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REINFORCEMENT LEARNING FOR PERFORMANCE OPTIMIZATION

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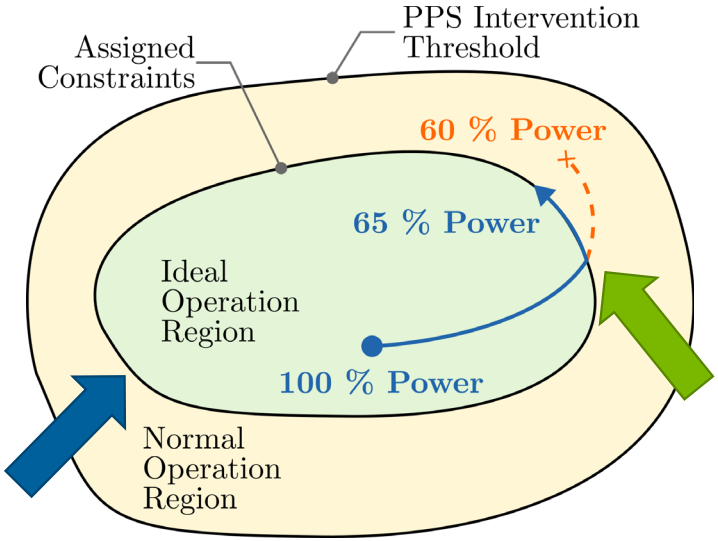
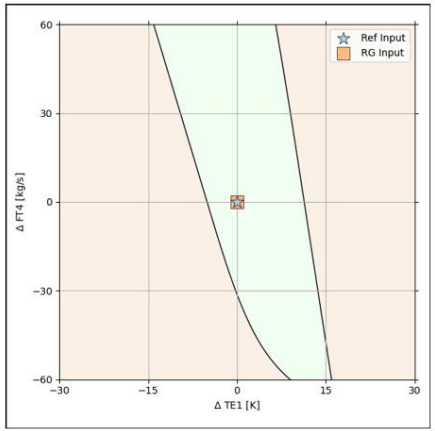
MOTIVATION
CONTROL DURING AUTONOMOUS OPERATION

- NPPs are under-actuated
  - Number of process variables we would like to control is greater than the number of actuators

- Problem we would like to address:
  - How do we enforce arbitrary constraints during routine transients to optimize performance?

