TVA Clinch River SMR Project
The PPE Approach to ESPA and Emergency Planning Exemptions

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TVA Created in 1933 to Make Life Better

“...a Corporation clothed with the power of government, but possessed of the flexibility and initiative of a private enterprise.”
- Franklin D. Roosevelt
The TVA Power System

Public Power Provider
7-state region
80,000 square miles
9 million people
154 local power companies
58 direct-served customers
Investing in Cleaner Energy

- RENEWABLE
- HYDRO
- NUCLEAR
- COAL
- NATURAL GAS

FY18 Actual Power System Mix:
- 53% Non-Emitting Renewables
- 39% Nuclear
- 26% Coal
- 21% Gas
- 10% Hydro
- 3% Wind and Solar
- 9% TVA Energy Efficiency

Generating Sources:
- Coal
- Gas
- Nuclear
- Hydro
- Wind and Solar
- TVA Energy Efficiency
Small Modular Reactors (SMRs)

SMRs are a next-generation nuclear technology with potential for improved safety and increased operational flexibility. SMRs,

- Support TVA’s technology innovation mission
- Are consistent with TVA’s vision to be one of the nation’s leaders in cleaner, low-cost energy.
- Are defined as nuclear reactors 300MWe or less, enabling factory fabrication
- Could safely shut down and self-cool, with no operator action, no electrical power, and no additional water
- Have smaller reactor core inventory and radiological source terms
- Have slower accident progression and time to fuel damage is long enough to allow ad-hoc emergency planning
- Have the potential for reduced emergency planning zones
Program Background
- 2009 TVA began exploring potential SMR Project
- 2014 - TVA shifts to PPE approach

Potential Candidate Areas
- Naval Support Activity Mid-South
- Oak Ridge Reservation
- Redstone Arsenal
- Arnold Air Force Base
- Columbus Air Force Base
- Fort Campbell

Regional Screening Criteria
- Seismology considerations
- Cooling-water availability
- Population density
- Proximity to targeted customer
Clinch River Site
Oak Ridge Reservation

- TVA Managed Property, Owned by the United States of America
- Clinch River Site - 935 acres
- Barge/Traffic Area - 196 acres
- Neighbor to DOE ORNL, an interested customer
- Access to 500 KV and 161 KV transmission
- Site of former Clinch River Breeder Reactor Project
- Not currently used for power generating activities
- Some basic infrastructure exists (e.g., retention ponds, roads)
- Strong community support
- Abundant and skilled workforce
Early Site Permit Application

Application includes:

- Site Safety Analysis Report (SSAR)
- Environmental Report (ER)
- Exemptions and Departures (Part 6)

**ESPA based on a “plant parameter envelope” (PPE)**

- Composite of reactor and engineered parameters based on the four U.S. light-water SMR designs under development when the application was prepared
- Developed based on NEI 10-01 guidance with margin added to specific parameters
- Up to 800MWt for a single unit with a combined nuclear generating capacity not exceeding 2420 MWt (800 MWe)
- Assumes two or more SMR units
ESPA Review Summary

- TVA submitted ESPA May 2016
- NRC Accepted and Commenced Review in December 2016
- Contains more than 8,000 Pages
- Supported by over 80,000 pages in referenced documents
- Efficient Use of Audits
- Minimal Requests for Additional Information (RAIs)
- Early, Open, Frequent, Clear, and Candid Communication with NRC
ESP - PPE Approach

NEI 10-01 [Revision 1] Industry Guideline for Developing a Plant Parameter Envelope in Support of an Early Site Permit, May 2012

- Supports an ESP application consistent with the requirements of 10CFR52
- Supports finality on siting issues prior to selecting a specific reactor technology
- Obtain four Vendor Information Worksheets
- Four SMR vendors, BWXT mPower, Holtec, NuScale, and Westinghouse,
- Select bounding parameters for the “surrogate” plant to effectively bound all designs
- Include “reasonable margin” for each PPE parameter
- Create PPE table and supporting basis documentation
- Includes normal and accident source terms
ESPÁ - PPE Approach

