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# ARCADE: Advanced Reactor Cyber Analysis and Development Environment

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## NUCLEAR CYBERSECURITY | RESEARCH NEEDS

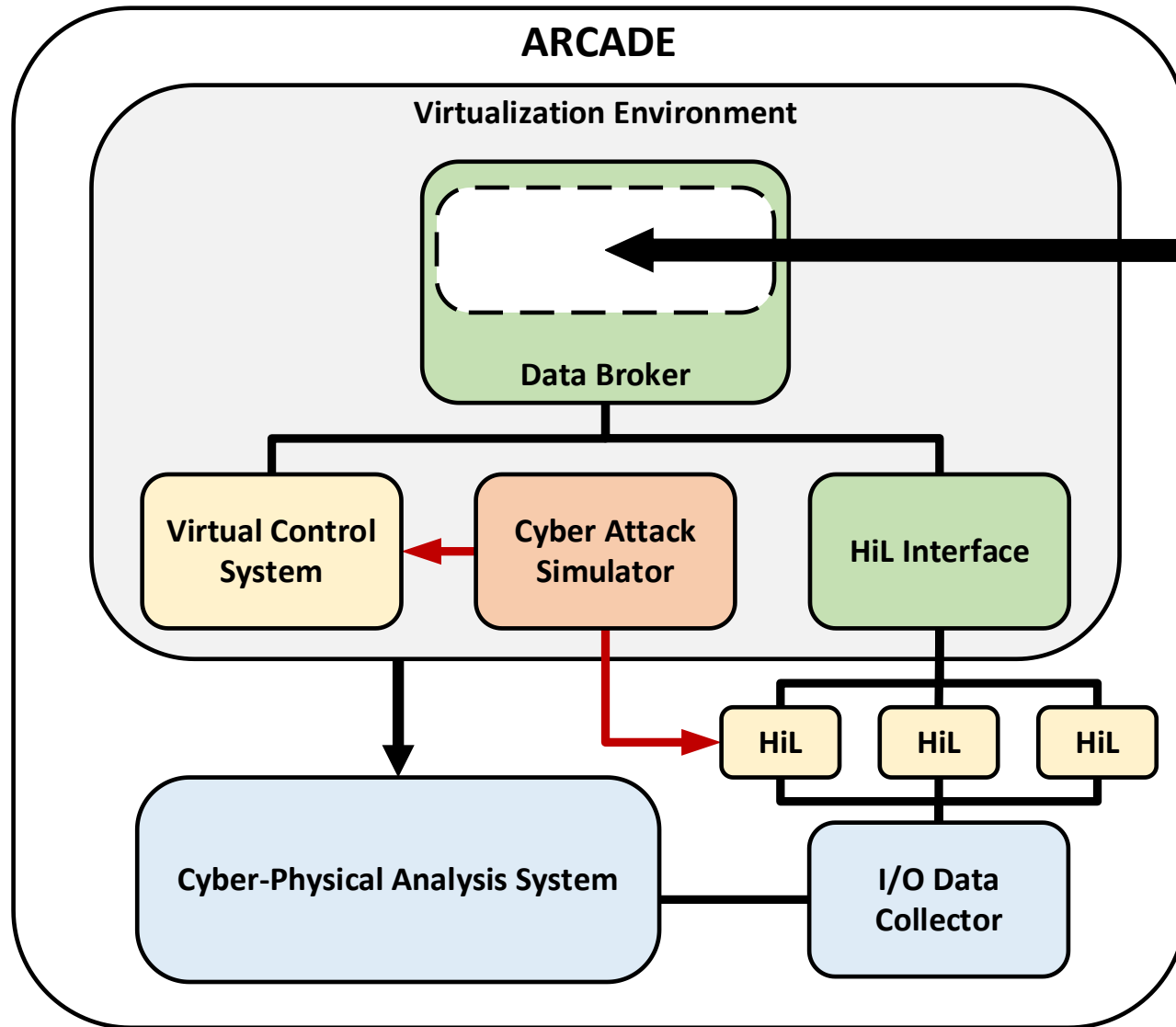
**Rigorous, repeatable, and evidence-based cybersecurity analysis and evaluations require complex modeling and simulation platforms**

