Why Do a “Demonstration”? 

- Collect data to validate and confirm the technical basis for extended storage of high burnup spent fuel.

- Similar to demonstration performed on low burnup fuel stored ~15 years in a CASTOR V/21 cask.
High Burnup Spent Fuel Data Project

Objectives

- Involves
  - Loading a commercial TN-32B storage cask with high burnup fuel in a utility storage pool
    - Well characterized fuel (Zircaloy-4, low-tin Zircaloy-4, ZIRLO™, and M5®-clad high burnup fuels)
    - Cask outfitted with additional instrumentation for monitoring
      - 7 lances each with 9 TCs axially spaced
    - License amendment required for lid design, high burnup fuel and additional heat load
  - Dry the fuel using typical process
  - Store cask at the utility’s Independent Spent Fuel Storage Installation (ISFSI)
  - Take temperature measurements and gas samples
  - The issue of where the cask will be opened after the storage period will be solved at a later date.

This is where the cask will be held at North Anna for 2-3 weeks after it is loaded.
A contract was awarded to EPRI on April 16, 2013

National Laboratories

- AREVA Federal Services
- AREVA Transnuclear
- AREVA Fuels
Activities for the EPRI Contract 2013-2018

- Acquire the cask
- Plan the fuel loading
- Develop a design and licensing basis document
- Submit License Amendment Request
- Extract sister rods
- Ship sister rods
- Modify the cask lid for instrumentation
- Secure the license amendment
- Load fuel in the cask
- Begin monitoring the cask and take internal gas samples
- Store the cask at North Anna ISFSI

North Anna Pool and Fuel Handling
Next Contract Activities 2018 to 2027

- Continue to monitor and record temperatures and potentially take additional internal gas samples
- Ship the cask to a hot cell facility
  - Eliminates the need to rewet the cask and fuel
- Open the cask after 10+ years, visually examine assemblies, and extract some fuel rods
- Perform testing on the extracted rods for comparison to previously tested sister rods
- Prepare report on the effects on the fuel that can be attributed to dry storage operations
Process for Monitoring the Cask

- Cask cavity data acquisition will capture the full evolution of draining, drying, and cooling to equilibrium
  - Thermocouple data recorded on a data logger at regular intervals
- After backfill and pressurizing, the cask will remain in cask prep bay for 2-3 weeks for cavity temperature, pressure, and gas composition monitoring
- Periodic cavity gas samples will be obtained and analyzed
  - Fission gas
  - Hydrogen content
  - Oxygen content
  - Moisture data will provide immediate valuable insight to cask drying method
- Cask to be loaded is a TN-32B cask
  - Initially fabricated and certified to meet CoC 72-1021 requirements
  - Cask is capable of storing high burnup fuels, but storage of high burnup fuel wasn’t a priority at the time this cask was originally licensed

- The Design and Licensing Basis Document provides the analytical bases and conclusions for departures from the existing approved analyses in the General License TN-32 FSAR
  - New lid design completed
  - New criticality safety analysis (including poison rod assemblies) completed
  - New thermal analysis completed
  - New radiological analysis completed

- Dominion submitted a License Amendment Request (LAR) for North Anna’s site specific ISFSI license
TN32B Cask is being Prepared

TN 32B cask at fabricator

Removing lid to inspect cask after years of storage
Current Project Schedule

High Level Milestones

- **12/31/14:** TN completes DLBD
- **1/31/15:** AREVA sister rods extracted
- **6/30/15:** Westinghouse sister rods extracted
- **8/24/15:** Dominion submits LAR to NRC
- **9/25/15:** NRC Accepts LAR
- **9/25/15:** NRC issues Request for Additional Information (RAIs)
- **1/15/16:** Sister rod shipment to ORNL
- **1/19/16:** Expected NRC review completion
- **1/31/17:** Cask Delivered to North Anna
- **2/15/17:** Dry run and functional tests complete
- **6/30/17:** Cask loading complete – begin initial monitoring
- **7/31/17:** Cask emplaced at pad/Begin at-pad monitoring
- **8/21/17:**
Final Fuel Selection Priorities

Fuel Selection was finalized based on the following priorities:

1. Get peak cladding temperatures as close to 400°C as possible.
2. Keep the total cask heat load below the temperature limit on the neutron resin material (149°C).
3. Put one of each of the four kinds of PWR cladding in the center four slots.
4. Surround 4 HBU assemblies in center with high burnup, short-cooled fuel to drive up temperatures.
5. Place similar assemblies of both ZIRLO™ and M5® in center, middle, and outer rings to obtain a wide variation in temperature.
6. Thermocouple lance positions: 2 in center, 2 in middle; 3 in periphery; keep some area clear on the lid for the helium overpressure tank et al.
Areva rods pulled January 2015
- Nine Areva M5® rods

Westinghouse rods pulled June 2015
- Twelve Westinghouse ZIRLO™ rods
- Two Westinghouse Low-tin Zircaloy-4 rods
- Two Westinghouse standard Zircaloy-4 rods

Sister rods sent to ORNL on 1/19/2016

Draft Sister Rod Test Plan is being completed and will be shared with others.
- Discusses in detail the methodology for selecting the sister pins
Sister Rod Testing

Proposed Action:
- ORNL: Test Performed on each Rod:
  1. Video Exam
  2. Profilometry
  3. Gamma Scan

Future Actions:
- PNNL: Material Properties Testing
- ORNL: Fatigue Testing
- ANL: Ring Compression Testing
- ORNL: Future Tests:
  1. Ring Compression
  2. Material Properties
  3. Fatigue
  4. TBD

Note: Time not to scale.

* The laboratory location and types of testing have been selected for analytical purposes.
Detailed Characterization Using ORNL ADEPT (Advanced Diagnostics and Evaluation Platform)
Non-destructive examination to obtain T0 characteristics to compare against rods extracted after 10+ years of storage
- Compare rod length and profilometry data to look for signs of creep

Destructive characterization
- Rod internal pressure, fission gas release, free volume determination

Simulated drying of either intact rods or pressurized rod segments under range of realistic temperatures and hoop stresses (similar to Radial Hydride Treatment performed at ANL) to obtain T1 characteristics.

Clad hydrogen analyses (visual and hot vacuum extraction)
- Determine hydride content and distribution (T0 and T1); compare against extracted rods to look for hydrogen redistribution, extent of radial hydride formation, signs of Delayed Hydride Cracking
High Priority Tests

- Test at both T0 and T1
- Determine temperature and strain rate dependencies
- Cyclic Integrated Reversible-Bending Fatigue Tests (CIRFT) to determine fatigue strength and flexural rigidity, modulus of elasticity, effects of fuel/clad composite
  - Examine transient shocks and cumulative effects performance
- Ring Compression Tests (RCT) to determine ductile to brittle transition temperature
- Material properties tests (e.g., yield strength, ultimate tensile strength, uniform plastic elongation) following ASTM-approved methodologies
  - Tube tensile
  - Tube compression
  - Tube burst
- Additional testing based on initial results