ZIONSOLUTIONS LLC
An Energy*Solutions* Company

Fuel Loading Plan for Dry Storage & Transport

Zion Nuclear Power Station

March 03, 2011 Presentation to NRC

ZNPS Decommissioning Status

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Zion*Solutions* has:

- 10 CFR 50 License Stewardship of ZNPS Units 1 & 2
- Acquired the entire assets of Zion NPS, except SNF
- Leased the ZNPS site property from Exelon
- Taken responsibility for safe storage of SNF
- Assumed all liabilities and obligations for decommissioning and site restoration
- Committed to return the site to Exelon within 10 years with all SNF in dry storage and transport license issued

Schedule of Fuel-Related Work

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Start Date

1. Dry storage canisters procurement……………...…………..In Progress
2. Fuel top nozzle modifications……...……………………...June 2011
3. Fuel inspections………………………….……..........December 2011
4. ISFSI engineering……………………………………………In Progress
5. ISFSI construction…………………………………………March 2012
6. Fuel Building SFP trolley procurement…..………...…...……In Progress
7. Trolley installation & FB upgrades…………..…………......March 2012
8. Fuel transfer operations………………………………..........March 2013

Meeting Objectives

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- Provide a brief overview of Zion*Solutions* License Stewardship
- Inform NRC staff of plans for dry cask storage at ZNPS – a key part of the decommissioning project now underway
- Present the basis for a fuel loading plan that meets dry storage and off-site transport regulations
- Solicit staff comments now so that all ZNPS fuel can be loaded in confidence

Dry Fuel Storage & Transport System

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- NAC MAGNASTOR Dry Storage Canisters
  - 61 canisters + 4 GTCC waste canisters
  - Up to 37 fuel assemblies / canister
  - Two types of canisters: DFC and non-DFC capable
- NAC MAGNATRAN Transport Cask
  - Fuel canisters
  - GTCC waste canisters

ZNPS Fuel Inventory

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- 2,226 Westinghouse 15x15 Assemblies
  - 13 full-length failed fuel rods (in failed rod storage basket)
  - 15 full-length intact fuel rods (in guide tubes of 2 assemblies)
- Top Nozzle IGSCC
  - 1,454 assemblies (65% of total)
- Inserts
  - 1,728 of various types
- Damaged Fuel: Current Count
  - 7 previously identified leaking fuel assemblies (ID by sipping)
  - 1 failed rod storage basket (13 failed fuel rods)
  - 1 fuel assembly with at least 1 breached fuel rod
  - 1 skeleton cage (containing 15 relocated “guide tube” rods)

ZNPS Fuel Inventory

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- High Burn Up Fuel
  – 36 assemblies (45,000 MWd/MTU and higher)
- High Reactivity Fuel
  – low burnup with higher initial enrichment
- All fuel well under thermal limit (>14 yr cooled)

ZNPS Fuel Inserts

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- All ZNPS inserts are defined contents in MAGNASTOR SAR, Amendment 3
- 219 full-length Rod Control Cluster Assemblies (RCCA)
  - Includes 6 spares (new RCCAs)
  - Maximum exposure level of 186,000 MWd/MTU
  - Very conservative definition of exposure
    - RCCA exposure = host assembly exposure for each fuel cycle
    - Effectively assumes full RCCA insertion in core at all times
- 16 partial-length RCCAs

ZNPS Fuel Inserts

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- 285 Burnable Poison Rod Assemblies (BPRA)
- 8 Hafnium Flux Reduction Assemblies (HFRA)
- 690 Wet Annular Burnable Assemblies (WABA)
- 14 Primary & Secondary Neutron Source Assemblies (NSA)
- 502 Thimble Plug Devices (TPD)

Fuel Modifications & Inspections

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- Modifications
  - Reinforce 1,454 top nozzles with Instrument Tube Tie Rods (ITTR)
  - Transfer 15 loose “guide tube” rods into assembly skeleton cage
- Inspections
  - Recorded 4-sided visual of all 2,226 assemblies
  - Top nozzle spring clamps on all 2,226 assemblies
  - Removable top nozzle lock tubes on 392 assemblies
  - Vacuum sipping of approximately 200 assemblies

Top Nozzle Modifications

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- Addresses Information Notice 2002-09
- Instrument Tube Tie Rods installed via design change process
- 50.59 safety evaluation
- Minimum axial structural capacity > 2 x fuel assembly weight
- Installation to be performed by Westinghouse team under Zion*Solutions* oversight