**An Advanced Reactor Cyber Analysis and Development Environment (ARCADE) is being developed to analyze advanced reactor (AR) systems**

ARCADE will:

- Support System Level Design Analysis (SLDA)
- Simplify secure-by-design (SeBD) analysis
- Allow evaluation of Defensive Computer Security Architecture (DCSA) implementations
- Enable analysis of cyber-attack impacts

# ARCADE | SYSTEM DESCRIPTION



Physics Simulator

## ARCADE Requirements:

- Real time physics
- High fidelity emulations
- Emulation and network transparency
- Hardware in the loop
- Automated evaluation and analysis
- Scalability

# ARCADE | SYSTEM DESCRIPTION

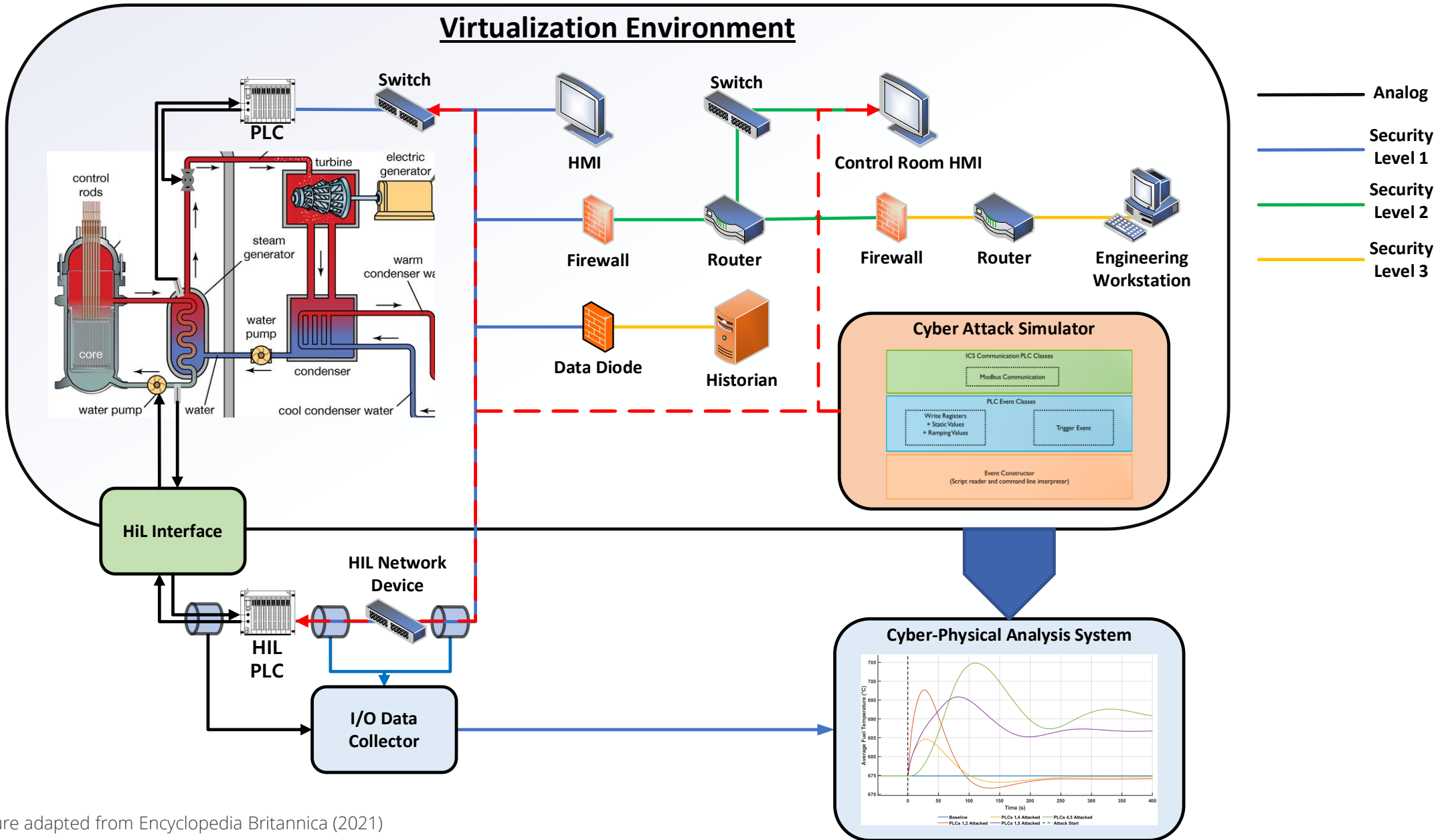
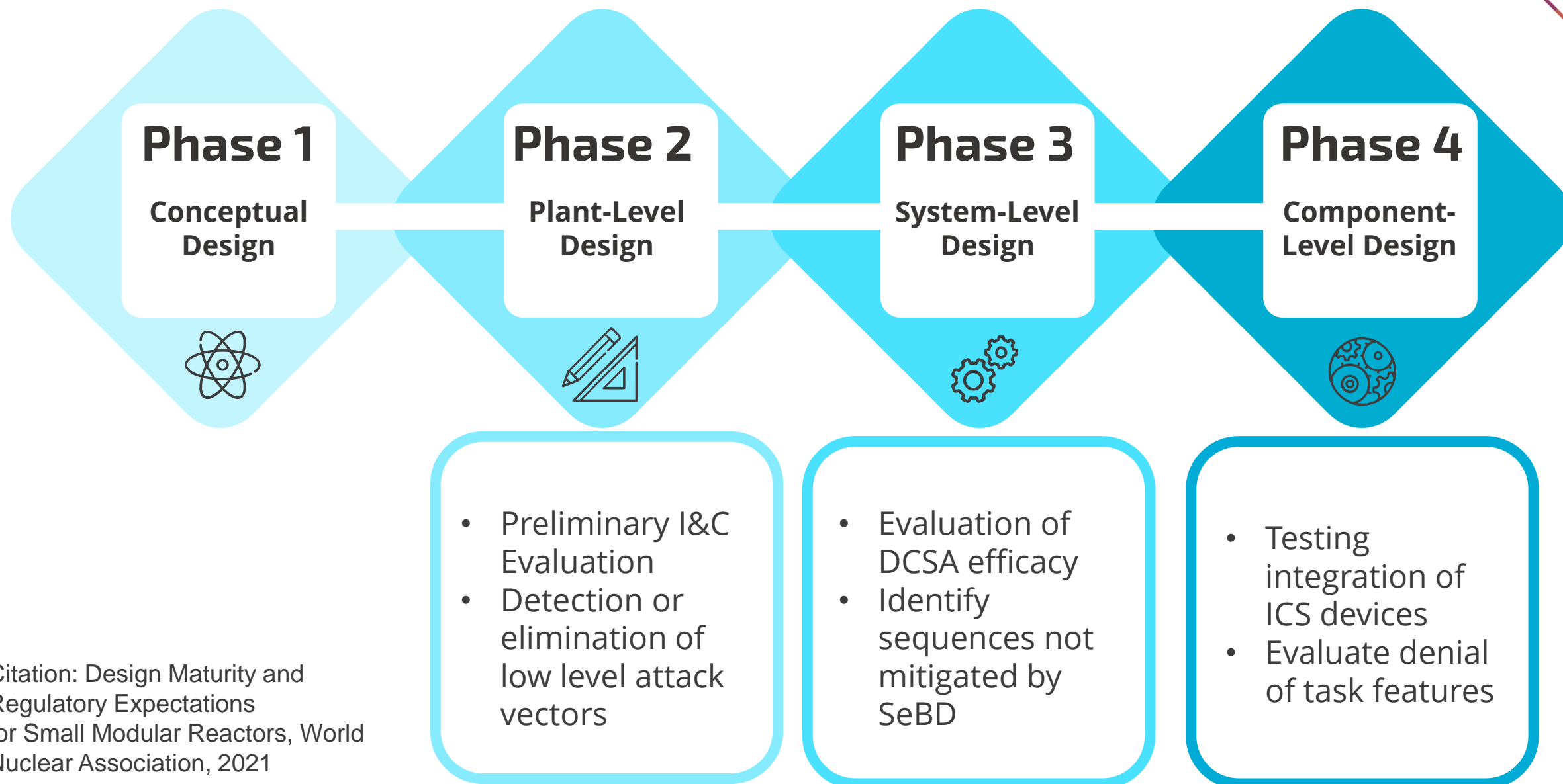


