TerraPower

NATRIUM

Decoupling Strategy

a TerraPower & GE-Hitachi technology

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

Objectives

- Natrium™ reactor licensing overview
- Natrium reactor safety and plant overview
- Explain Decoupling Strategy within the Natrium design

Natrium Reactor Licensing Overview

- Regulatory Engagement Plan submitted 6/8/2021
- 10 CFR 50 licensing process will be followed
  - Construction Permit Application 8/2023
  - Operating License Application 3/2026
- Numerous pre-application interactions are planned to reduce regulatory uncertainty and facilitate the NRC's understanding of Natrium technology and its safety case
- The LMP (NEI 18-04), as endorsed by RG 1.233, will support this application

Natrium Reactor Licensing Overview

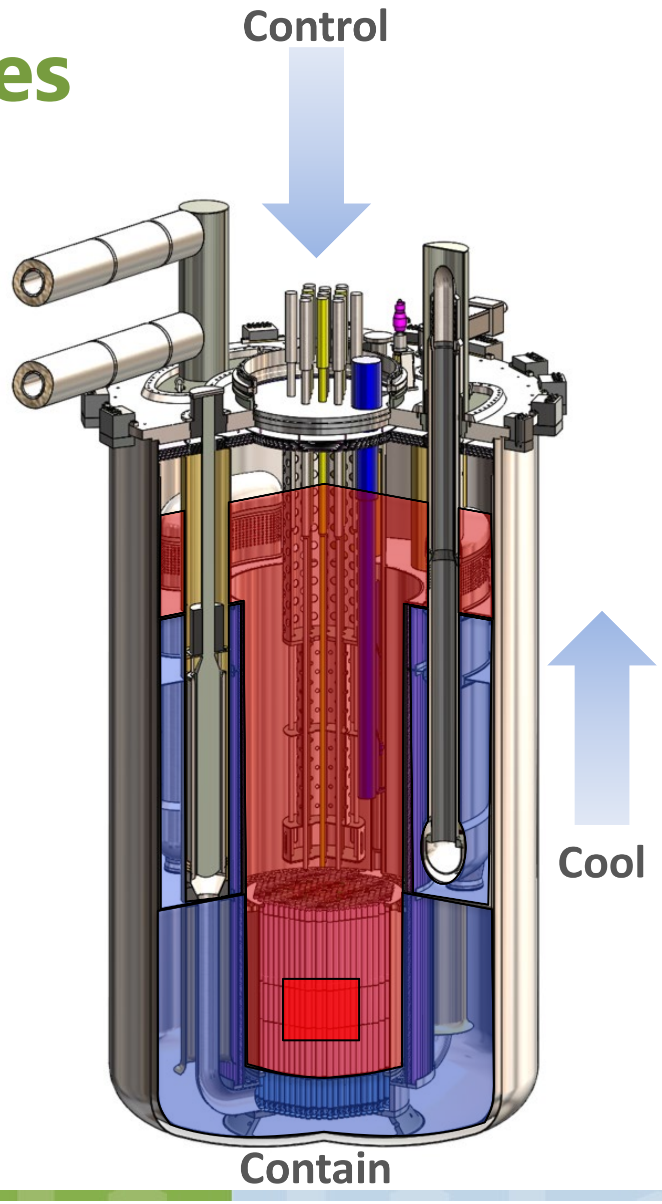
- Each pre-application interaction will build upon risk insights from prior interactions to demonstrate the Natrium reactor's safety case.
- Future Meetings and Presentations include:
  - Principal Design Criteria
  - Source Term Methodology
  - Testing Plan and Methodology

Advanced Reactor Demonstration Program

- Demonstrate the ability to design, license, construct, startup and operate the Natrium reactor within the Congressionally mandated seven-year timeframe
- Include improvements in safety, security, economics, and environmental impacts
- Utilize a simple, robust, reliable, and proven safety profile
- Lower emissions by initiating the deployment of a fleet of Natrium reactors – Demonstrate that the plants can be built economically and that they will be attractive for future owner/operators

