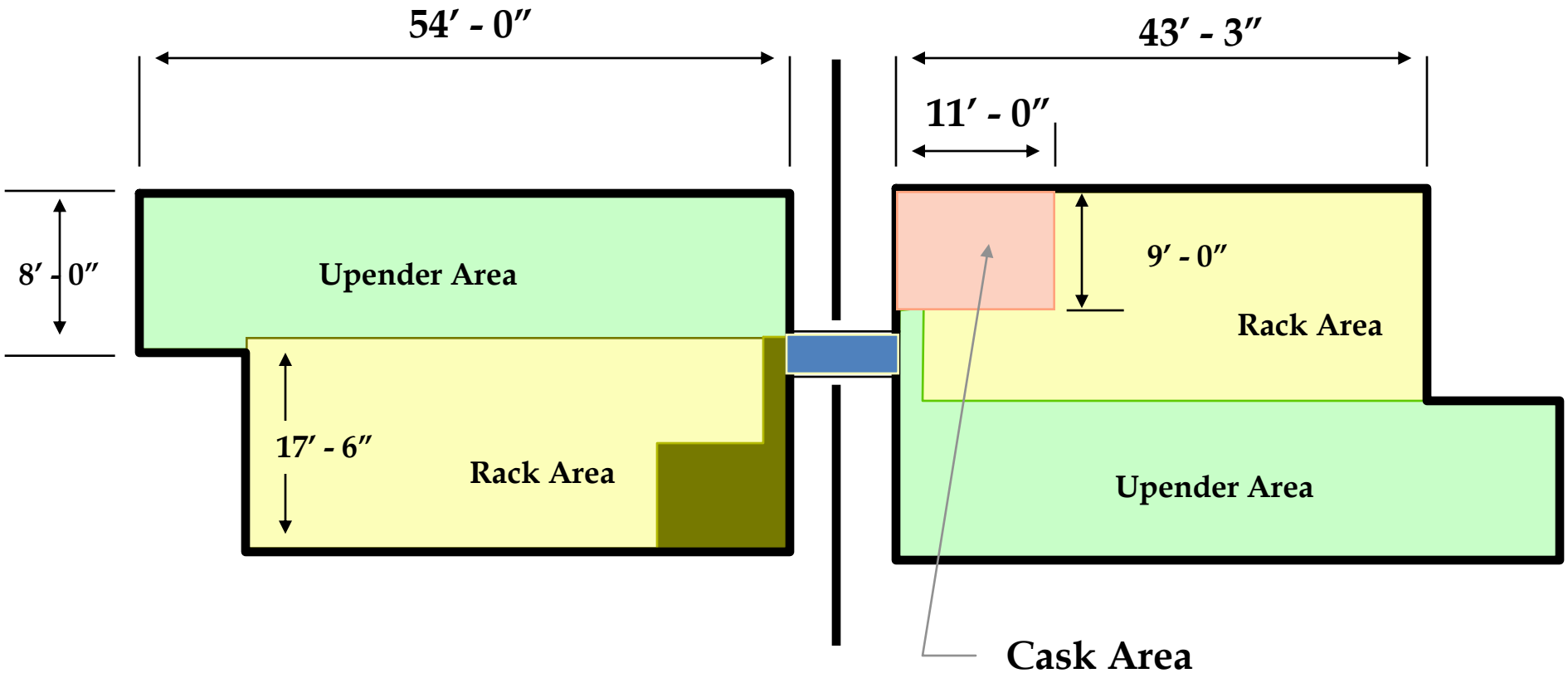
Transfer from Reactor to Wet Storage





CENG
a joint venture of
Constellation Energy
EDF

Used Fuel Pool Layout



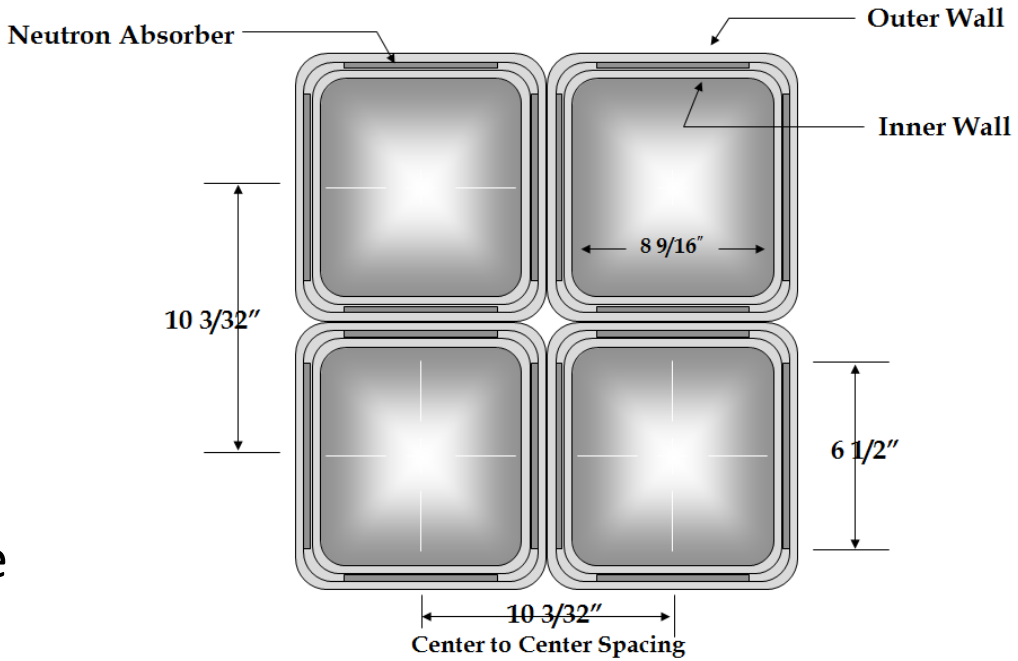


CENG
a joint venture of
Constellation Energy
EDF

47

Used Fuel Pool – Criticality Safety

- Must show $k_{eff} < 1.0$ without credit for soluble boron
- With credit for limited soluble boron must show that $k_{eff} < 0.95$ unless two unlikely and independent events occur.
- Fuel Cell Pitch (Flux Traps)
- Fixed Neutron Absorber in Racks
  - Coupons or BADGER Testing for Aging Management
- For PWR only – minimum soluble boron 2000 – 2300 ppm
- Burnup Credit

