



NATRIUM

a TerraPower & GE-Hitachi technology

Emergency Planning Strategy and Emergency Planning Zone Sizing Methodology

NATD-LIC-PRSNT-0024



SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054
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Overview

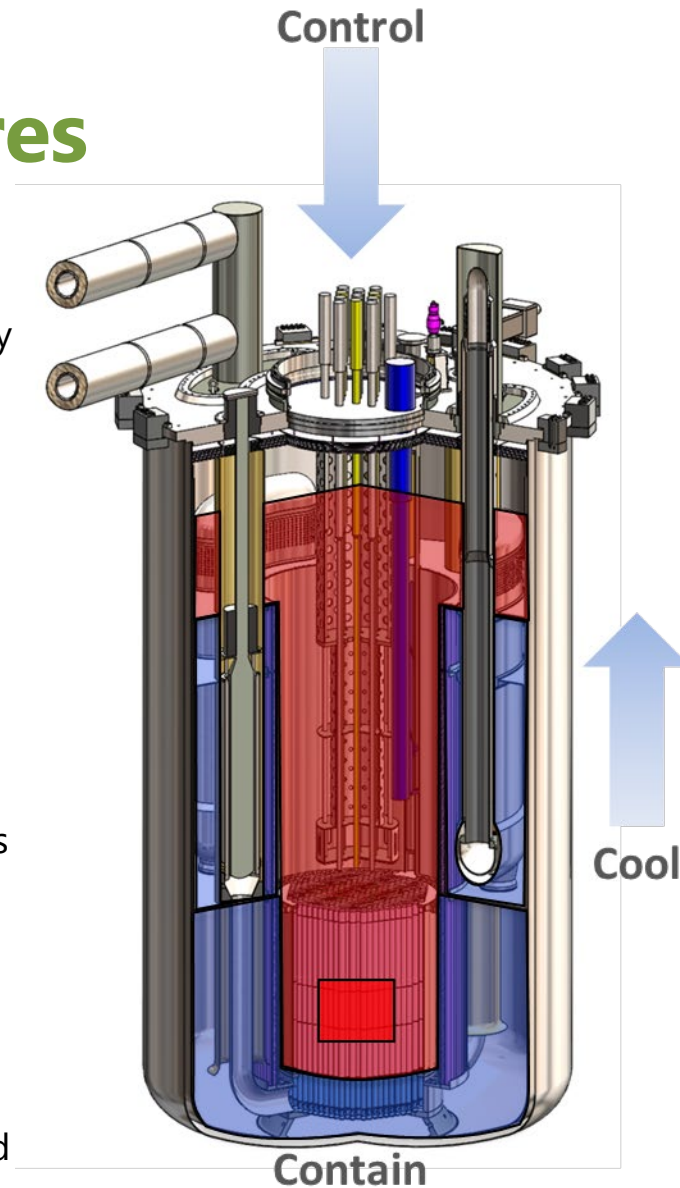
- Natrium™ Reactor Overview
- Natrium™ Emergency Planning Strategy
- Natrium™ Plume Exposure Pathway EPZ Methodology and Application
- Questions

Natrium Reactor Overview

- Regulatory Engagement Plan submitted 6/8/2021
- 10 CFR 50 licensing process will be followed
 - Construction Permit Application planned for 8/2023
 - Pre-application interactions are ongoing, intended to reduce regulatory uncertainty and facilitate the NRC's understanding of Natrium technology and its safety case
- Natrium Reactor is demonstrating the ability to design, license, construct, startup and operate the Natrium reactor within a seven-year timeframe