Natrium 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

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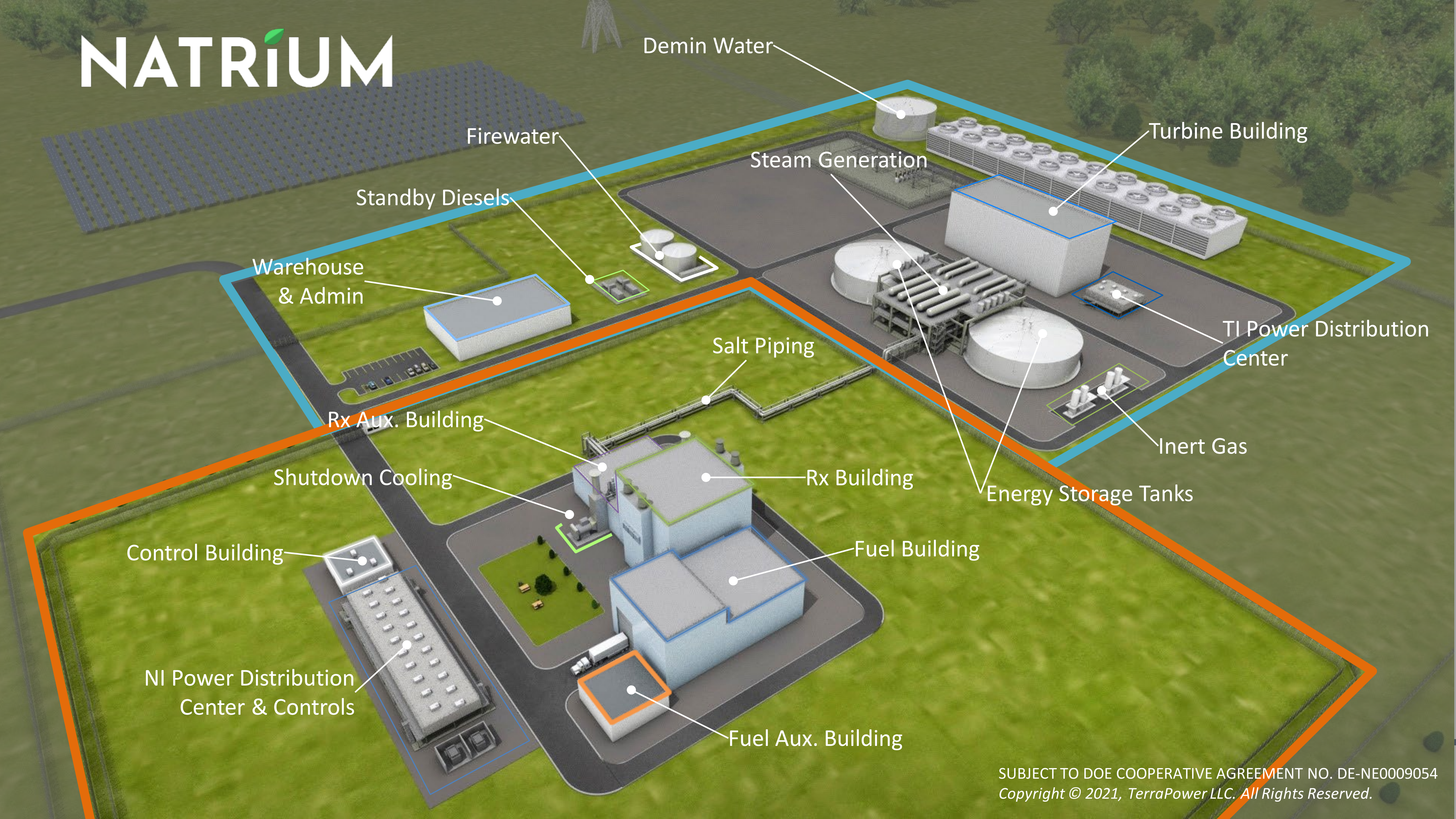
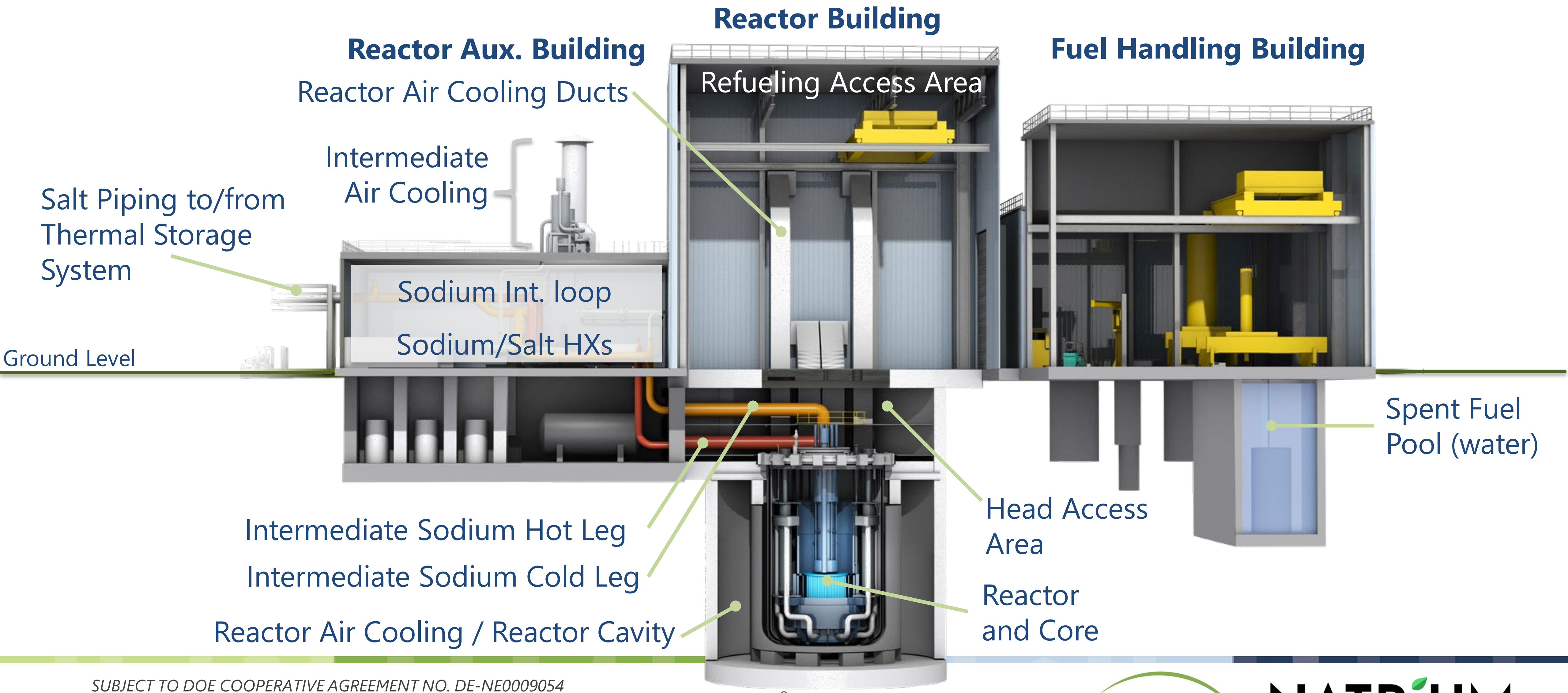

