TerraPower

NATRIUM

Engineering Computer Programs

a TerraPower & GE-Hitachi technology

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

Agenda

- Advanced Reactor Demonstration Program
- Licensing Overview
- Natrium™ Safety Features
- Engineering Computer Programs
- Methodology Maturation Elements

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

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

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

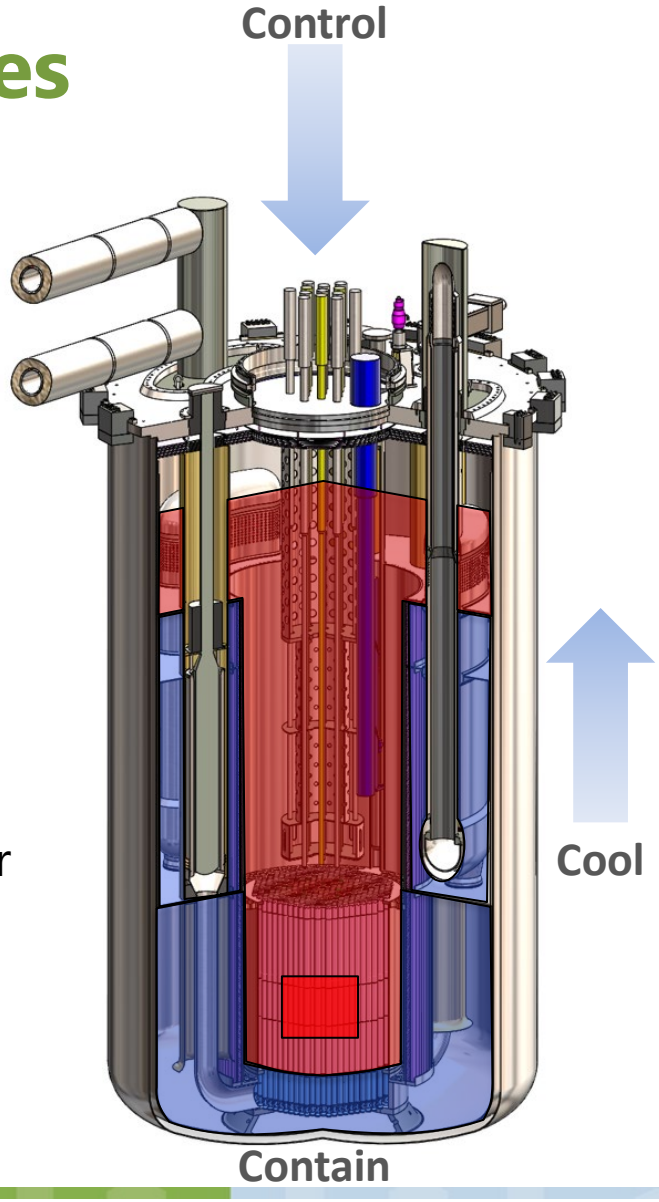
Licensing Overview

- This pre-application engagement on engineering computer programs is the first in a planned series of related meetings and presentations to the NRC:
  - Testing Plan and Methodology
  - Source Term Methodology Plans
  - Design Basis Accident Transient Methodology
  - Radiological Release Consequences Methodology
  - Reactor Stability Methodology
  - Partial Flow Blockage Methodology
  - LBE with and without Releases Methodology

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

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 Control Systems, 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