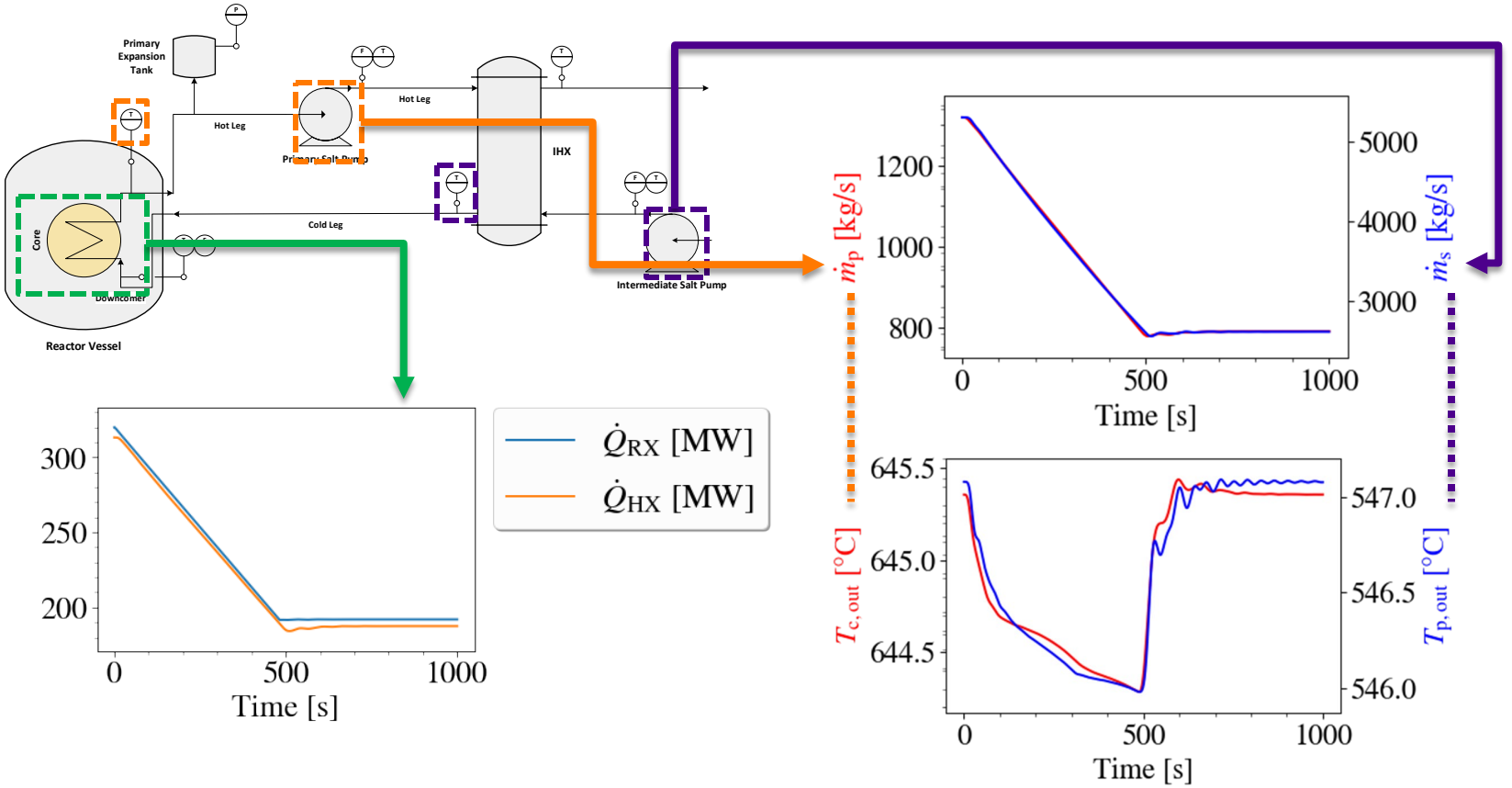




Safe Region

Constraint violation

CLASSIC CONTROL DURING LOAD-FOLLOW TRANSIENT



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