NATRIUM
Demin Water
Firewater
Turbine Building
Steam Generation
Standby Diesels
Warehouse & Admin
TI Power Distribution Center
Salt Piping
Rx Aux. Building
Inert Gas
Shutdown Cooling
Rx Building
Energy Storage Tanks
Fuel Building
Control Building
NI Power Distribution Center & Controls
Fuel Aux. Building

Plant Overview



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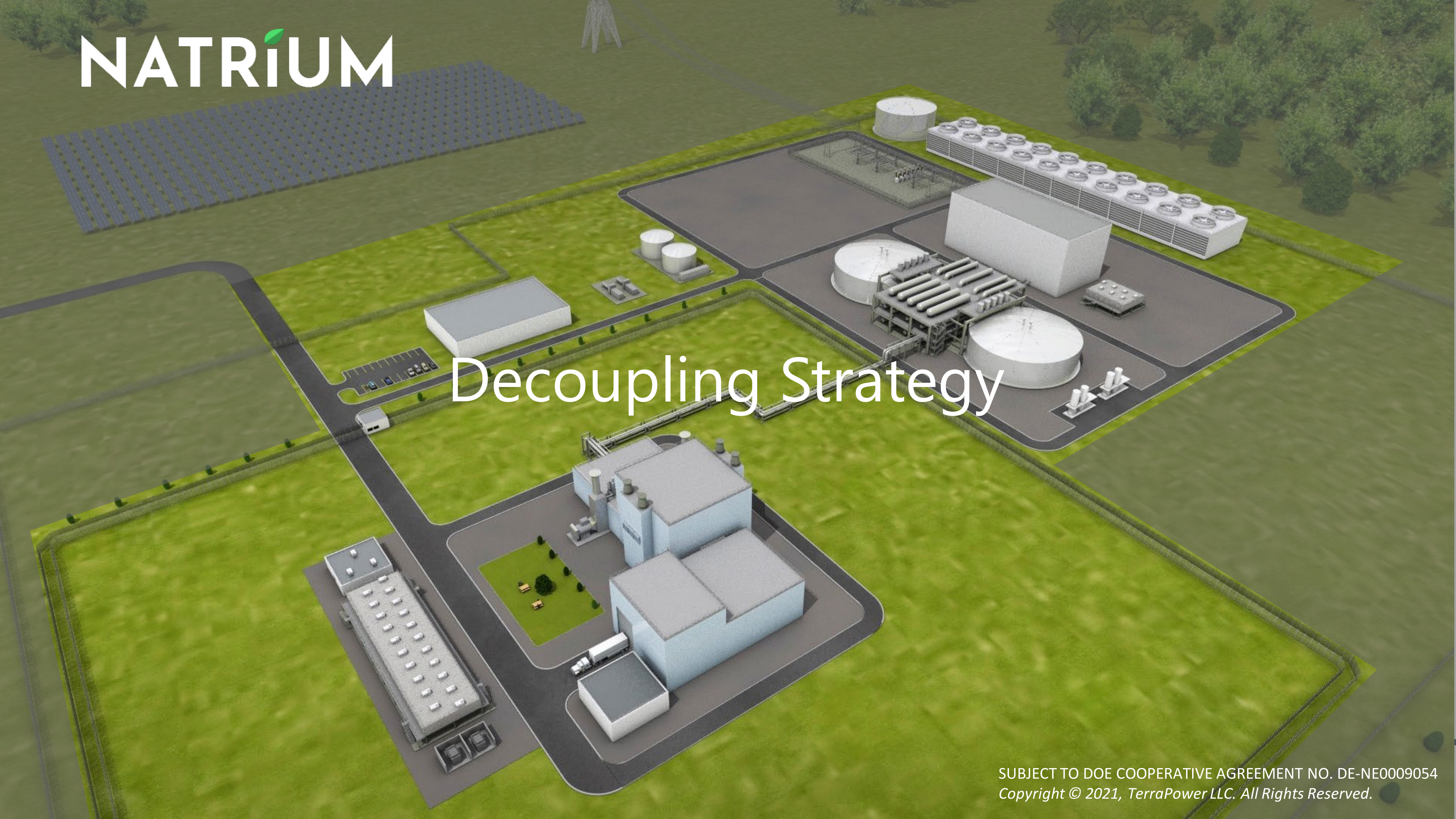