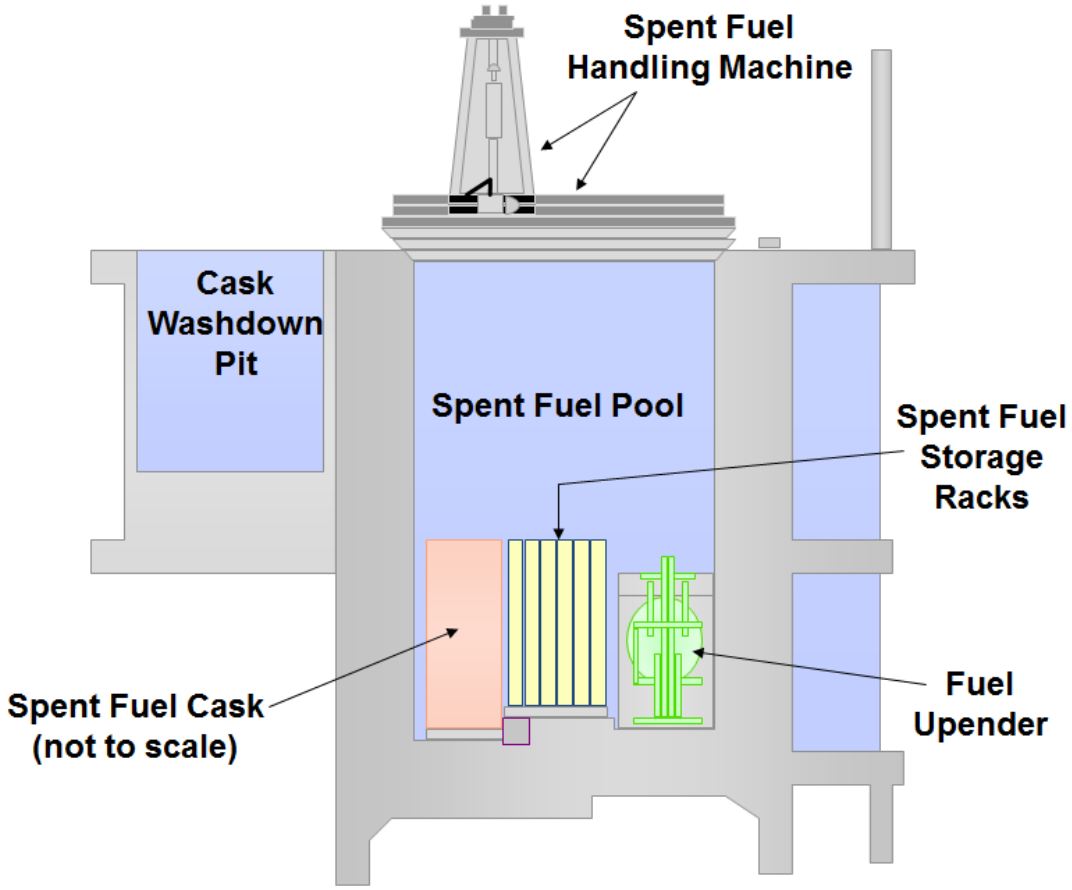




CENG
a joint venture of
Constellation Energy
EDF

Used Fuel Pool – Radiological Safety

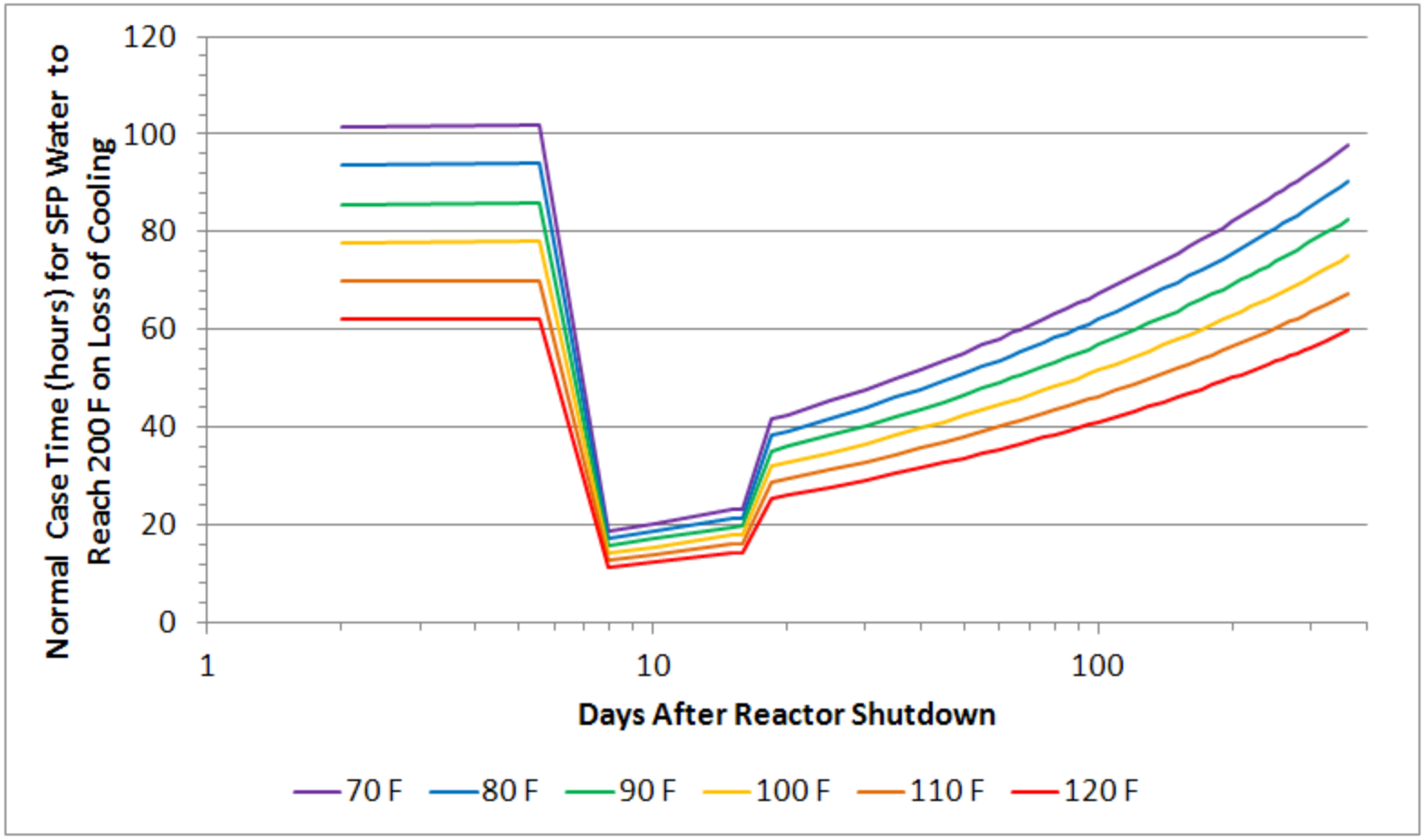
- Shielding
  - ~9 feet of water needed above fuel at discharge to keep doses < 2.5 mrem/hr at water surface
  - 5 to 6 feet of water needed above top of rack to keep SFP deck < 100 mrem/hr
- Radiological Release
  - 23 feet of water provides factor of 200 reduction in iodine release during a fuel handling accident