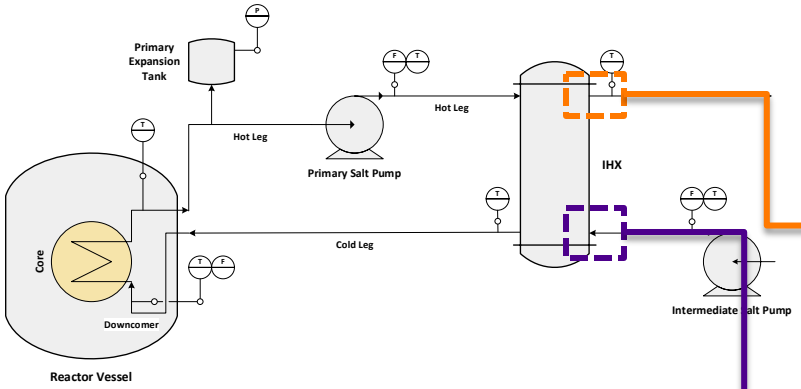
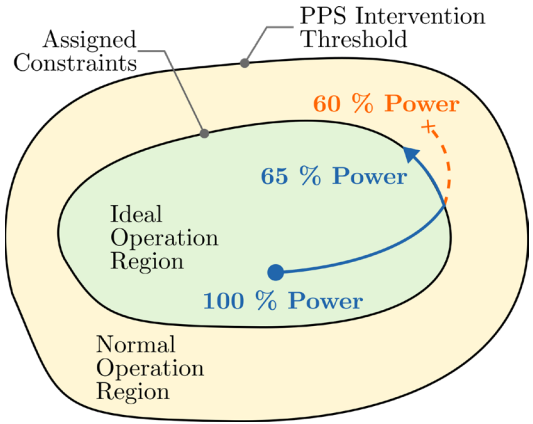
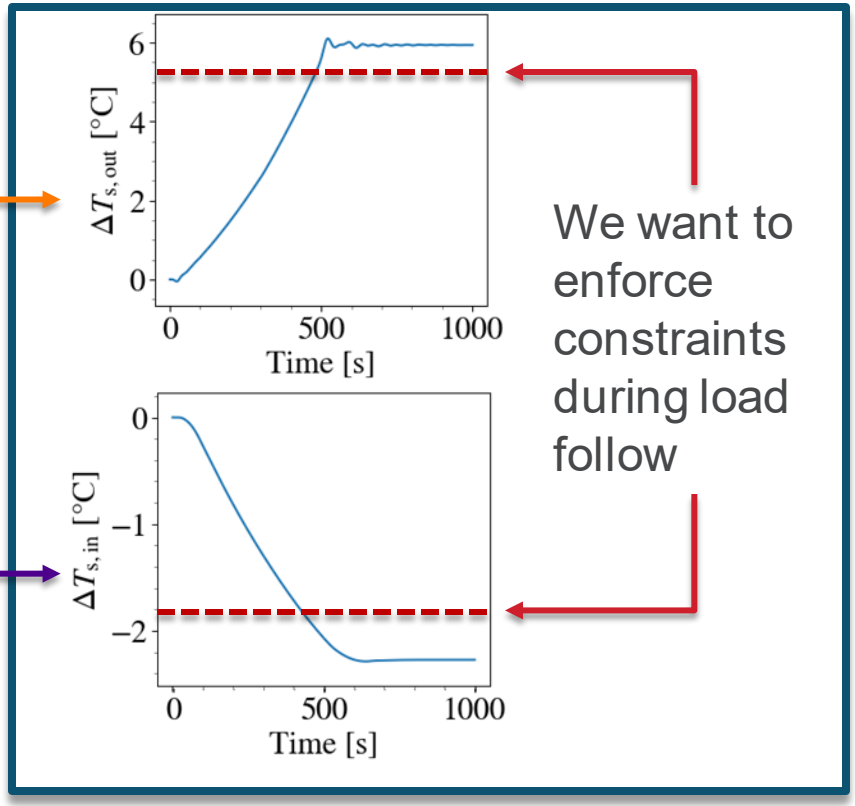
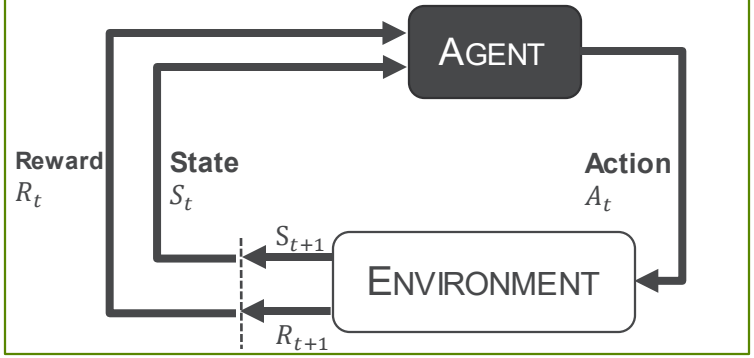