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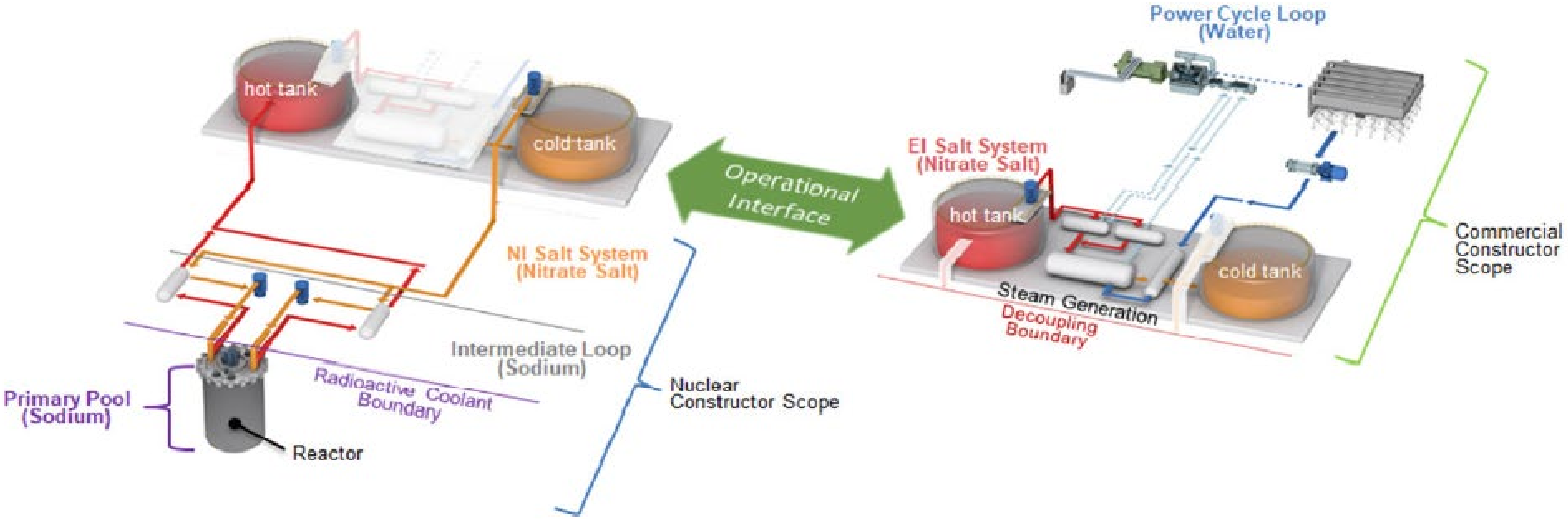
Decoupling Strategy

Decoupling Strategy

- Strategy documents in the Natrium design process
- Plant designed with as much *independence as practicable* between Nuclear Island and Energy Island
- "Decoupling" is used to describe this level of independence, which is enabled using molten salt thermal storage system
- Decoupling enables:
  - Operational flexibility
  - Transient separation
  - Regulatory separation

Decoupling Strategy



- Molten salt storage tanks eliminate direct coupling of reactor power and turbine output that are inherent in PWR and BWRs