Top Nozzle Modifications

- Dry Storage – 10 CFR 72
  - Conformance to MAGNASTOR CoC criteria
    - ITTR is a subcomponent of the fuel assembly
    - Modified fuel is intact and moved with standard tooling
    - Structural, thermal, shielding, criticality, confinement evaluated in MAGNASTOR SAR Application, Amendment 3
  - NEI Generic Issue I-10-01 Top Nozzle IGSCC
    - ITTR modifications are consistent with NEI White Paper
    - MAGNASTOR SAR Application, Amendment 3 specifically addresses ITTR modification

Top Nozzle Modifications

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- Transport – 10 CFR 71
  - Conformance to MAGNATRAN CoC criteria
    - ITTR meets structural criteria for normal and accident conditions of transport
    - Spacers, inserts and basket configuration
      - Constrains lateral movement of top nozzle
      - Reduces secondary impact effects on ITTR assemblies by minimizing gap between top nozzle and canister lid
- Physical properties used consistently in 72/71 analyses

High Burn Up Fuel

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- ISG-11, revision 3 Regulatory Guidance
  - “Fuel with burnup generally exceeding 45 GWd/MTU”
  - Application of uncertainty factor not stipulated
  - Place all damaged assemblies in Damaged Fuel Cans
- ZNPS Loading Plan
  - Place 36 fuel assemblies with nominal burn up > 45 GWd/MTU in Damaged Fuel Cans

High Reactivity Fuel

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- Under burned fuel mostly resulted from premature plant shutdown (normally 3 cycle fuel)
- Key issue for decommissioned plants
  - Must load, dry store, and eventually ship all SNF
  - No opportunity to repackage this fuel in the spent fuel pool
- 10 CFR 71 Criticality Requirement
  - $K_{eff} < 0.95$ under fresh water ingress
  - Results in assembly minimum burnup requirements
- Some ZNPS under burned fuel with higher enrichments fall below the MAGNATRAN loading curves

High Reactivity Fuel

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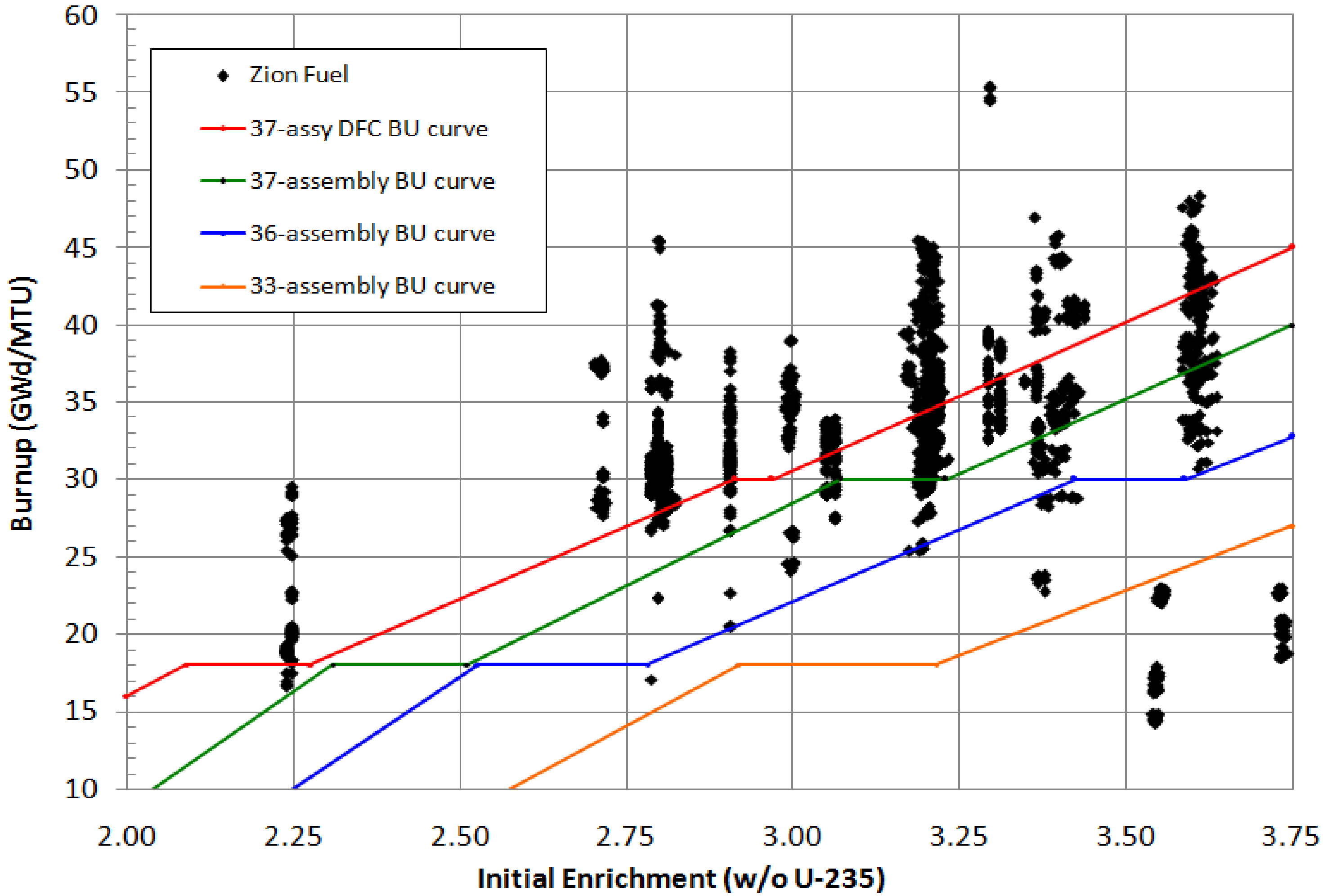
- Loading Plan to Meet Minimum Burnup Requirements
  - Compare fuel burnup & enrichment to MAGNATRAN SAR burnup curves
  - Qualify under-burned fuel by
    - Using partially-loaded canister configurations
    - Inserting (and crediting) Rod Control Cluster Assemblies in very-low-burnup assemblies
  - Accounting for effects of burnup uncertainty to demonstrate MAGNATRAN SAR & CoC compliance