CENG
a joint venture of
Constellation Energy
EDF

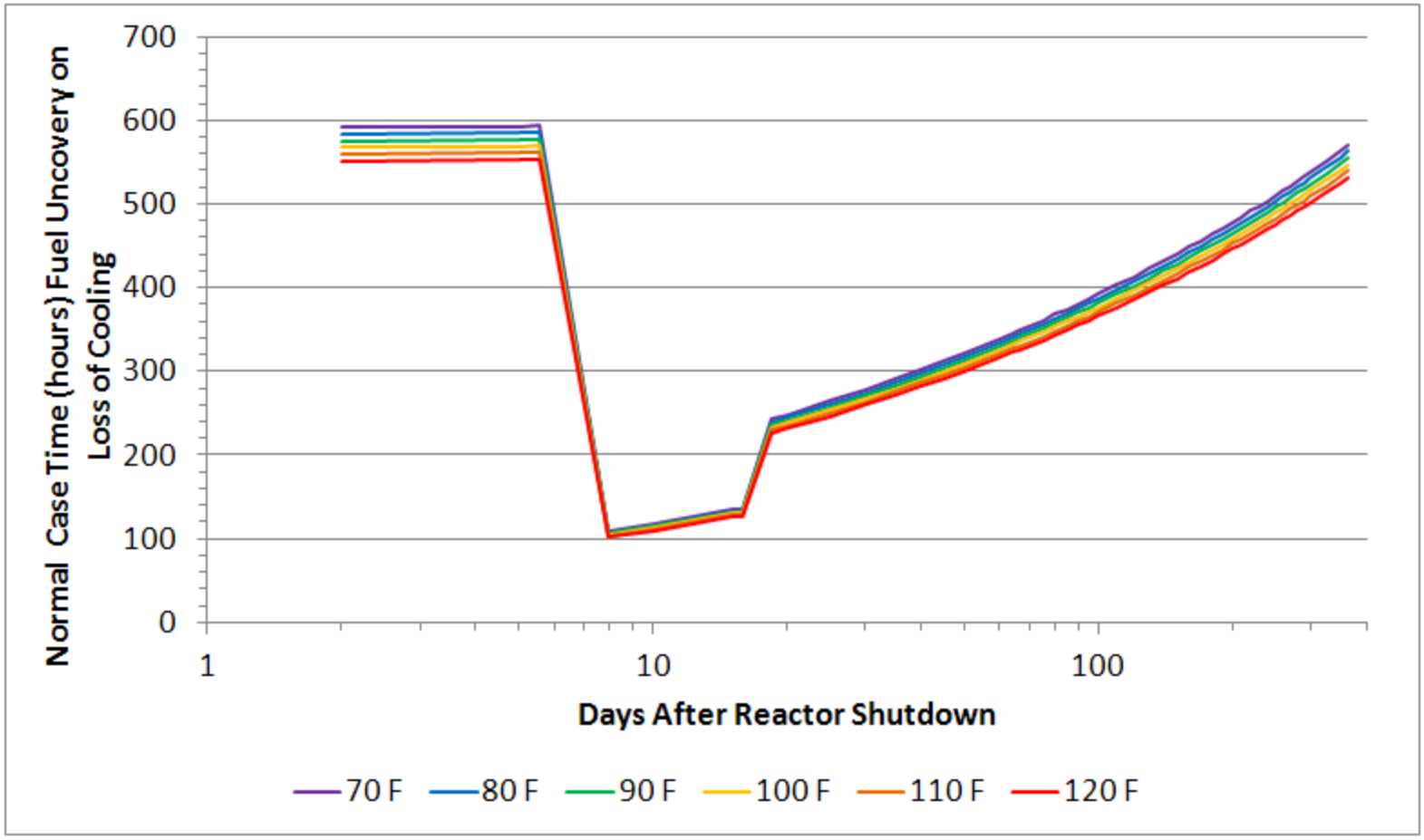
Used Fuel Pool – Time To Boil on Loss of Cooling