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Operational Flexibility

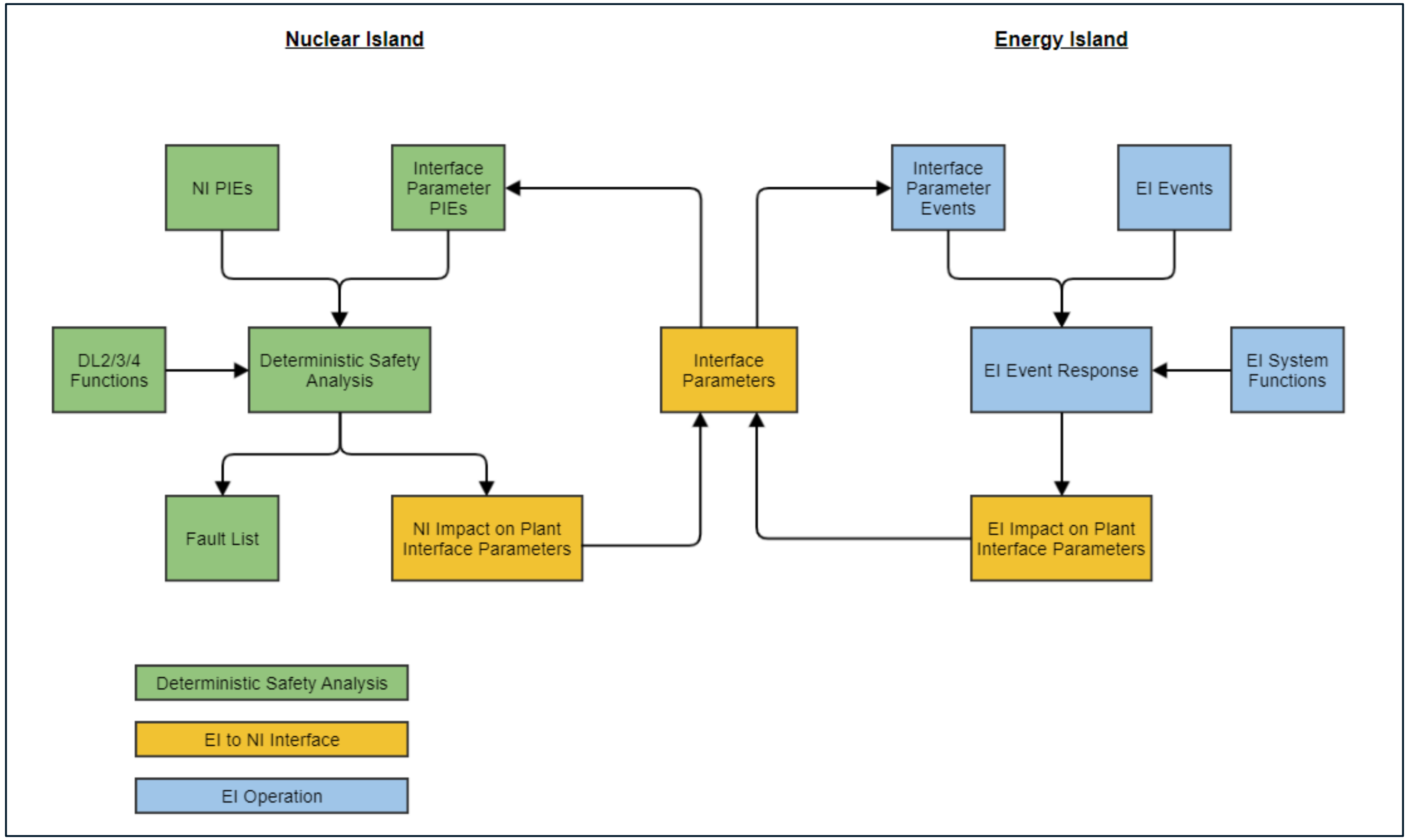
- NI control manages reactor power and cold salt flow to the NI via ESS cold tank pumps
- EI control manages turbine output based upon grid demand while maintaining salt tank levels within *controlled bands*
- *Alerts* notify NI and EI operators when salt tank parameters are outside of control bands
- Deviation of parameters outside of controlled band are considered AOOs and will be evaluated via safety analyses
- Requirements related to salt tank levels, controlled bands, alert levels, and response times will be verified by initial modeling and reflected throughout design process

Operational Flexibility

- Narrows the scope of NI command and control
  - Allows NI operators to focus on safely operating the nuclear heat source
- Reactor power independent of turbine output
  - Reactor remains at full power while turbine output variations are accommodated via salt tank inventory management
- Immediate reactor plant response to changes in EI heat rejection systems are not necessary