TerraPower NATRIUM

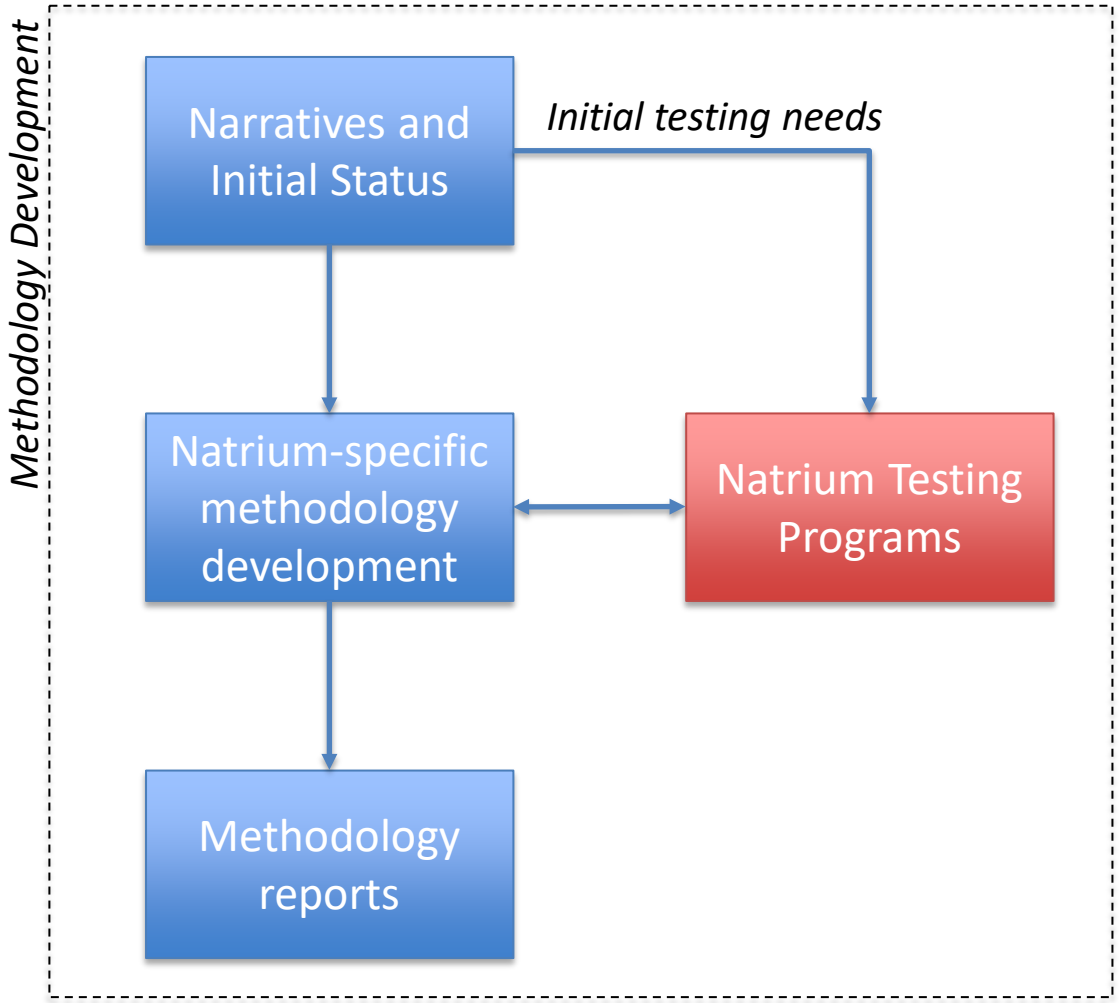
Engineering Computer Programs Selection Basis

- Determination of Natrium plant performance under normal and off-normal conditions to ensure the safety of the public and environment requires analytical methodologies where one or more computer programs are used.
- ECPs selected for this early engagement are to be used in design and licensing methodologies across the following five topical areas:
  - Safety Analyses
  - Absorber and Fuel Pin Performance
  - Core Mechanical
  - Neutronics and Shielding
  - Thermal-Hydraulics

Engineering Computer Programs Selection Basis

- Natrium ECPs selection is based on
  - Analytical approaches developed and used by TerraPower for the TWR® Program
  - Prior and ongoing work by the U.S. DOE National Laboratories to analyze sodium-cooled fast reactors.
- ECPs can be organized in 3 broad category of suppliers
  - Developed by other suppliers, including many commonly used within the nuclear industry
  - Developed by the DOE, including many with a long history for sodium fast reactor applications
  - Under development at TerraPower, initially as part of the TWR Program

Engineering Computer Programs Selection Basis



- Natrium methodology narratives and initial status established
  - Scope
  - Important phenomena
  - **ECPs selection**
  - Existing benchmarks and validation data
  - Key interfaces
  - Initial testing needs