CENG
a joint venture of
Constellation Energy
EDF

Used Fuel Pool – Time To Uncover Fuel on Loss of Cooling

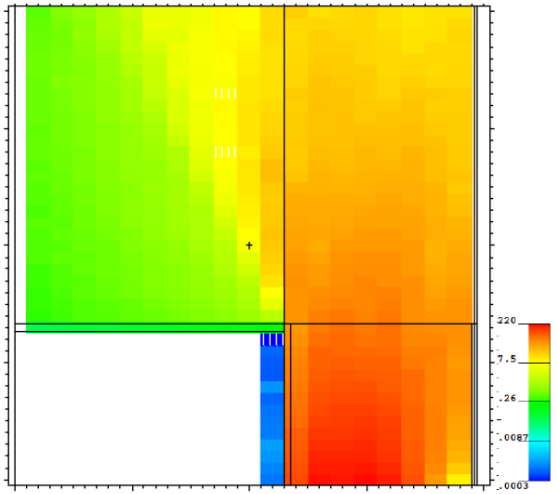




CENG
a joint venture of
Constellation Energy
EDF

Used Fuel Pool - Emergency Planning

- Post TMI
  - Abnormal operating procedures for low SFP level
  - Visual reference for wide range level
- Post-9/11
  - Requirements to disperse recently discharged fuel heat load to air coolable geometry
  - Hardware to spray pool
  - Portable diesel driven pumps
  - Severe accident procedures for SFP
- Post-Fukushima
  - Wide range level instrumentation
  - Action levels
  - FLEX





CENG
a joint venture of
Constellation Energy
EDF

Dry Storage – ISFSI

- Independent Spent Fuel Storage Installation (ISFSI)
  - 20-year License Granted in Nov 1992
  - Applied for 40-year License Renewal in Sept 2010
  - 72 HSMs Built and Loaded
  - Licensed for 120 HSMs
  - Room for 132 HSMs
- Sufficient storage space between pool and ISFSI for 60 years operation