Sodium Safety Features

- Pool-type Metal Fuel SFR with Molten Salt Energy Island
 - Metallic fuel and sodium have high compatibility
 - No sodium-water reaction in steam generator
 - Large thermal inertia enables simplified response to abnormal events
- Simplified Response to Abnormal Events
 - Reliable reactor shutdown
 - Transition to coolant natural circulation
 - Indefinite passive emergency decay heat removal
 - Low pressure functional containment
 - No reliance on Energy Island for safety functions
- No Safety-Related Operator Actions or AC power
- Technology Based on U.S. SFR Experience
 - EBR-I, EBR-II, FFTF, TREAT
 - SFR inherent safety characteristics demonstrated through testing in EBR-II and FFTF



Control

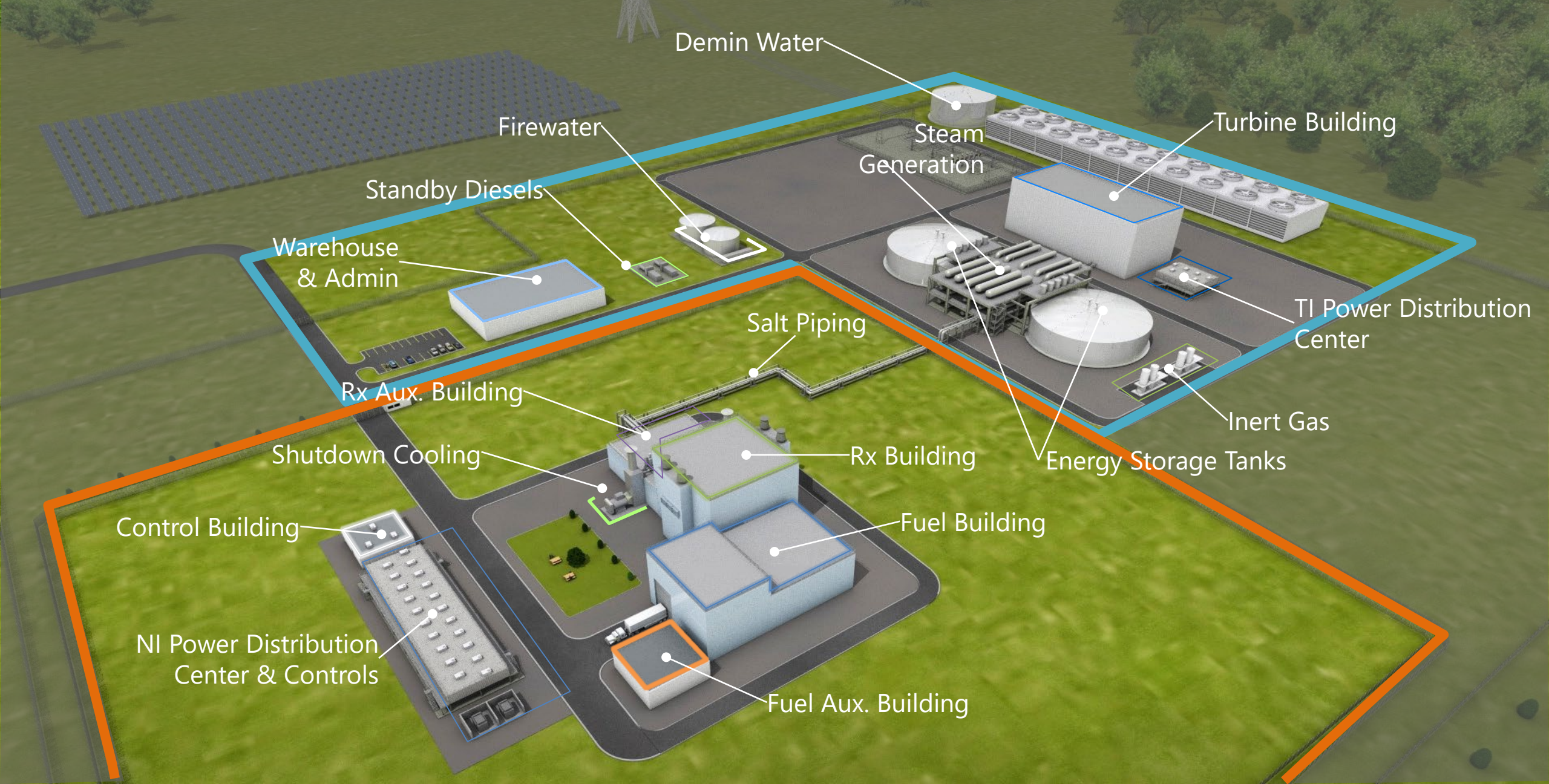
- Motor-driven control rod runback
- Gravity-driven control rod scram
- Inherently stable with increased power or temperature