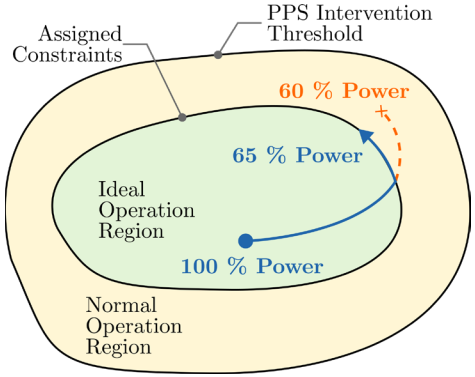




METHODS

Canonical RL framework

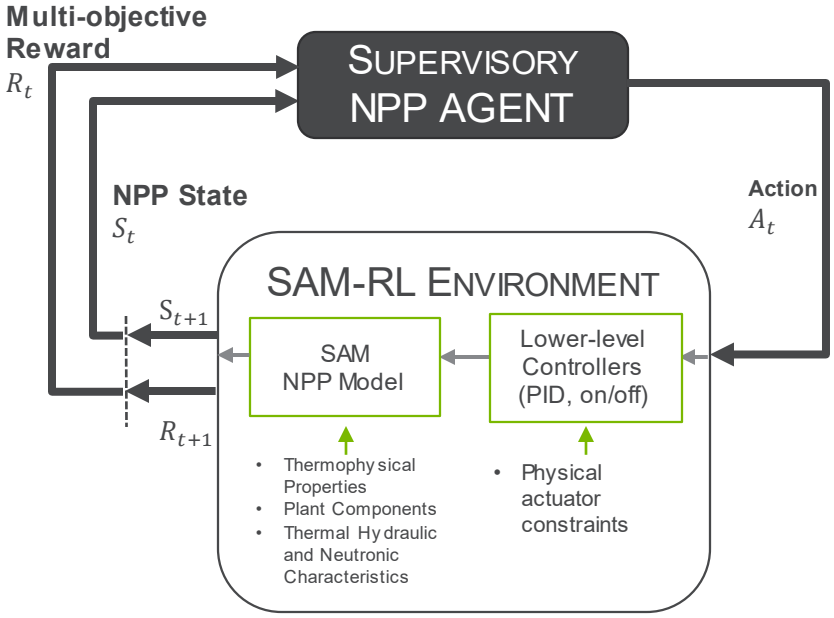




SAFE RL

Application of RL for supervisory NPP Control

- Reward for meeting power demand (revenue)
- Penalties for violating constraints (wear/tear)



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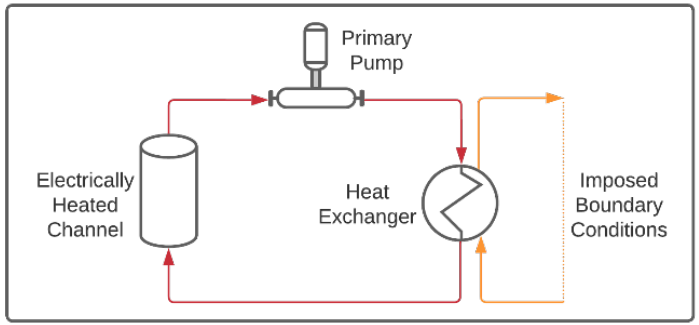
METHODS

- Issues with using system codes as models:
  - Execution time for a 1000 s transient is approximately 16 h
- Transfer learning with surrogate SINDYc model:

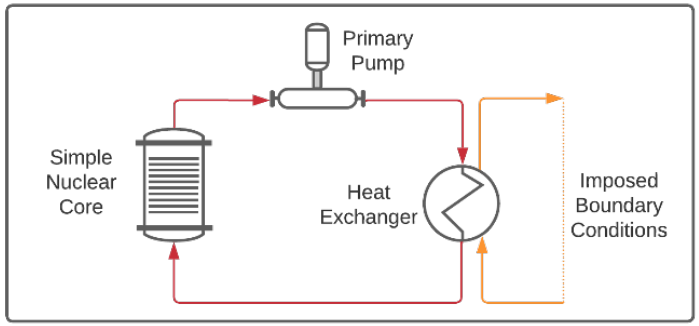
$$\dot{X} = \Xi \Theta^{T}(X)$$

$$\Theta(X) = \begin{bmatrix} 1 \\ X \\ X^2 \\ \vdots \\ \sin(X) \\ \sin(2X) \\ \vdots \end{bmatrix}$$

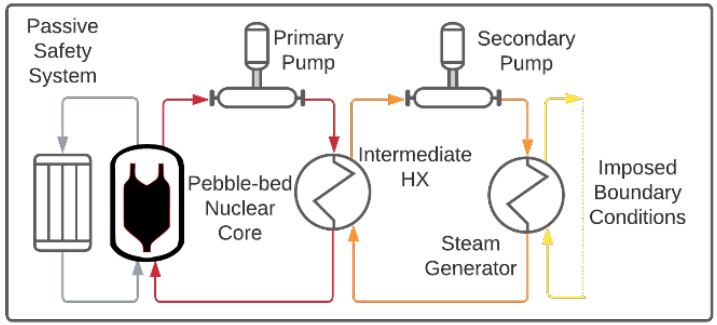
Model A: Simple molten salt loop with an electrical heater



Model B: Simple molten salt loop with a nuclear core. Non-linear nuclear dynamics are introduced.



