



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

**TERRAPOWER, LLC - U.S. NUCLEAR REGULATORY COMMISSION STAFF
FEEDBACK AND OBSERVATIONS REGARDING NAT-3049,
“NASCENT THERMAL HYDRAULIC MODEL WHITE PAPER”
(EPID NO. L-2023-LRO-0015)**

SPONSOR INFORMATION

Sponsor: TerraPower, LLC
Sponsor Address: 15800 Northup Way
Bellevue, WA 98008
Project No.: 99902100

DOCUMENT INFORMATION

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Purpose of the White Paper: TerraPower, LLC (TerraPower) stated that the purpose of NAT3049, "Nascent Thermal Hydraulic Model White Paper," is to provide an overview and description of the Sodium Simplified Coolant Energy Transport (Nascent) model, which will be used to predict steady-state coolant temperatures within fuel assembly subchannels.

Requested Action: TerraPower requested the U.S. Nuclear Regulatory Commission (NRC) staff's feedback and observations on the information discussed in its white paper (WP). TerraPower specifically asked for feedback regarding topics for which additional discussion or consideration may be beneficial.

FEEDBACK AND OBSERVATIONS

The NRC staff has reviewed the TerraPower WP and provided feedback and observations, below. The NRC staff is making no regulatory findings on this WP and nothing herein should be interpreted as official agency positions. The NRC staff observations in this response are not intended as comprehensive feedback. Lack of comment or observations regarding a certain aspect of the WP should not be interpreted as the NRC staff's agreement with TerraPower's position.

Enclosure

General Feedback and Observations

- The WP notes that the Nascent model [[[REDACTED]]].
- None of the codes or methods discussed in the WP have been previously reviewed or approved by the NRC staff. This is not meant to imply that they are unacceptable, or that they must be subject to the NRC staff review and approval. However, the NRC staff notes that review efficiency may be gained by more substantial interaction, especially on those codes that may be directly used in or provide significant support to analyses necessary for future licensing submittals. In the case of this WP, that would appear to include at least [[[REDACTED]]].
- Section 2 of the WP states that TerraPower intends to [[[REDACTED]]]. Section 5 of the WP provides further detail on [[[REDACTED]]], and states that “high-fidelity CFD calculations cannot supplant the role of experiments, but they can complement the experiments and serve a crucial role in the tuning and validation of the Nascent model.” The NRC staff observes that Computational Fluid Dynamics (CFD) does not provide validation data due to issues such as modeling, approximations, assumptions, and numerical discretization (with some possible exceptions for CFD methods that provide direct numerical simulation of the Navier-Stokes equations). However, CFD does provide a useful benchmark and can also be used to better understand and interpret experimental results. TerraPower appears to understand this distinction based on the discussion in Section 5.1.2 of the WP, yet the WP still references CFD providing both tuning and validation data. TerraPower should clarify the specific role CFD is intended to play in validation (i.e., the results that CFD will be expected to provide and the purpose for which they will be used).
- The May 25, 2023, presentation provided by TerraPower on Core Thermal-Hydraulic design and approaches (ML23146A113 (public) and ML23146A114 (non-public)) provides helpful context for the Nascent model, including which codes are used for which thermal-hydraulic analyses and the overall approach to methodology development and assessment. TerraPower should consider whether such context would be beneficial in any future licensing applications involving Nascent. The NRC staff also notes that a substantial amount of feedback was given at this meeting, and TerraPower should consider that feedback for future interactions and licensing submittals relating to thermal-hydraulics.
- The range of applicability of the Nascent model is not clear from the WP. Certain simplifying assumptions were made in the development of Nascent, and while these assumptions may be good for some conditions that occur in the reactor, they may not be for others. In licensing applications of Nascent, the NRC staff would expect more clarity on the parameters TerraPower would use to judge whether Nascent is applicable (e.g., [[[REDACTED]]]) and the specific criteria on those parameters relative to planned plant operating characteristics.

- As mentioned in Sections 3.2 and 4.2 of the WP, [[[REDACTED]]]. The NRC staff is interested in [[[REDACTED]]]. TerraPower should consider discussing [[[REDACTED]]].
- If the uncertainty in the Nascent model is to be quantified, TerraPower should consider [[[REDACTED]]].

Specific Feedback and Observations:

- Section 3
 - Section 3.4 of the WP indicates that hot channel factors (HCFs) will be used to [[[REDACTED]]]. The NRC staff observes that very little detail on the development or use of HCFs is provided in the WP. Given that HCFs are intended to [[[REDACTED]]], the NRC staff is interested in better understanding the HCFs and how they are developed and applied in Natrium analyses.
- Section 4
 - The WP identified phenomena included in the Nascent model in Section 4.1 and simplifications in Section 4.2. The staff did not observe a systematic approach to identifying and dispositioning these phenomena, such as a phenomena identification and ranking table (PIRT). While such an approach is not specifically required, it can help the staff to understand whether the phenomena considered are sufficient, why certain phenomena are more important, and why other phenomena can be appropriately simplified or neglected.
- Section 5
 - Section 5 of the WP [[[REDACTED]]]. The NRC staff notes that most of what TerraPower considers [[[REDACTED]]] is considered by the NRC staff to be [[[REDACTED]]]. To the NRC staff, [[[REDACTED]]] only appropriately applies to the [[[REDACTED]]] since it is [[[REDACTED]]]. The NRC staff notes that [[[REDACTED]]].
 - Section 5.1.2 of the WP notes that assumptions may be made in the large eddy simulation (LES) CFD calculations. These assumptions should be justified on a

case-by-case basis, as appropriate. For example, the WP states that constant molecular viscosity will be assumed; this may be inappropriate for scenarios with steep thermal gradients.

- Section 5.3.1.2 of the WP provides a methodology for determining subchannel-level friction factors and indicates that [[[REDACTED]]]. TerraPower should provide information demonstrating that [[[REDACTED]]].
- The assessment of the wire induced mixing model as discussed in Section 5.4 of the WP appears to be generally consistent with what the NRC staff would expect for a model of this type at this stage of the plant design and licensing process. One aspect that is not clear to the NRC staff is whether [[[REDACTED]]]. [[[REDACTED]]].
- In future licensing interactions, TerraPower should demonstrate that the [[[REDACTED]]]. This is particularly important because [[[REDACTED]]].
- Section 6
 - The NRC staff observes that the comparison of Nascent to Mongoose++ is of limited utility because [[[REDACTED]]]. Nevertheless, the results do appear to demonstrate that Nascent appropriately accounts for key phenomena.
 - While Figure 5 of the WP demonstrates [[[REDACTED]]], the NRC staff observes that [[[REDACTED]]].

Principal Contributor(s): Reed Anzalone, NRR