St. Lucie Unit 2
Fuel Transition Project

November 3, 2014

AGENDA

- Introduction and Purpose
- Proposed Technical Specifications Changes
- Fuel Mechanical Design
- Nuclear Design
- Thermal Hydraulic Design
- Accident and Transient Analyses
- Impact on Other Analyses
- License Amendment Request Contents
- Summary and Schedule
- Public Questions

Introduction and Purpose

- **Purpose**: Discuss the planned License Amendment Request for the transition to the AREVA High Thermal Performance (HTP) fuel design at St. Lucie Unit 2.
- St. Lucie Unit 2 has experienced some grid-to-rod fretting fuel failures in the current fuel design.
- The AREVA HTP fuel has operated successfully in St. Lucie Unit 1 for 8 complete cycles without fuel failures.
- The transition to AREVA HTP fuel design is planned for Cycle 23 – Current operating cycle is Cycle 21.

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St. Lucie Unit 2 Description

- St. Lucie 2 is a Combustion Engineering 2x4 plant with a 16x16 fuel lattice array.
- Except for fuel array, Units 1 and 2 are very similar
  - 217 fuel assemblies in core
  - 4 guide tubes, 1 center instrument tube
  - 8.18 inch bundle pitch
  - 136.7 inch fuel column
  - 3,020 MW(th) core power

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Proposed Technical Specifications Changes

- **Technical Specifications changes:**
  - TS 4.2.1.3 (Surveillance Requirements for LINEAR HEAT RATE)
    - -- Delete bullets d – f.
      - – Deletion of Fq surveillance with W(z), when monitoring on excore detector system, is consistent with AREVA methods & similar to St. Lucie Unit 1.
  - TS 5.3.1 (Fuel Assemblies)
    - -- Add M5 as a fuel rod cladding material.
      - – Change “Zircaloy or ZIRLO” to “Zircaloy, ZIRLO or M5”
  - TS 6.9.1.11 (CORE OPERATING LIMITS REPORT)
    - -- Revise to include AREVA NRC approved methods for Neutronics, Fuel Mechanical, Thermal-Hydraulics, and Safety Analyses.

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Proposed Technical Specifications Changes (Contd.)

-- Neutronics Methods

- EMF-96-029(P)(A), Volumes 1 & 2
- XN-NF-78-44 (NP)(A)
- XN-75-27(A), and Supplements 1 through 5

-- Fuel Mechanical Design Methods

- XN-NF-82-06 (P)(A), Rev 1 and Supplements 2, 4 and 5
- XN-NF-85-92(P)(A)
- ANF-88-133(P)(A) and Supplement 1
- EMF-92-116(P)(A), Rev 0
- BAW-10240(P)(A), Rev 0

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Proposed Technical Specifications Changes (Contd.)

-- Thermal Hydraulics Methods

- XN-NF-82-21(P)(A), Revision 1
- EMF-92-153(P)(A), Revision 1
- EMF-1961(P)(A), Revision 0
- EMF-2310(P)(A), Revision 1
- XN-75-32(P)(A), Supplements 1, 2, 3 and 4

-- Safety Analyses Methods

- EMF-2310(P)(A), Revision 1 (S-RELAP5 Non-LOCA)
- BAW-10231P-A, Revision 1 (COPERNIC)
- EMF-2103(P)(A) Revision 0 (RLBLOCA)
- EMF-2328(P)(A) Revision 0 (SBLOCA)

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Proposed Technical Specifications Changes (Contd.)

- **Other Affected Technical Specifications**
  - TS Condition 3.K (ZIRLO Requirements)
    - -- This TS is applicable to ZIRLO cladding. Since ZIRLO clad fuel will remain in the core during transition cycles, this TS is retained.
  - TS Condition 3.N (FATES3B Safety Analyses)
    - -- Current more restrictive requirements retained for Westinghouse fuel.
    - -- Requirement for re-analyses for thermal conductivity degradation effects for Westinghouse fuel are deleted due to transition to AREVA fuel.

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Proposed Technical Specifications Changes (Contd.)

  - TS Figure 2.1-1 (Thermal Margin Safety Limit Lines)
    - -- Remains unchanged
      - Figure verified to be applicable for the fuel design change.

- **COLR Changes**
  - Delete Fq surveillance W(z) requirements and Table 3.2-3, consistent with the change to TS 4.2.1.3.
  - Revise Figure 3.2-1 to change peak linear heat rate limit from 12.5 kW/ft to 13 kW/ft.
  - Revise the list of methodology consistent with the changes to TS 6.9.1.11.
- **TS Bases Changes**
  - Revise TS Bases consistent with the above TS changes.

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Fuel Mechanical Design

- AREVA HTP Fuel Design
  - Overall assembly geometrical dimensions similar to AREVA HTP design in St. Lucie-1
  - HTP design robust and grid-to-rod fretting resistant
  - MONOBLOC guide tube
  - M5 fuel rod cladding
  - FUELGUARD debris filter
- Operating Experience
  - Significant successful operating history of base HTP design in B&W 15x15 plants, Westinghouse 15x15 and 17x17 plants, and CE 14x14, 15x15, and 16x16 plants in the US, as well as worldwide experience.