Figure adapted from Encyclopedia Britannica (2021)



# ARCADE | SMR DESIGN MATURITY PHASE INTERACTION



Citation: Design Maturity and Regulatory Expectations for Small Modular Reactors, World Nuclear Association, 2021

## FY23 ACCOMPLISHMENTS

- **NDA's established with partner AR designers**
  - X-Energy, Radiant, NuScale
- **Received AR physics model from partner AR designer**
  - X-Energy physics model received, integration started.
- **Integrated University of Pittsburgh's AR model**
  - SmAHTR Simulink model integrated into ARCADE.
- **Proof of concept architectural analysis with SLDA/SeBD**
  - ARCADE analysis of SmAHTR control system architecture concepts cyber resilience.



## FY24 WORK

- **Fully integrate AR partner designs**
  - Integrate X-Energy's Xe-100 physics model into ARCADE
  - Stretch goal: receive and integrate Radiant's SimEngine into ARCADE
- **Emulate an Advanced Reactor control system architecture**
  - Replicate the control system logic in the Xe-100 physics model in the ARCADE emulation environment.
- **Develop an cyber resiliency analysis system**
  - Evaluate analysis capability to SeBD & CIE needs
  - Evaluate the cyber resiliency of an AR design at Phase 2 maturity
- **Opensource ARCADE**
  - Public release of all the tools and resources in ARCADE