Partially-Loaded Canister Configurations

- Configurations evaluated in MAGNATRAN SAR
  - Configuration-specific burnup curves
  - Specific tech specs for each partial configuration
  - 37, 36, and 33-assembly configuration options in SAR
  - Canister with damaged fuel cans also specifically evaluated
- Preferential (zone) loading not used
  - Assembly qualification applies for all basket locations
- Permanently blocked canister basket locations
  - Physically blocked to prevent assembly mis-loading
  - Significant canister reactivity reduction

Zion Spent Fuel Inventory vs.MAGNATRAN Burnup Curves



MAGNATRAN CoC Basis for Use of RCCA's

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- Fuel & (full-length) RCCA physical parameters
  - Key physical dimensions
  - Initial RCCA absorber and cladding materials (e.g., Ag-In-Cd)
- Maximum allowable RCCA exposure (200 GWd/MTU)
  - Licensee determines method of calculating RCCA exposure
- Assemblies with RCCAs restricted to nine center basket locations
- Burnup & enrichment requirements for assemblies
  - Initial enrichment ≤3.8% for assemblies with RCCAs (covers Zion)
  - No minimum burnup for assemblies with RCCAs
  - Other assemblies must meet applicable minimum burnup requirements

Loading High Reactivity Fuel with RCCA’s

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- All ZNPS fuel loaded with <u>any</u> ZNPS RCCA qualify for loading in a fully-loaded (37 assembly) canister, including DFC canisters
- There are enough RCCA’s to cover all high-reactivity ZNPS fuel
  - Number of RCCA’s (219) exceeds number of assemblies (186) that do not qualify for fully-loaded or 36-element canister
  - With full use of RCCA’s, only 37 and 36-element canisters are needed for all ZNPS fuel

Assembly Burnup Uncertainty Effects

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- MAGNATRAN SAR places responsibility for determination of burnup uncertainty on the licensee (Zion*Solutions* in this case)
- Zion*Solutions* will account for uncertainty by reducing recorded burnup by total uncertainty before comparing to SAR burnup curve
- Assembly mis-load event addressed in MAGNATRAN SAR

Published Guidance on Burnup Uncertainty

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- ISG-8
  - Suggests burnup measurements for all loaded fuel or a large sample of assemblies
    - Addresses uncertainty in recorded burnup values
    - Addresses possibility of mis-loaded fuel
  - Suggests combining measurement and calculation error to determine total uncertainty level
  - Uncertainty determined by comparing measured and calculated burnup values for large sampling of assemblies