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Fuel Mechanical Design (Contd.)

- Bundle and Component Testing
  - Performed extensive component and fuel assembly mechanical testing.
  - Performed hydraulic testing on AREVA HTP and co-resident fuel design.
  - Testing in the same flow loop ensures comparable results.
  - Supports thermal-hydraulic compatibility in transition cores.

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Fuel Mechanical Design (Contd.)

- Mechanical Compatibility
  - Fuel determined to be compatible with reactor components and co-resident fuel.
- Mechanical Design Evaluations
  - Acceptable results for fuel rod analysis and structural analysis.
  - Analysis meets all NRC-approved mechanical criteria established per EMF-92-116(P)-A, BAW-10240(P)-A, and BAW-10133(P)-A, Rev. 1, and Addendums 1 and 2.
    - Requirements of the Standard Review Plan 4.2. (NUREG-0800) are satisfied.
    - Issues identified in IN-2012-09, Irradiation Effects on Fuel Assembly Spacer Grid Crush Strength, are addressed.

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Fuel Mechanical Design (Contd.)

- TCD impacts have been incorporated.
- Performed full seismic/LOCA evaluation for BOL and EOL conditions using BAW-10133P-A.
- Seismic models include a full core of AREVA HTP fuel as well as a series of mixed-core configurations with the co-resident design.

- Conclusions
  - The mechanical and structural design requirements are demonstrated to be met through mechanical testing and analyses.
  - All fuel rod and fuel assembly criteria are met.
  - Structural integrity is acceptable under seismic (OBE and SSE), and combined SSE+LOCA loading conditions.
  - The coolable geometry and control rod insertability requirements are satisfied.

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Nuclear Design

- Core/Neutronics Design
  - The reload methodology unchanged from the current methodology used for St. Lucie-2 (ANC). AREVA PRISM code will be used for selected analyses.
  - BEACON core monitoring system will continue to be used.
  - FPL's ANC-based physics methodology will continue to be used with AREVA safety analysis codes – same as current St. Lucie-1 methodology.
  - AREVA PRISM code used for transition analyses.
    - -- Benchmarked to St. Lucie-2 Cycles 14-20.
      - showed acceptable results.
    - -- Developed representative transition cycle designs.
    - -- Generated power histories, axial shapes, and other safety inputs
      - Parameters similar to current designs and within the current cycle-to-cycle variations.

Thermal Hydraulic Design

- Mixed core evaluations
  - Pressure drop testing of HTP and co-resident fuel
  - Hydraulic Compatibility
    - -- Core Pressure Drop, RCS Loop Flow, and Bypass Flow
      - Calculated change in pressure drop and core flow due to transition.
    - -- Crossflow Velocities
      - Assured satisfactory mechanical performance during transition.
    - -- DNB Performance
      - Determined relative DNB performance during transition.
    - -- Guide Tube Heating
      - Verified no boiling.

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Thermal Hydraulic Design (Contd.)

- Mixed core evaluations
  - Hydraulic Compatibility (contd.)
    - -- Control Rod Drop Time
      - Validated no change to Tech Spec drop time.
    - -- Hydrodynamic instability
      - Evaluated susceptibility to thermo-hydrodynamic instabilities.
- Setpoint analysis verified no changes to setpoints.
- Analysis met the acceptance criteria of EMF-92-116(P)-A.
- Results and Conclusions
  - Thermal-hydraulic compatibility between AREVA fuel and co-resident fuel was confirmed.
  - DNB and FCM analyses meet requirements.
  - Setpoint verifications maintain positive margin.

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Accident and Transient Analyses

- Methodology used for St. Lucie Unit 2 transition work (LOCA and non-LOCA Safety Analyses) is the same as recently approved for St. Lucie Unit 1 EPU.

- **Non-LOCA Analyses**
  - EMF-2310 Revision 1 methodology as modified and approved for St. Lucie-1, applied to events affected by fuel design change
  - S-RELAP5 non-LOCA analyses provide boundary conditions for MDNBR and peak LHR calculations
  - S-RELAP5 calculates peak fuel centerline temperature for “fast” events

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Accident and Transient Analyses (Contd.)

- **Non-LOCA Analyses (contd.)**
  - Analysis Codes Used
    - -- S-RELAP5
    - -- RODEX2
    - -- COPERNIC
    - -- X-COBRA-IIIC
    - -- PRISM
  - Disposition of events
    - -- Identified events not affected by fuel design change
    - -- Identified events affected by fuel design change but bounded by other analyses
    - -- Identified affected events for re-analysis with AREVA methodology

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Accident and Transient Analyses (Contd.)

- Analysis of affected events
  - -- Analyzed for SAFDLs
    - Feedwater system malfunctions
    - Increase in steam flow
    - Pre-trip steamline break
    - Post-trip steamline break
    - Loss of condenser vacuum
    - Loss of forced reactor coolant flow
    - Reactor coolant pump shaft seizure
    - Uncontrolled CEA withdrawal
    - Dropped CEA
    - Inadvertent opening of a PORV
    - CEA Ejection (also analyzed for energy deposition)
  - -- CVCS malfunction (boron dilution) - analyzed for sub-criticality
  - -- Loss of coolant accidents

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Accident and Transient Analyses (Contd.)