Cool

- In-vessel primary sodium heat transport (limited penetrations)
- Intermediate air cooling natural draft flow
- Reactor air cooling natural draft flow – always on

Contain

- Low primary and secondary pressure
- Sodium affinity for radionuclides
- Multiple radionuclides retention boundaries



Demin Water

Firewater

Standby Diesels

Warehouse
& Admin

Steam
Generation

Turbine Building

TI Power Distribution
Center

Salt Piping

Rx Aux. Building

Shutdown Cooling

Rx Building

Energy Storage Tanks

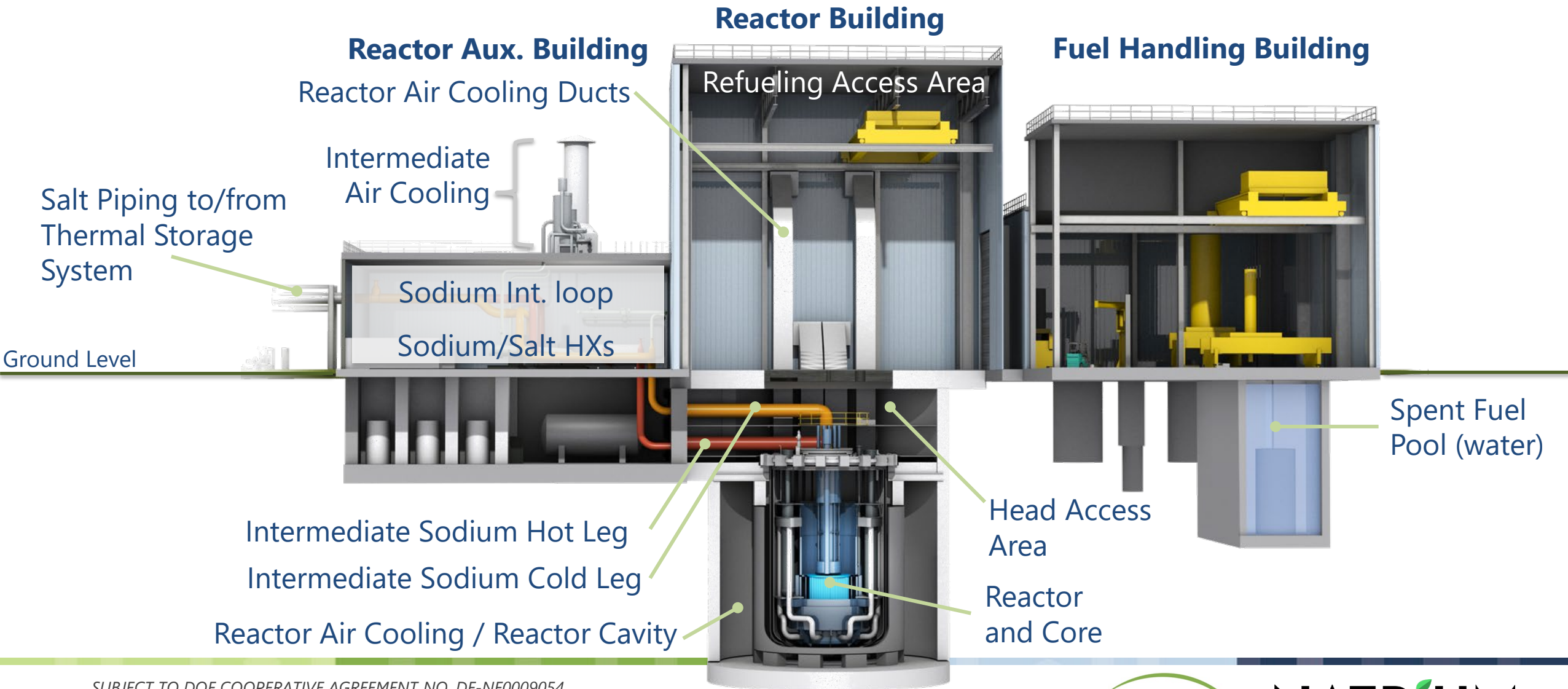
Control Building

Fuel Building

NI Power Distribution
Center & Controls

Fuel Aux. Building

Plant Overview



Natrium Emergency Planning Strategy

- Proposed Final Rule “Emergency Preparedness for Small Modular Reactors and Other New Technologies”
 - Alternate performance-based, technology-inclusive, risk-informed, and consequence-oriented approach
 - Proposed 10 CFR 50.160, in lieu 10 CFR 50.47(b) and Appendix E of 10 CFR 50 (Deterministic approach)
- Proposed Regulatory Guide 1.242, “Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities”

Natrium Emergency Planning Strategy

- If SMR and ONT Emergency Preparedness Proposed Final Rule is not approved prior to Operating License submittal
 - Follow current requirements in 10 CFR 50.33(g), 10 CFR 50.47, and Appendix E
 - Request exemptions to address EPZs and offsite response as justifiable

Natrium Emergency Planning Strategy

- Exemptions under consideration with OLA if SMR and ONT Emergency Preparedness Proposed Final Rule not approved
 - 10 CFR 50.33(g) Radiological E-Plans of State and Local Governments
 - 10 CFR 50.47(b) Offsite E-Plan Standards
 - 10 CFR 50.47(c)(2) Emergency Planning Zones
 - 10 CFR 50, Appendix E Offsite Emergency Response Considerations
 - Section IV, Content of E-Plans
 - Evacuation and Evacuation Time Estimates
 - State, Local and Public Notification