Four SMR Vendors considered for the Clinch River Site

<table>
<thead>
<tr>
<th>Vendor</th>
<th>MWt</th>
<th>MWe</th>
<th>Number of Units</th>
<th>MWt Total</th>
<th>MWe Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWXT mPower</td>
<td>530</td>
<td>171</td>
<td>4</td>
<td>2,120</td>
<td>684</td>
</tr>
<tr>
<td>Holtec</td>
<td>525</td>
<td>154</td>
<td>4</td>
<td>2,100</td>
<td>616</td>
</tr>
<tr>
<td>NuScale</td>
<td>160</td>
<td>47.5</td>
<td>12</td>
<td>1,920</td>
<td>570</td>
</tr>
<tr>
<td>Westinghouse</td>
<td>805</td>
<td>240</td>
<td>3</td>
<td>2,420</td>
<td>720</td>
</tr>
</tbody>
</table>
1.2.1 Maximum Rainfall Rate

**Site Safety Analysis Report:** The plant shall be designed to withstand the most severe climatological events anticipated for the areas of concern. Included in this evaluation is consideration for the maximum local rainfall rates in a 1 hour period in 1 square mile.

**Vendor Worksheets**
Vendor 1 Value: 19.4 inches within 1 hour,  
Vendor 2 Value: 20 inches within 1 hour  
Vendor 3 Value: 19.4 inches within 1 hour  
Vendor 4 Value: 19.4 inches within 1 hour

**Site Value:** TVA Clinch River site maximum precipitation values determined from Hydrometeorological Report HMR 52, Figure 24: 18.8 inches/hour is the site characteristic.

**Conclusion:** Comparison of the vendor values to the site characteristic shows each of the listed vendor precipitation values are greater than the site characteristic values supporting the conclusion that each vendor will design a plant to withstand the maximum rainfall rate for the CRN Site.

**Design Margin:** No additional margin will be included in this value.
### ESPA - PPE Example Table

<table>
<thead>
<tr>
<th>PPE Section</th>
<th>Definition</th>
<th>Comments</th>
<th>Parameter Type</th>
<th>PPE Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3.3 Mechanical Draft Cooling Towers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3.4 Blowdown Flow Rate</td>
<td>The normal (and maximum) flow rate of the blowdown stream from the cooling water systems to the receiving water body for closed system designs</td>
<td>Values for Site</td>
<td>Eng</td>
<td>Maximum: (2 COC) 12,800 gpm, Expected: (4 COC) 4,270 gpm See Figure 1</td>
</tr>
<tr>
<td>3.3.9 Makeup Flow Rate</td>
<td>The expected (and maximum) rate of removal of water from a natural source to replace water losses from closed cooling water systems.</td>
<td>Values for Site</td>
<td>Eng</td>
<td>Maximum: 25,608 gpm, Expected: 17,078 gpm See Figure 1</td>
</tr>
<tr>
<td>3.3.14 Maximum Consumption of Raw Water</td>
<td>The expected maximum short-term consumptive use of water by the cooling water systems (evaporation and drift losses).</td>
<td>Value for Site</td>
<td>Eng</td>
<td>12,808 gpm</td>
</tr>
</tbody>
</table>
ESPA - PPE Example Figure
ESPA – Emergency Preparedness Approach

Emergency Planning Information located in 3 Parts of the ESPA

- Part 2 – SSAR, PEP EPZ Sizing Methodology
  - SSAR, Section 13.3, *Emergency Preparedness*
  - Dose-Based, consequence-oriented and risk-informed approach
  - Reasonable assurance for adequate protection

- Part 5 - Emergency Plan
  - Two major features Emergency Plans
    - Part 5A – Site Boundary plume exposure pathway (PEP) emergency planning zone (EPZ) Emergency Plan
    - Part 5B – 2-Mile PEP EPZ Emergency Plan

- Part 6 - Exemptions and Departures
  - 2 sets of exemption requests – accompany the less than 10-mile EPZ emergency plans in Part 5
    - Exemption requests for a PEP EPZ at Site Boundary
    - Exemption requests for a 2-mile PEP EPZ