Published Guidance on Burnup Uncertainty

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- NUREG/CR-6998
  - Error in recorded burnup values < 5%
    - Comparison of in-core measured values to recorded values
    - Uncertainty level closer to 2% in most cases
  - Historically, in-pool burnup measurement techniques not as accurate as in-core measurements
    - In-pool (~2-5%) vs. in-core (~2%)
    - Measurements may not be useful for estimating recorded burnup value uncertainty

Published Guidance on Burnup Uncertainty

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- NUREG/CR-6998
  - Assembly mis-load guidance
    - Chance of mis-load in a dry storage cask: 10^{-3} to 10^{-5}
    - Suggests that double mis-load not credible (< 10^{-6})
    - Single unburned assembly increases k_{eff} by 2.0-3.5%
    - Crude burnup measurement sufficient to detect unburned fuel

Industry Precedents on Burnup Uncertainty

- Uncertainty Factors
  - Typically 2% to 5% uncertainty factor applied for dry cask storage loading (non-criticality)
  - Similar uncertainty factors applied for spent fuel pool loading (criticality)
  - In-pool assembly burnup measurements not performed
- Calculation Methods
  - Comparison of core physics calculations to in-core measurements (95% confidence level)
  - Comparison of core calorimetry data to calculated core thermal output
- In-pool assembly burnup measurements not performed

Burnup Uncertainty Effect on ZNPS Load Plan

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- ZNPS-Specific Evaluation Methodology
  - Model ZNPS assembly inventory and burnup curves for 37, 36 and 33-assembly cask configurations
  - Consider burnup uncertainty levels of 0%, 2%, and 5%
  - Reduce fuel assembly burnup values by applying uncertainty %
  - Compare resulting burnup to three burnup curves
  - Determine number of assemblies that qualify for each cask configuration
  - Account for effects of RCCA inserts (for criticality suppression)
  - Determine number of casks required to load all ZNPS fuel

Burnup Uncertainty Impact Evaluation Results

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Number of Zion Assemblies Qualified for Loading (with RCCA Inserts)

	Assembly Burnup Uncertainty			
	0%	2%	5%	10%
37-assembly DFC Configuration	1454	1331	1095	728
37-assembly Intact Configuration	2052	1978	1858	1590
36-assembly Intact Configuration	All	All	All	2175
33-assembly Intact Configuration	All	All	All	All

Canister Type Distributions Required for Zion Assembly Inventory

	Assembly Burnup Uncertainty			
	0%	2%	5%	10%
37-assembly DFC Configuration	39	35	29	18
37-assembly Intact Configuration	17	19	21	25
36-assembly Intact Configuration	5	7	11	16
33-assembly Intact Configuration	0	0	0	2
Spare Assembly Locations	26	24	20	7

ZNPS Assembly Burnup Determination

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- Uncertainty Factor Applied to Recorded Burnup Values
  - 5% factor is planned to be applied, consistent with:
    - NUREG/CR-6998 guidance
    - Industry precedent
- In-pool assembly burnup measurements not planned for ZNPS
  - Sufficient basis to conservatively assume 5% (NUREG/CR-6998)
  - In-pool measurements probably not useful for correcting recorded values or determining their uncertainty (NUREG/CR-6998)

Assuring Load Plan Compliance

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- Addressing Potential Assembly Mis-Loads
  - MAGNATRAN SAR evaluation
    - Shows k_{eff} < 0.97 for single assembly mis-load
    - Mis-loaded assembly bounds all ZNPS fuel (4.0%-15 GWd/MTU)
    - Multiple mis-loads not credible (< 10^{-6})
    - Actual k_{eff} < 0.95 by wide margin (fission products)
  - Conclusion: Criticality due to mis-loaded fuel not credible for ZNPS fuel inventory

Assuring Load Plan Compliance

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- Fuel Loading Operational Verifications
  - Load plan development using CaskLoader software
  - Fuel assembly move sheet generation using TracWorks software
  - Stringent fuel handling administrative controls including serial number dual verification
  - Continuous Quality Control and Engineering oversight
  - All fuel loads videotaped to document fuel / insert serial number independent verification

Load Plan Summary

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- 2,226 assemblies in 61 MAGNASTOR canisters
- 1,728 fuel inserts
- 1,454 assemblies modified with ITTR's
- Damaged & High Burnup Fuel
  - Load in Damaged Fuel Cans (~10 + 36)
- High Reactivity Fuel
  - Use of partially loaded canisters & RCCA's
  - Fuel relying on RCCA's will be placed in center 9 basket slots
  - Burnup uncertainty of 5% will be applied
- Load plan compliant with MAGNASTOR and MAGNATRAN storage and transport systems