 - Full Participation Exercises with State and Local Governments

Natrium Emergency Planning Strategy

- Major provisions of proposed 10 CFR 50.160
 - Demonstrate effectiveness including response in drills and exercises
 - Hazard analysis of contiguous or nearby facilities that could adversely impact E-Plan implementation
 - Scalable EPZ for plume exposure pathway
 - 10 CFR 50.33(g)(2) technical analysis for PEP EPZ at Site Boundary
 - Description of licensee, Federal, State, and local agency resources to respond to ingestion pathway
 - Rule does not provide for a specific IPZ

Natrium Emergency Planning Strategy

- Plume Exposure Pathway for SMRs and ONTs
 - Proposed 10 CFR 50.33(g)(2)
 - Analysis to determine whether the criteria in §50.33(g)(2)(i)(A) and (B) are met
 - Size of the PEP EPZ
 - Proposed 10 CFR 50.33(g)(2)(i)
 - (A) Public dose projected > 10 mSv (1 rem) TEDE over 96 hours from release considering accident likelihood and source term, timing of the accident sequence, and meteorology
 - (B) Pre-determined, prompt protective measures are necessary

Natrium Emergency Planning Strategy

- Ingestion Planning for SMRs and ONTs
 - Proposed 10 CFR 50.160(b)(4) - describe or reference the capabilities that provide actions to protect contaminated food and water from entering the ingestion pathway

Natrium Emergency Planning Strategy

- Ingestion Exposure Pathway E-Plan Application (Proposed RG 1.242, Item C.3)
 - Address major exposure pathways associated with the ingestion of contaminated food and water
 - Describe the Federal, State, local, or licensee capabilities to
 - Support intermediate and long-term monitoring, analysis, and interdiction or embargo products
 - Describe Federal, State, and local resources to
 - Provide actions to prevent contaminated food and water from entering the ingestion pathway
 - Assess, sample, and notify to interdict foods and waters in a timely manner sufficient to avoid exceeding ingestion PAG doses