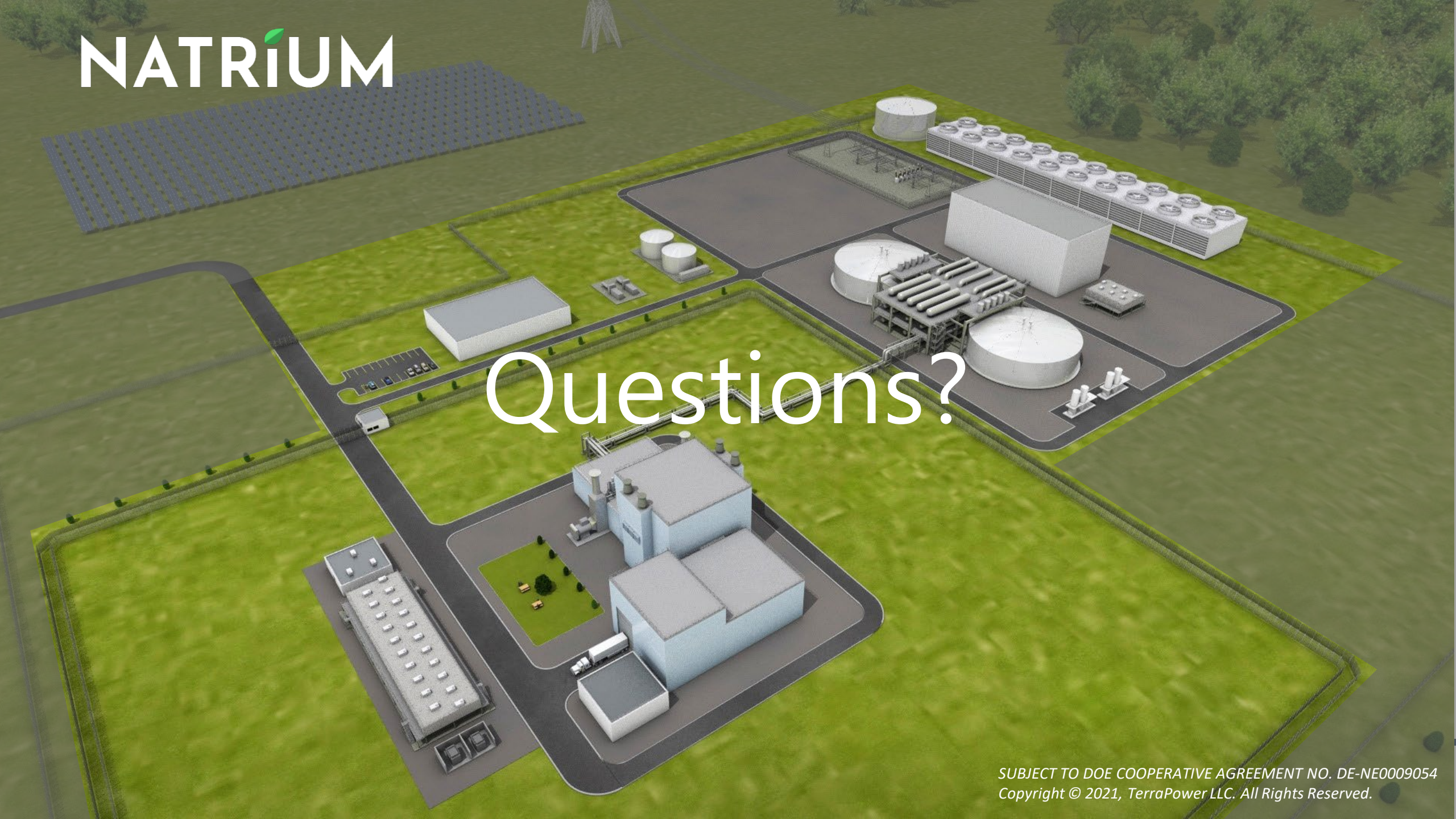
Methodology Maturation Elements

- Several processes are being put in place to support the maturation of methodologies for the Natrium plant
  - Methodology Development and Assessment Guide
  - Technical Evaluation of Software
  - Testing Needs Determination Process
  - Verification and Validation Guide
  - Predictive Capability and Maturity Model
- More detailed work on individual methodologies has been initiated in parallel will have some impact on the list of computer programs

Closing

- Purpose of Pre-Application Engagement: Early introduction to the analytical scope for the Natrium reactor design and licensing with emphasis on those more specific to a sodium fast reactor
  - More specifically:
    - Highlight programmatic relationships between verification & validation, testing, programs, maturation activities, and ECPs
    - Provide an overview of the analytical methodologies
    - Identify ECPs for these methodologies
- Identify additional engagements needed (meetings or submittals)

NATRIUM



Questions?

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

Acronym List

DOE - Department of Energy
ECP - Engineering Computer Programs
LBE – Licensing Basis Events
LMP – Licensing Modernization Project
RG – Regulatory Guide
TWR - Traveling Wave Reactor