Transient Separation

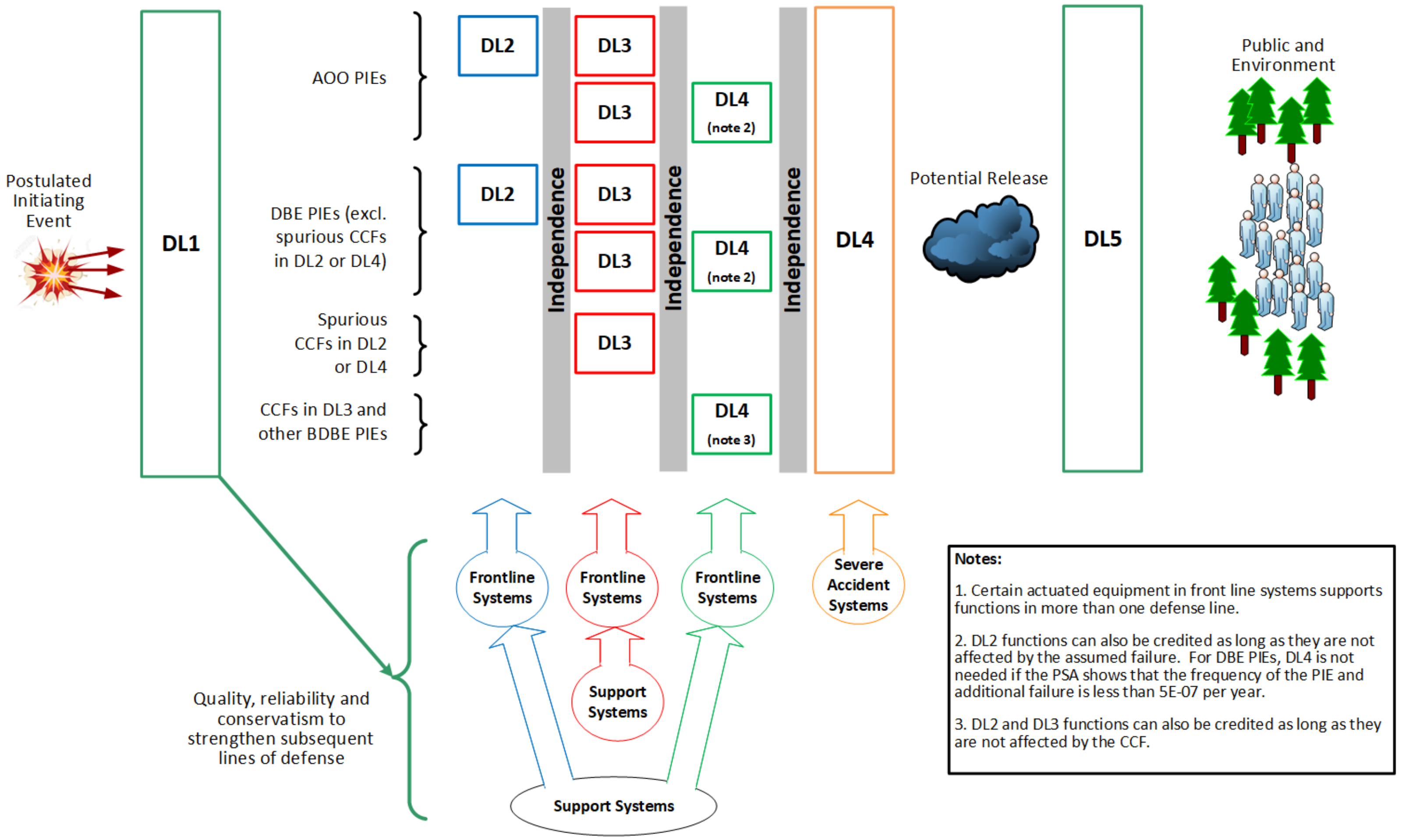
- With operational flexibility, most events on the EI that would affect the NI in a typical nuclear power plant have no immediate impact
- EI events can lead to Postulated Initiating Events (PIEs) if resulting change to an *interface parameter* occurs
- Plant design ensures that EI SSCs are not required to perform any defense line functions other than very few selected DL2 sensors on the EI
  - Enables no safety related DL3 SSCs on the EI



Transient Separation

Defense-in-Depth

- Plant safety analyses only model PIEs that directly impact the NI.
- All defense line 2, 3, and 4 functions are performed by NI systems