Planned Licensing Submittals

- E-Plan
 - PSAR will cover highlights
 - Final will be submitted to NRC for review/approval
- PEP EPZ Methodology Topical Report will be submitted to NRC for review/approval in 11/2022
- Final PEP EPZ calculation will be available for NRC review/audit

NATRIUM PLUME EXPOSURE PATHWAY EPZ METHODOLOGY AND APPLICATION

Application of
NEI 18-04, “Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light
Water Reactor Licensing Basis Development”
and
Proposed RG-1.242, “Performance-Based Emergency Preparedness for Small Modular
Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities”

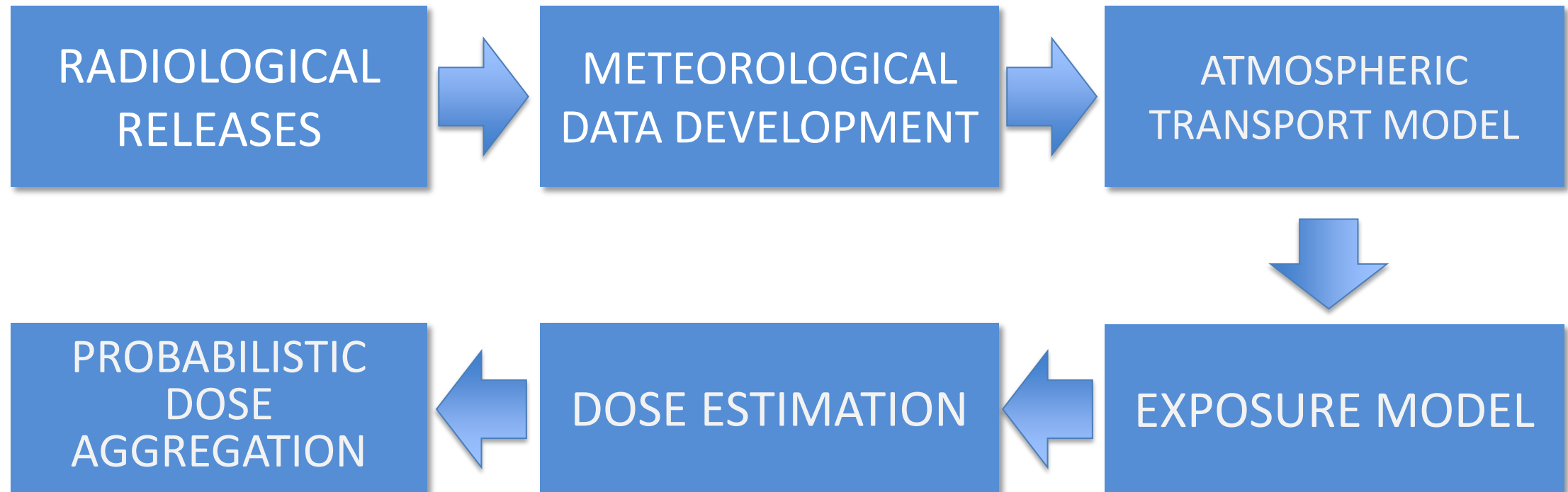
PEP EPZ at Site Boundary and Emergency Planning

- E-Plan will
 - Outline the protective measures that are necessary to protect the public in the event of a radiological release
 - Identify the protective measures that are necessary to protect the ingestion pathway from radiological releases
- PEP EPZ
 - Area in which predetermined, prompt protective measures are necessary
 - Methodology will outline the process for identifying relevant events, assessing their dose impacts to the general public, and establishing the sizing of the EPZ boundary