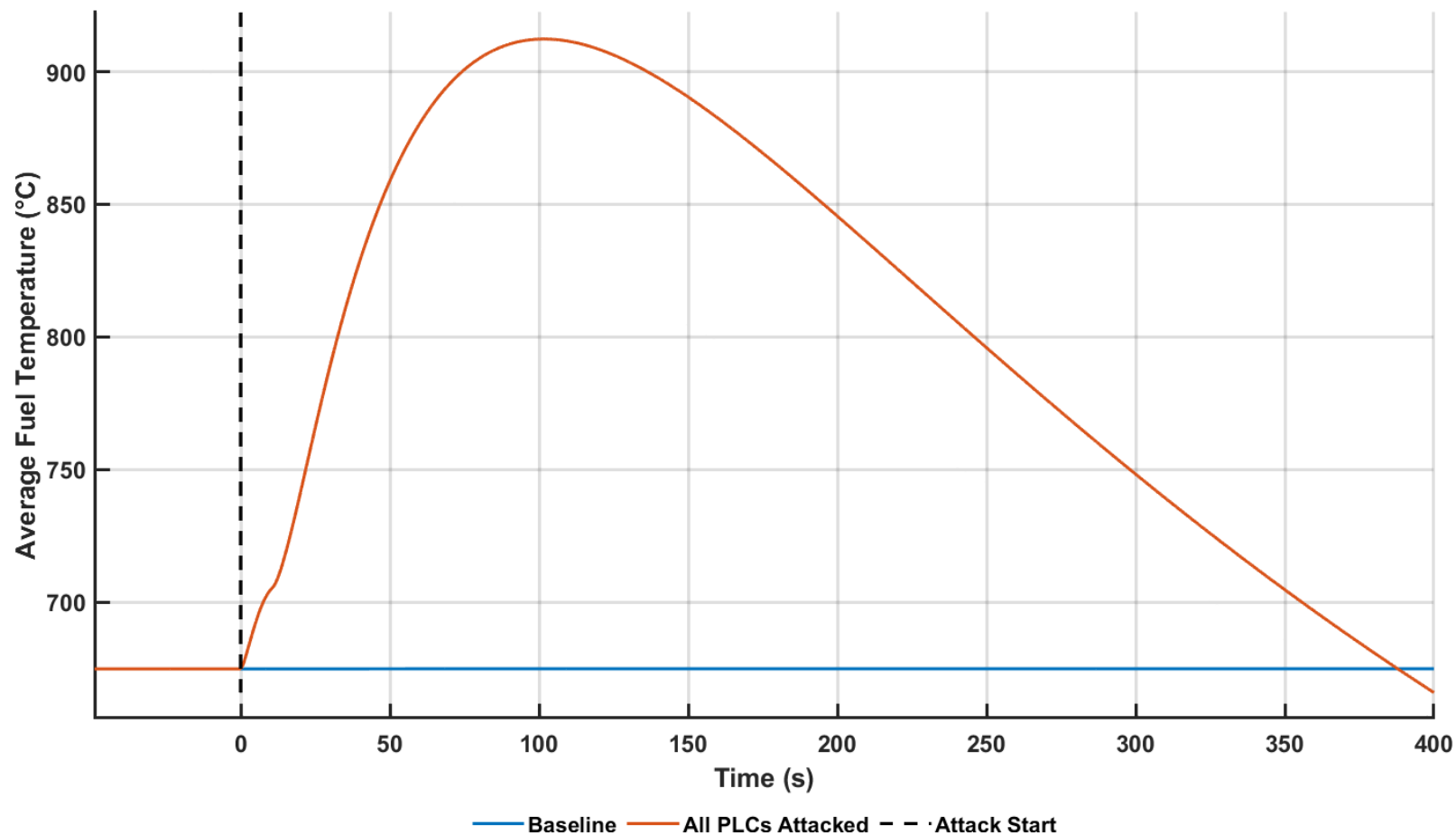
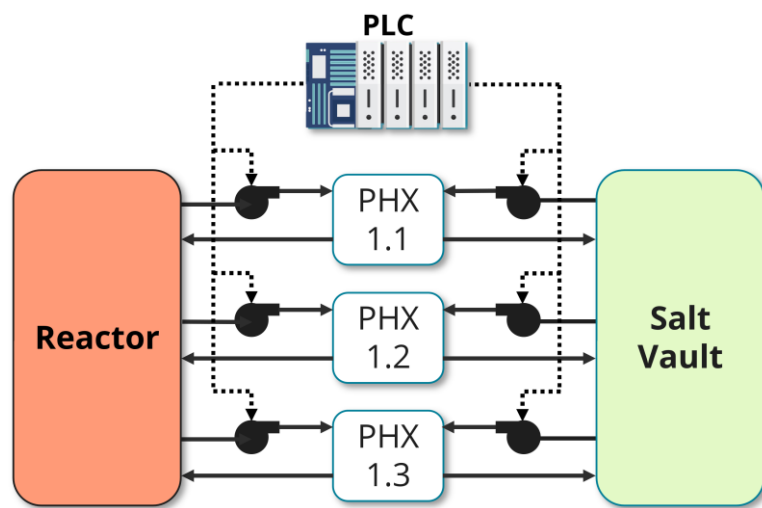


QUESTIONS?