Model C: Advanced nuclear power plant model. Geomtery of nuclear reactor core is complex (pebble-bed reactor). Additional non-linearities due to passive safety system are introduced.



Model Complexity

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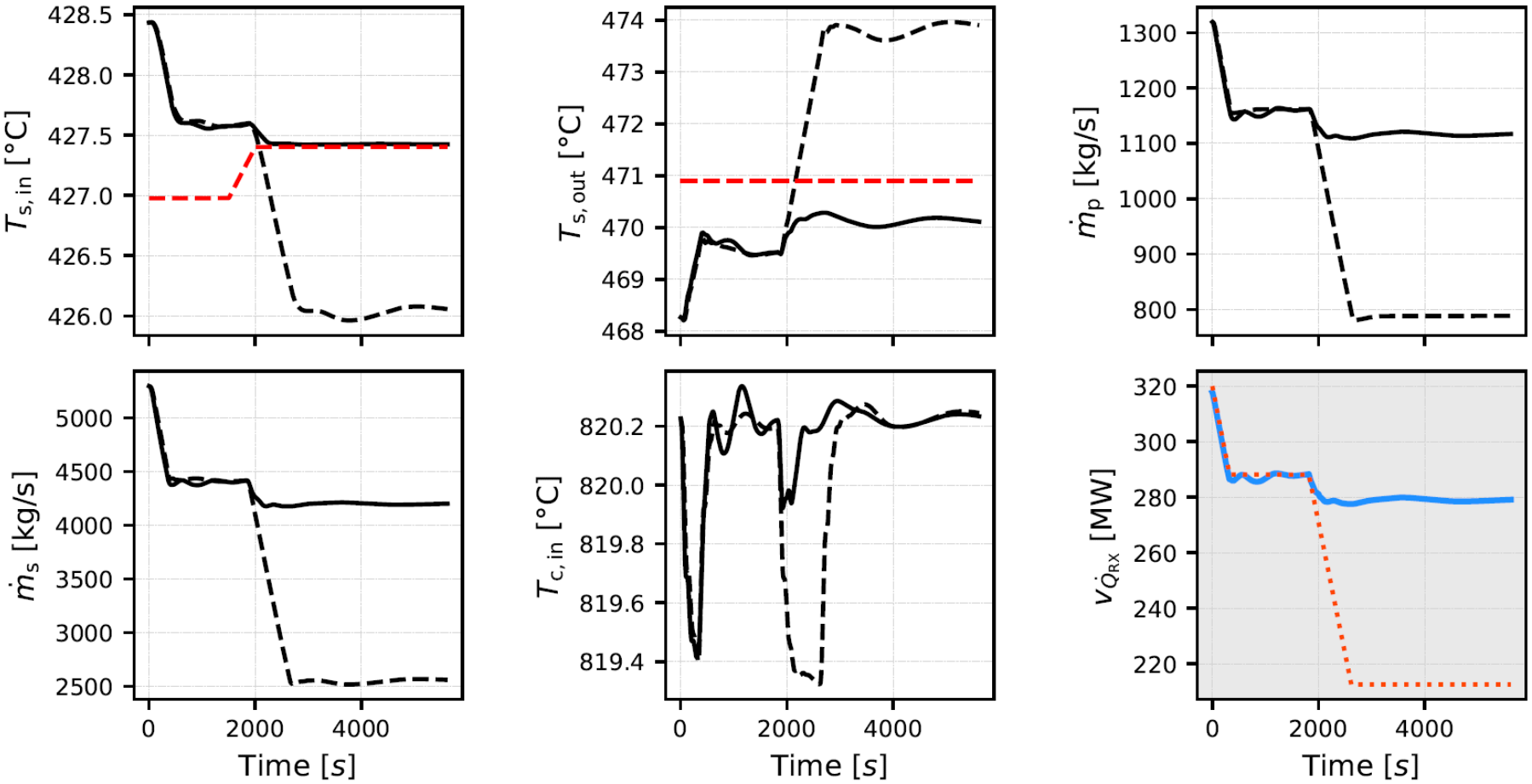