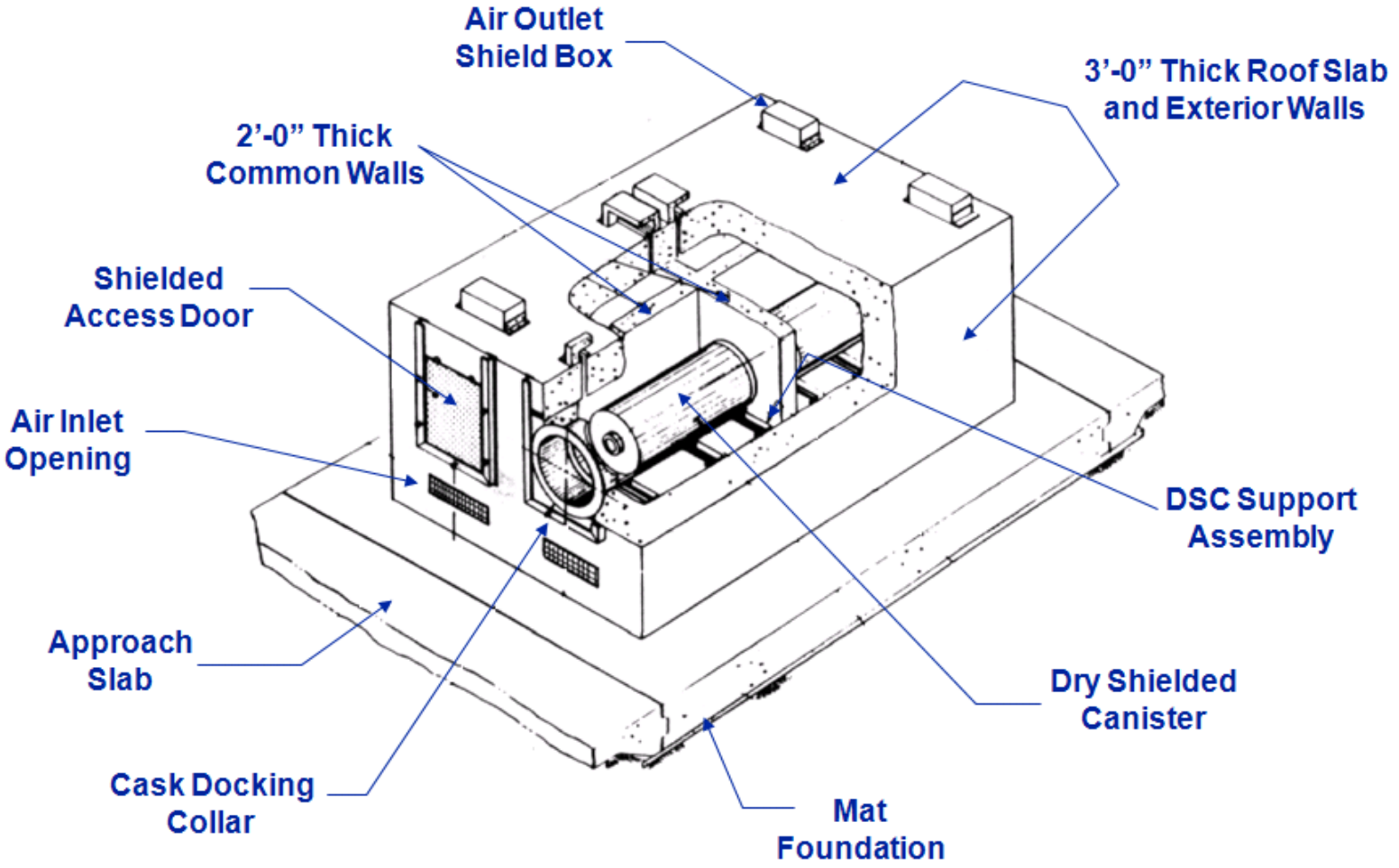


CENG
a joint venture of
Constellation Energy
EDF

Dry Storage - HSMs and DSCs (CCNPP)