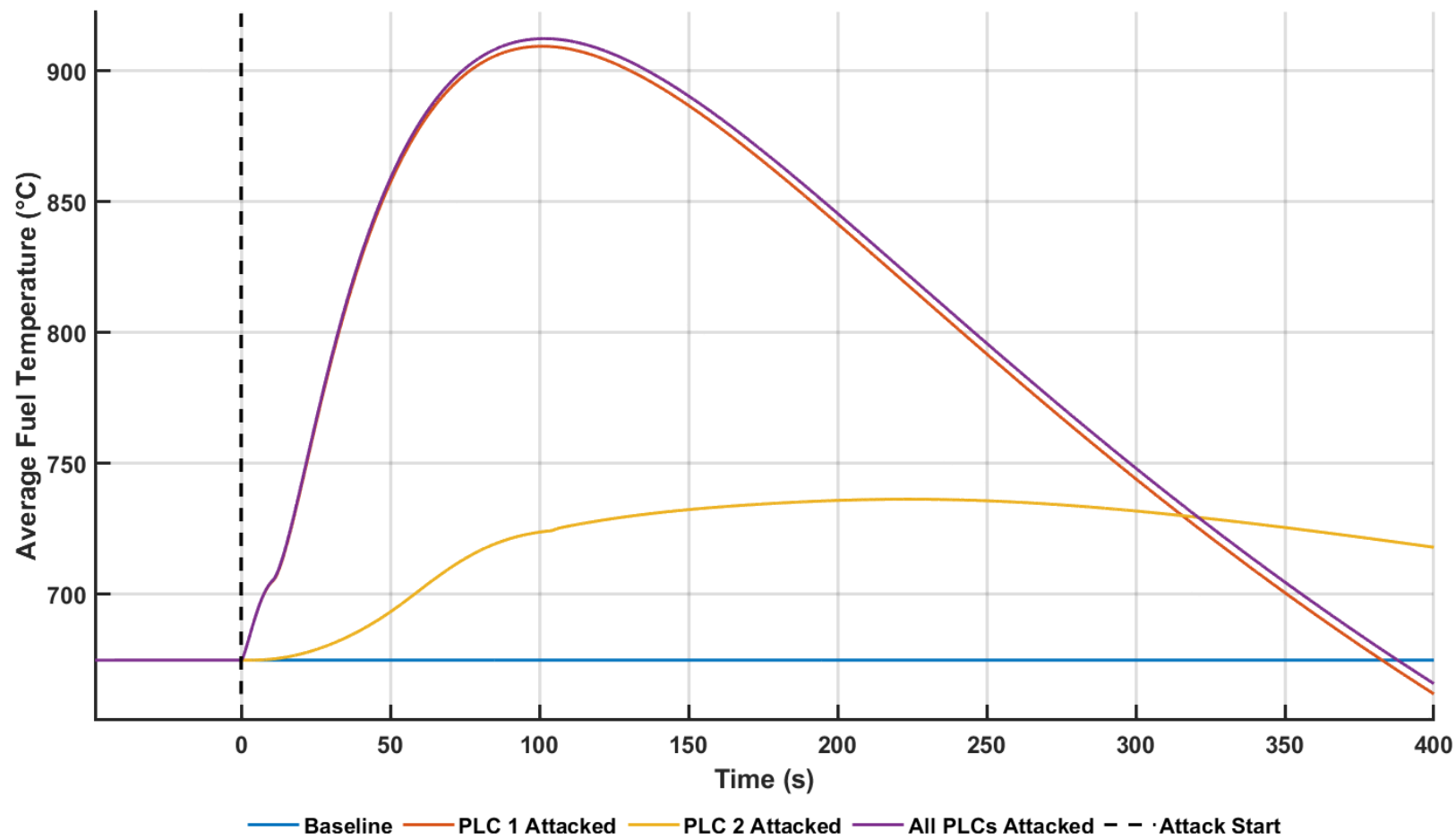
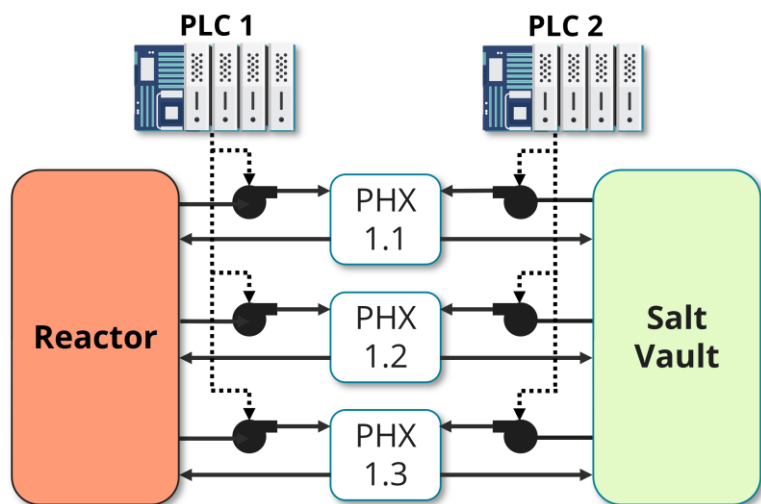