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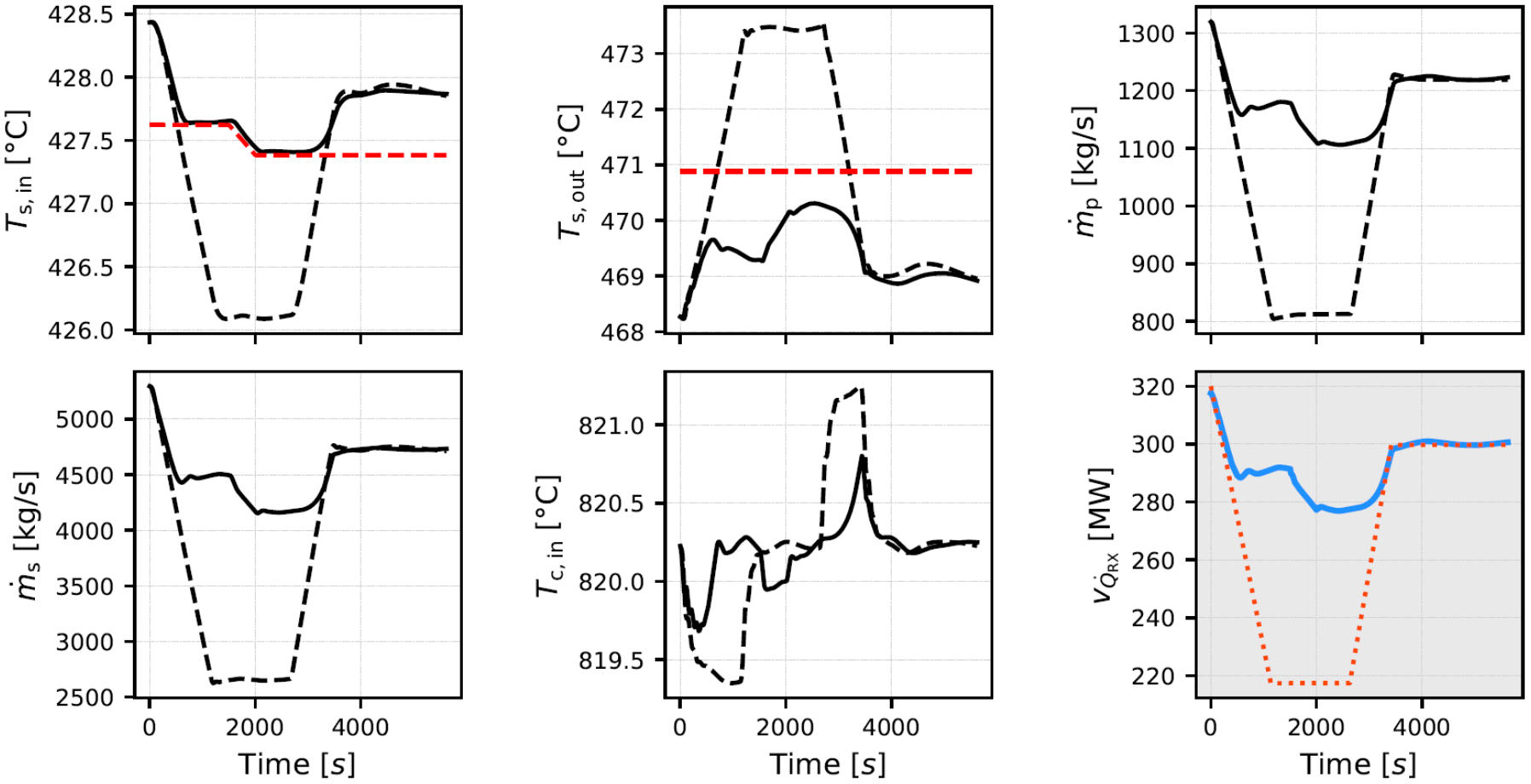

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