The final EPZ size for the Clinch River Site will be determined in COL or CP
Part 5A – Emergency Plan (Site Boundary EPZ)
Part 5B – Emergency Plan (2-Mile EPZ)

Legend
- Clinch River Site Center Point
- EPZ Boundary
- 2 mile radius
- County Boundary
- Tennessee State Parks
- Incorporated Areas
- Railroad
- Interstate
- Highway
- Major Road
- Local Road
Part 6 – Exemptions and Departures

Pursuant to 10 CFR 52.7, Specific Exemptions, which is governed by 10 CFR 50.12, Specific Exemptions, TVA requested exemptions from:

- 10 CFR 50.47(b) regarding onsite and offsite emergency response plans for nuclear power reactor
- 10 CFR 50.33(g) and 10 CFR 50.47(c)(2) to establish PEP EPZ for nuclear power plants
- 10 CFR Part 50, Appendix E, which establish the elements that make up the content of emergency plans

Two Sets of Exemptions

- Exemptions for an approximate 2-mile PEP EPZ
  - Deviate from 10-mile PEP EPZ

- Exemptions for a PEP EPZ established at the Site Boundary
  - Deviate from 10-mile PEP EPZ
  - Various elements of a formal offsite emergency plan
  - Evacuation time estimates
  - Certain elements of offsite notifications and exercises
Part 2 – PEP EPZ Sizing Methodology

- SMR design and safety advancements
- Consistent with NUREG-0396 sizing rationale
  - Addresses a broad spectrum of accidents
  - Aligns with recommended dose criteria
  - Environmental Protection Agency (EPA) early-phase (Protection Action Guides) (PAGs) – 1 roentgen equivalent man (rem) total effective dose equivalent (TEDE)
Part 2 – PEP EPZ Sizing Methodology Technical Criteria

- **Criterion A – design basis accidents**
  - EPA early-phase PAG dose less than 1 rem TEDE.

- **Criterion B – less severe core melt accidents**
  - Core Damage Frequency (CDF) greater than 1E-6 per reactor-year (rx-yr)
  - Intact containment
  - EPA early-phase PAG dose less than 1 rem TEDE.

- **Criterion C – more severe core melt accidents**
  - CDF greater than 1E-7 per rx-yr and
  - Containment bypass or failure
  - Sufficient size to provide Reduction in Early Severe Health Effects [distance at which the conditional probability to exceed 200 rem (whole body) exceeds 1E-3 per rx-yr] [1 in a 1000]

A future application would implement the EPZ size methodology, with site- and design-specific input, to determine the final EPZ size for the Clinch River Site.
### Evaluates NuScale Power Plant at Clinch River Site

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Site Boundary Dose TEDE (rem)</th>
<th>EPA Early Phase PAG Limit TEDE (rem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.104</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>0.158</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>No accident scenarios met the required screening criteria.</td>
<td></td>
</tr>
</tbody>
</table>

Site specific consequences are determined by the ratio of the $\chi/Q$ methodology described in NEI 10-01

EPA-400 PAG Manual Protective Action Guides and Planning Guidance for Radiological Incidents *JANUARY 2017*
Summary – Emergency Preparedness Approach

Part 5 Emergency Plan
- Approval of the major features of the Site Boundary (Part 5A) and 2-mile emergency plan (Part 5B)
- A future application would describe a complete and integrated emergency plan

Part 6 Exemptions
- Primarily to deviate from the current 10-mile PEP EPZ size requirement based implementation of the dose-based, consequence-oriented methodology

Part 2 Plume Exposure Pathway EPZ Methodology
- Risk-informed, dose-based, consequence-oriented approach customized for SMR technology
- Approval to use the methodology for design and site specific implementation in a future application [COLA or CP]
Question?

Kingston Fossil Plant – downstream

Melton Hill Dam - upstream

Artist Rendering NuScale SMR
Acknowledgement and Disclaimer

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