CENG
a joint venture of
Constellation Energy
EDF

Dry Storage - Horizontal Storage Module



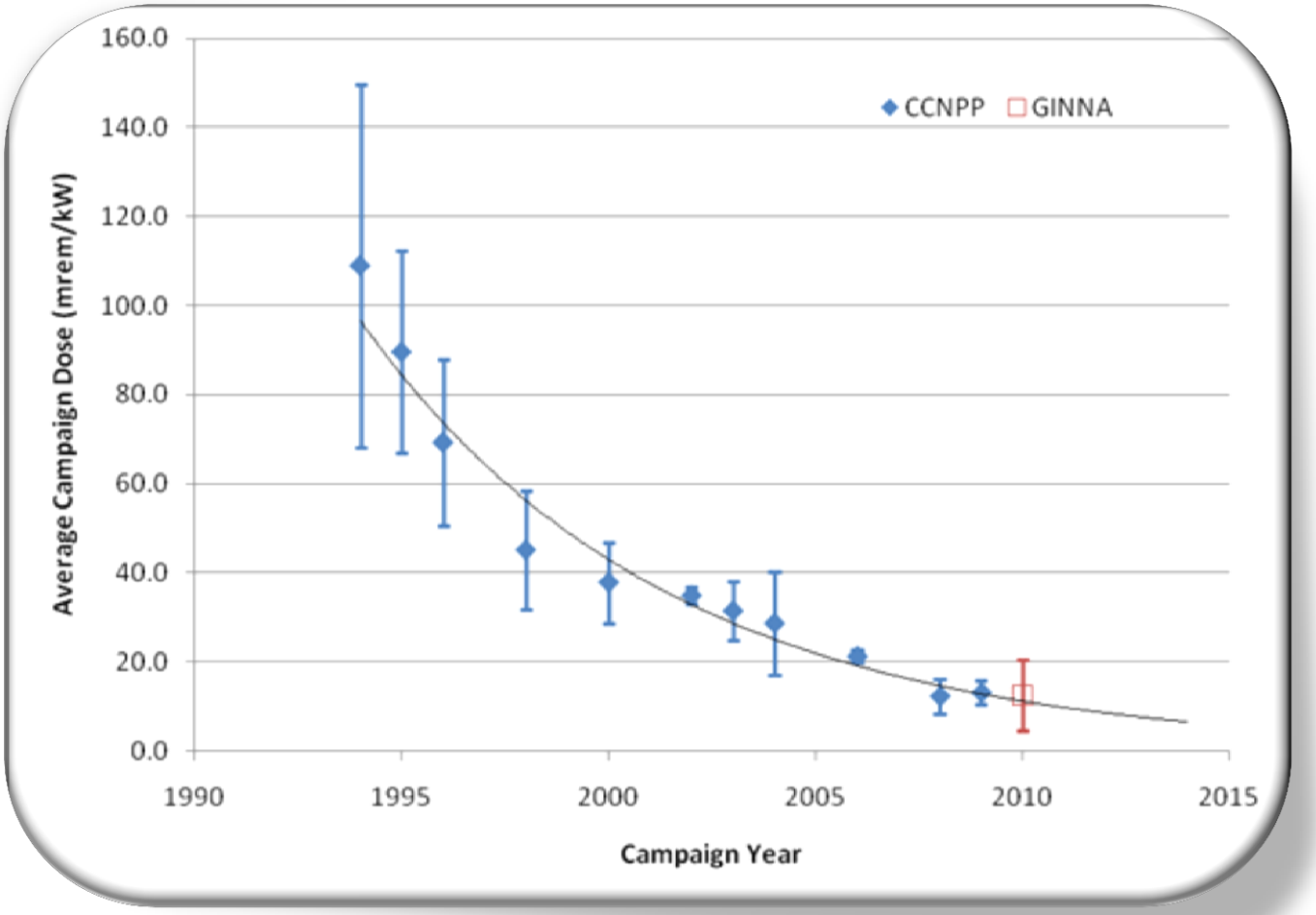


CENG
a joint venture of
Constellation Energy
EDF

Dry Storage - Transfer Cask, Trailer & Hydraulic Ram

CENG
a joint venture of
Constellation Energy
EDF

Dry Storage – Keeping Loading Doses ALARA



CENG
a joint venture of
Constellation Energy
EDF

Dry Storage – Aging Management

CENG
a joint venture of
Constellation Energy
EDF