Plume Exposure Pathway Requirements

- Proposed RG 1.242, Appendix A, A-1 PEP EPZ determination should demonstrate the following in the technical analysis:
 - a. Area in which it is expected that prompt protective measures will be necessary
 - b. Events screened into the analysis (or not)
 - c. If the PEP EPZ extends beyond the Site Boundary, then the exact shape of the PEP EPZ and how it impacts the capabilities of the E-Plan
 - d. If no PEP EPZ is defined, then a supporting analysis that shows either the events will not exceed 10 mSv (1 rem) TEDE over 96 hours or prompt protective measures are not necessary

Plume Exposure Pathway Generalized Methodology



Radiological Releases

- All relevant internal events will be included into the analysis to establish the PEP EPZ
 - Selection criteria will be as follows:
 - DBEs will be included
 - All accident sequences contributing 1% or more to overall release frequency
 - Evaluate the sequences for equipment availability and timing and group accordingly
 - Groups with sums greater than the frequency $1\text{E}-8$ will be considered
 - All relevant events will have identified source term information
- External event selection will be proposed in Topical Report
 - Intend to use most recent NEI criteria under consideration by NRC
- PRA will include all hazards, all modes, and all significant radionuclide sources
- Uncertainty will be considered, and cliff-edge events will be included into the analysis

Meteorological Data Development

- Data collection will occur in accordance with RG 1.23, “Meteorological Monitoring for Nuclear Power Plants”
- Meteorological data that will be collected will include wind speed, wind direction, and temperature
- Meteorological data will be taken at least at two elevations to ensure atmospheric stability
- Quality and completeness of data will be assessed
- Data collection will occur for two years

Atmospheric Transport Model/Exposure Model/Dose Estimation

- Source term information will be used in the analysis
- χ/Q s will be developed for the events up to Site Boundary and possibly beyond for specific events
- MAACS will be used to determine individual and societal dose to demonstrate the NRC QHOs are met
- Comparison with the PEP EPZ Curve to ensure that dose meets QHOs and incorporates margin and uncertainty

