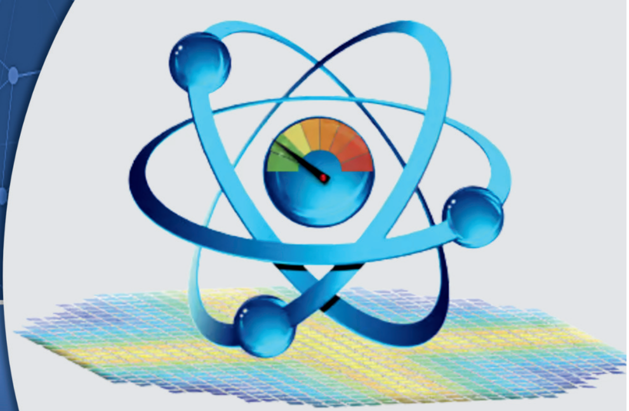
BLUE WAVE
AI LABS

ThermalLimits.ai

Accurate Thermal Limit Prediction for Streamlined Operating



Predict with Precision, Operate with Confidence

ThermalLimits.ai leverages historical fuel cycle data and machine learning to provide unparalleled accuracy in forecasting online thermal limits for BWR operators enabling:

- ✓ reduced reload fuel costs
- ✓ more efficient core design and cycle management
- ✓ improved compliance with technical specifications

Accurate predictions of core-wide and local core behavior are crucial to maintaining targeted operating limits margins. Deviation between measured performance and design predictions can lead to operational challenges, such as unplanned derated conditions, premature coast down, increased fuel costs by loading more fuel than required, or challenged core design and cycle management.

There exists an inherent bias between offline and online methods that stems from the nature of the two systems. These calculations are approximations, and until recently there has been no reliable method to bridge the gap between methods leading to inaccurate and inconsistent predictions of online thermal limits.

Our proprietary, physics-informed approach uses machine learning (ML) to leverage historical fuel cycle data, outputs from core simulators, and past online thermal performance to construct a reliable offline surrogate to replace the online feed-back provided by the in-core instrumentation.

> ***"It's now an integral part of our design process, helping us get our key design margins just right."***
> **-Jeremy Barnhart, Constellation Nuclear**

PROVEN SUCCESS

The ThermalLimit.ai model is successfully proven and implemented at the Limerick Clean Energy Center.

Problem: The bias between the design thermal limits and the on-line operating thermal limits is *unpredictable*.

1. If the thermal limit design margin is increased, fuel costs increase.
2. If the fuel cycle bias is larger than the design margin, thermal limits expensively increase.

Causing avoidable:

✗ generation revenue losses,

✗ unplanned operational maneuvers,

✗ significant rework

Solution: A convolutional neural network based on Constellation's data trained to predict future on-line thermal limits for the planned core conditions.

- Each network has approximately 3.6 million trainable parameters. The final output layer predicts over 30,000 nodal and fuel bundle parameters corresponding to the monitored thermal limits.

Results: ThermalLimits.ai improves predictive accuracy for online thermal limits by more than a factor of four (x4).

✓ optimized fuel cycles,

✓ reduced fuel costs, and

✓ avoided generation losses.

Continued Success: The predictive model has since been implemented at several other Constellation BWR stations.

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