- Events unaffected by fuel design change
  - -- Loss of condenser vacuum (overpressurization)
  - -- Loss of AC Power (overpressurization)
  - -- Loss of normal feedwater
  - -- Feedwater system pipe break
  - -- Reactor coolant pump shaft seizure (overpressurization)
  - -- Uncontrolled CEA withdrawal (overpressurization)
  - -- CVCS malfunction (increase in RCS inventory)
  - -- Steam generator tube rupture
- Events bounded by other events
  - -- Inadvertent opening of a MSSV or ADV
  - -- Loss of AC power (SAFDL)

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Accident and Transient Analyses (Contd.)

- **SBLOCA Analysis**
  - SBLOCA EMF-2328 Rev. 0 methodology with modifications (same method as approved for St. Lucie-1)
  - Conservative analysis inputs
    - -- peak LHR of 13 kW/ft
    - -- Fr of 1.65
    - -- SG tube plugging of 20%
  - S-RELAP5 break spectrum and SI line break analyses
  - PCT and Oxidation confirmed to meet limits
  - SI Line Break not limiting

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Accident and Transient Analyses (Contd.)

- **RLBLOCA Analysis**
  - RLBLOCA EMF-2103 Rev. 0 methodology with Transition Package and changes (same method as approved for St. Lucie-1)
  - Conservative analysis inputs
    - -- peak LHR of 13 kW/ft
    - -- Fr of 1.65
    - -- SG tube plugging of 20%
  - S-RELAP5 best-estimate uncertainty analysis
  - Included LOOP and no-LOOP
  - PCT and Oxidation confirmed to meet limits

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Impact on Other Analyses

- **Radiological Consequences Analysis**
  - No change in power level
  - No change to the applicable peaking limits
  - No change to plant systems
  - Accident analysis results within the fuel failure assumptions used in the dose analysis
  - UFSAR analyses continue to remain applicable

Impact on Other Analyses (Contd.)

- **Spent Fuel Pool Criticality Analysis**
  - Criticality analysis remains bounding
    - -- Power level remains unchanged.
    - -- No change in fuel parameters input to criticality analysis.
    - -- Spent fuel pool configuration and poison remain unchanged.
- **Post-LOCA Long Term Cooling**
    - -- Boron precipitation analysis unaffected by the fuel design change.
    - -- Post-LOCA criticality analyzed/evaluated every cycle based on cycle specific core design.

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Contents of License Amendment Request

- **Proposed Technical Specifications Changes**
  - Description/Justification of changes
  - COLR/TS/Bases changes
  - Regulatory Analysis
    - -- Regulatory requirements/Criteria
    - -- No Significant Hazard Consideration Determination
    - -- Environmental Evaluation
- **Evaluation of TS and Fuel Design Changes**
  - Technical Report
  - Non-LOCA Summary Report
  - SBLOCA Summary Report
  - RLBLOCA Summary Report

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Contents of License Amendment Request (Contd.)

- Other analysis
  - -- Radiological consequences analysis
  - -- Post-LOCA long-term cooling analysis
  - -- SFP criticality analysis

- **Technical Report**
  - Description of fuel design
  - Fuel mechanical design/analysis description
    - -- mixed core effects, including impact on co-resident fuel
  - Neutronics design / methodology
  - T&H analysis / fuel compatibility
  - Non-LOCA analysis results
  - SBLOCA analysis results
  - RLBLOCA analysis results

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Contents of License Amendment Request (Contd.)

- **Non-LOCA summary report**
  - Details of non-LOCA analyses
- **SBLOCA summary report**
  - Details of SBLOCA analysis
- **RLBLOCA summary report**
  - Details of RLBLOCA analysis
- M5 Cladding 10 CFR 50.46 and 10 CFR 50 Appendix K Exemption Request (recently approved for St. Lucie Unit 1)

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Summary

- **Summary**
  - Improved fuel design
    - -- operating parameters unchanged
    - -- Benefits in fuel reliability – resistance to grid-to-rod fretting
  - Analyses confirm that acceptance criteria using approved Topical Reports are met for all analyses.
  - No change in FPL Neutronics methodology.
  - Safety analysis methodology - previously approved and currently used for St. Lucie Unit 1.
  - Lessons learned from recent AREVA fuel transitions and St. Lucie Unit 1 EPU incorporated in the transition work.
  - M5 Exemption - previously approved by NRC for other licensees and St. Lucie Unit 1.

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Schedule

Key Milestones	
Pre-Submittal Meeting	November 3, 2014
License Amendment Request, M5 Cladding Exemption Request	December 2014
Post-Submittal Meeting (as necessary)	TBD
SER request date	1Q 2016
Initial AREVA Fuel delivery	1Q 2017
Implementation	Cycle 23

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