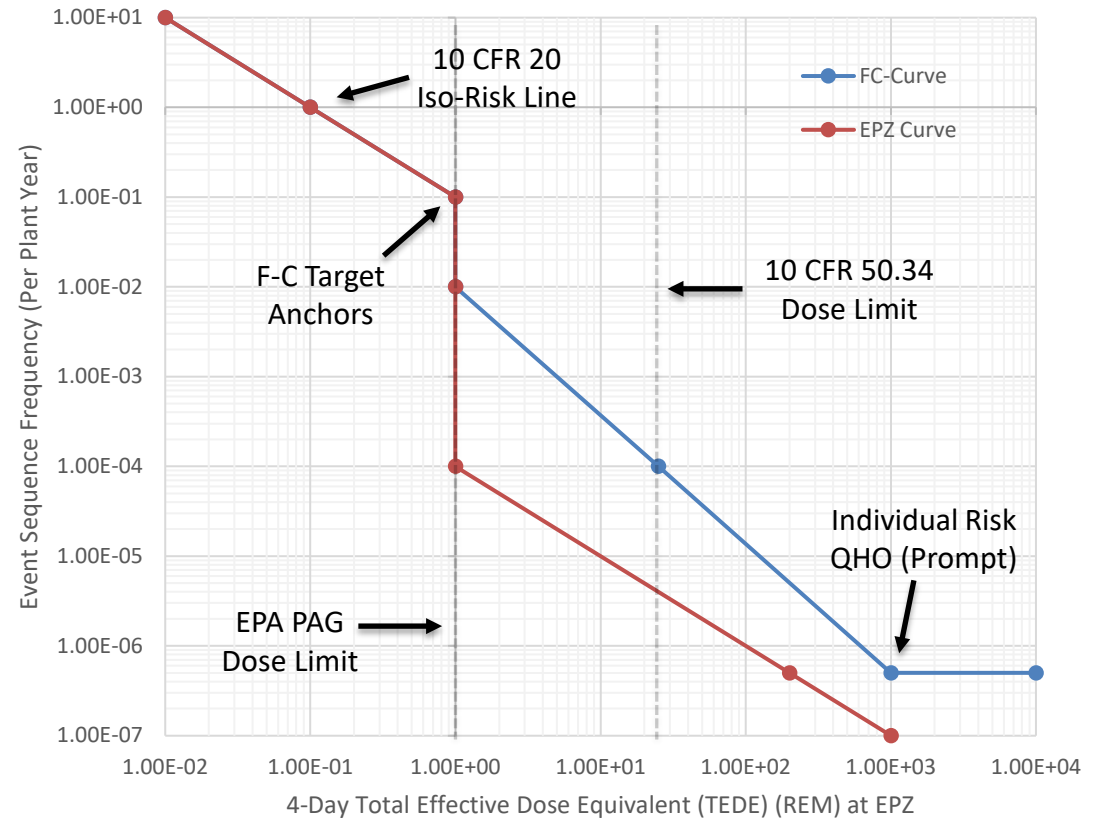
Probabilistic Dose Aggregation

- Probabilistic dose aggregation in NUREG-0396¹ demonstrated the PEP EPZ was of sufficient size such that the following conditions were met:
 - a. Projected doses from the traditional design-basis accidents would not exceed PAG levels outside the PEP EPZ
 - b. Projected doses from most core melt sequences would not exceed PAG levels outside the PEP EPZ
 - c. Worst core melt sequences, immediate life-threatening doses would generally not occur outside the PEP EPZ

¹ NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants"

Evaluation Against the F-C Curve Using PEP EPZ Curve

- Iso-risk line pinned at the EPA PAG of 1 rem for the 4-day dose to the bottom of the DBE region ($1\text{E-}4$)
- Line then goes to the 200 rem 4-day dose to the bottom of BDBE range ($5\text{E-}7$)
- Events will be considered down to $1\text{E-}8$ depending on if events are found in this region
- Line is anchored at 1,000 rem at $1\text{E-}7$
- Line below the F-C curve allows for uncertainty as conservatism



Considerations on Whether Prompt Protective Measures are Necessary

- Analysis will consider whether predetermined prompt protective measures are necessary in addition to the consequence analysis
 - Timing from the initiation of the event to the start of radiological release to the environment for all accident scenarios evaluated in the radiological dose assessment to aid in the determination of the PEP EPZ will be considered
 - Capability to protect the public without needing to develop predetermined prompt protective measures will also be considered

Wrap Up / Summary

- No planned deviations from proposed RG 1.242 when developing the E-Plan and for mitigation responses to the ingestion pathway
- Goal is to establish the PEP EPZ at the Site Boundary
- Analysis will be performed to identify the relevant events, calculate the expected dose to the public considering weather, time, and distance from site
- Events will be evaluated to ensure that they do not exceed the NRC QHOs



Acronym List

CFR – Code of Federal Regulations
DBE – Design Basis Event
DOE – Department of Energy
EBR – Experimental Breeder Reactor
EPA – Environmental Protection Agency
E-Plan – Emergency Plan
EPZ – Emergency Planning Zone
F-C – Frequency-Consequence
FFTF – Fast Flux Test Facility
IPZ – Ingestion Pathway Zone
MAACS – MELCOR Accident Consequence Code System
mSv – Milli-Sievert
NEI – Nuclear Energy Institute

NRC – Nuclear Regulatory Commission
OLA – Operating License Application
ONT – Other New Technologies
PAG – Protective Action Guidelines
PEP – Plume Exposure Pathway
PRA – Probabilistic Risk Assessment
QHO – Qualitative Health Objective
REM – Roentgen Equivalent Man
RG – Regulatory Guide
SFR – Sodium Fast Reactor
SMR – Small Modular Reactor
TEDE – Total Effective Dose Equivalent
TREAT – Transient Reactor Test