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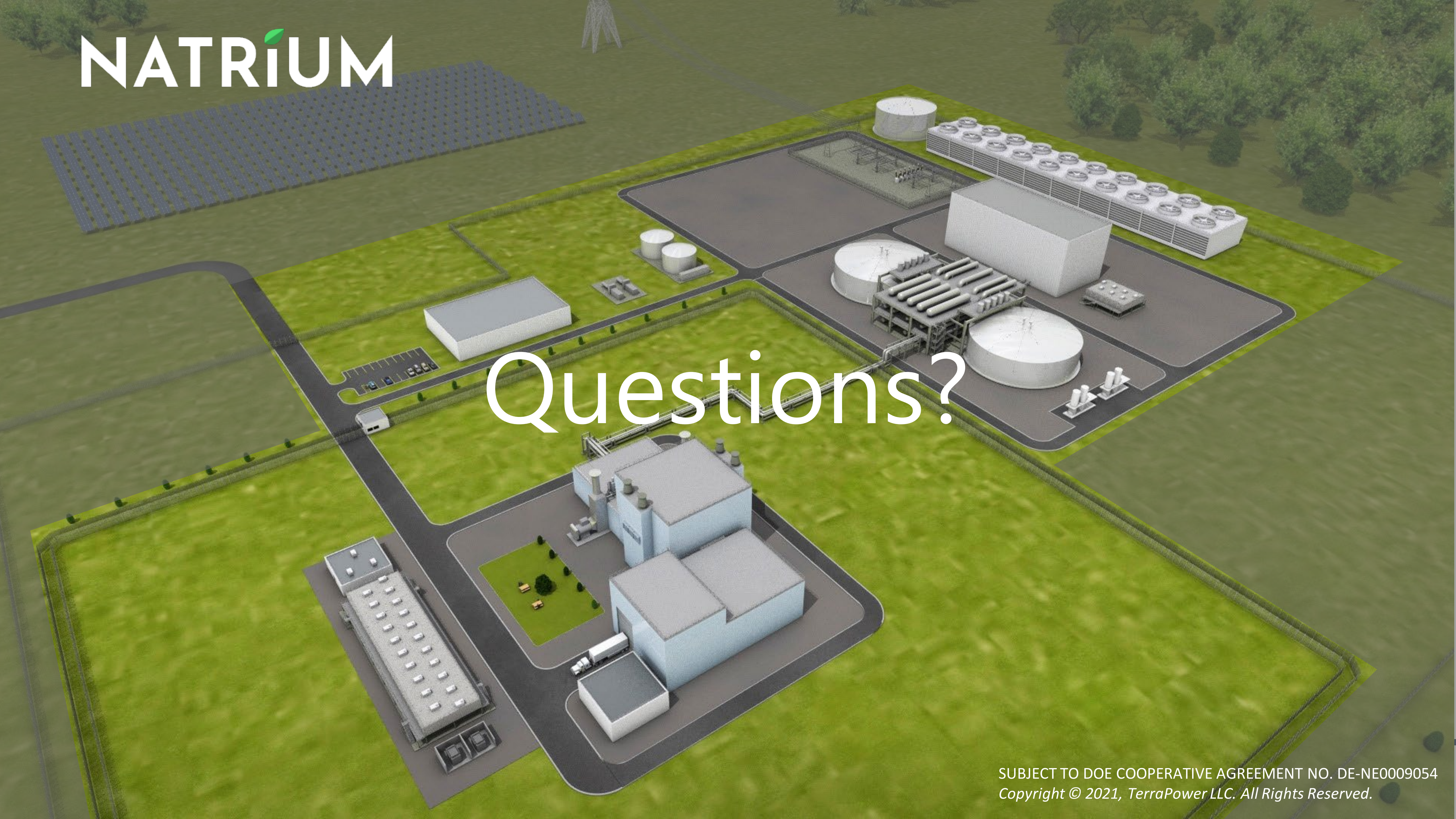
Regulatory Separation

- Transient separation allows performance of defense line functions by NI SSCs, except for selected DL2 sensing functions, which are NSR
  - Regulatory review of EI is significantly reduced
- Ability to adapt non-nuclear commercial technologies to the EI
- Opportunity to construct EI independently, under a non-nuclear QA program
- Physical separation of NI and EI provide opportunity for limited security to EI facilities and SSCs



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Questions?

Acronym List

AOO – Anticipated Operating Occurrence
ARCAP – Advanced Reactor Content of Application Project
ARDC – Advanced Reactor Design Criteria
ARDP – Advanced Reactor Demonstration Program
CFR – Code of Federal Regulations
DID – Defense-in-Depth
DL – Defense Line
EBR – Experimental Breeder Reactor
EI – Energy Island
ESS – Energy Storage System
FFTF – Fast Flux Test Facility
GDC – General Design Criteria
LBE – Licensing Basis Event
LMP – Licensing Modernization Project
NI – Nuclear Island
PDC – Principal Design Criteria
PIE – Postulated Initiating Event
PSAR – Preliminary Safety Analysis Report
RIPB – Risk-Informed, Performance-Based
SFR – Sodium Fast Reactor
SSC – Structures, systems, and components
TICAP – Technology Inclusive Content of Application Project
TREAT – Transient Reactor Test

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