# SLDA | PRELIMINARY ANALYSIS



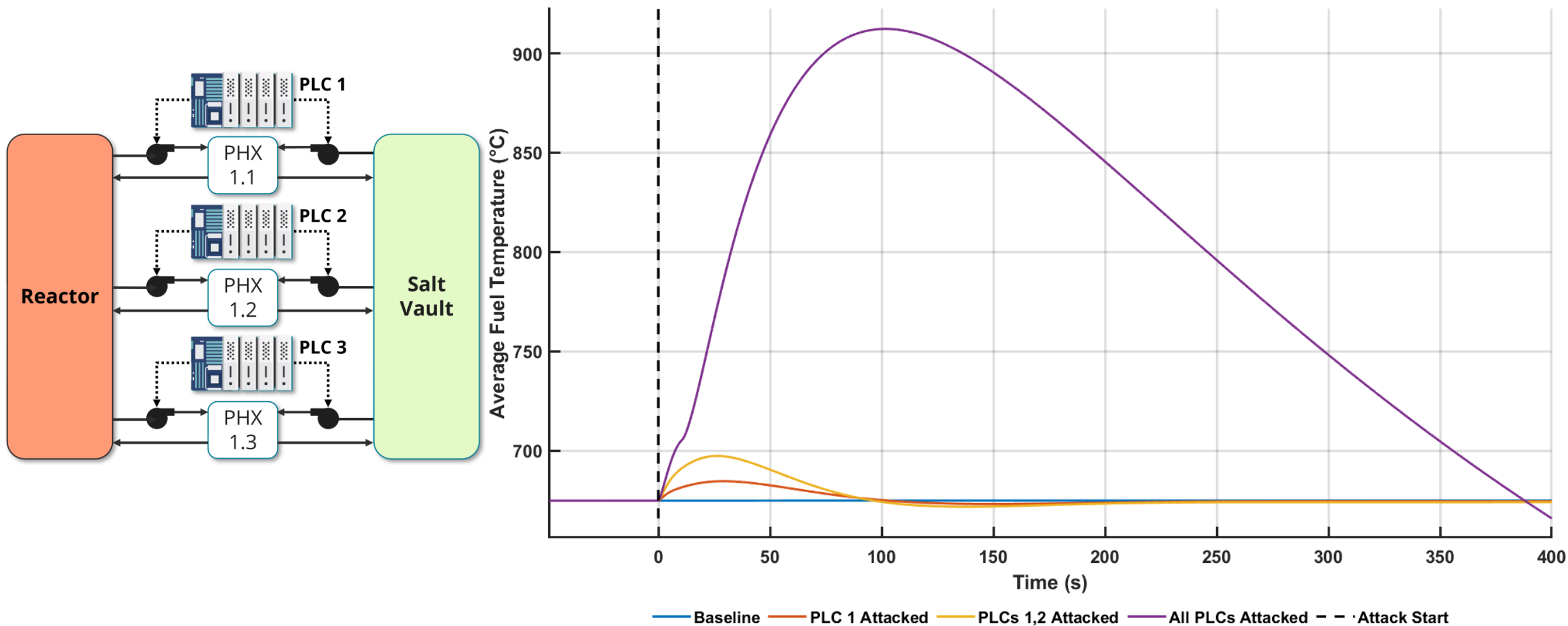


# SLDA | PRELIMINARY ANALYSIS



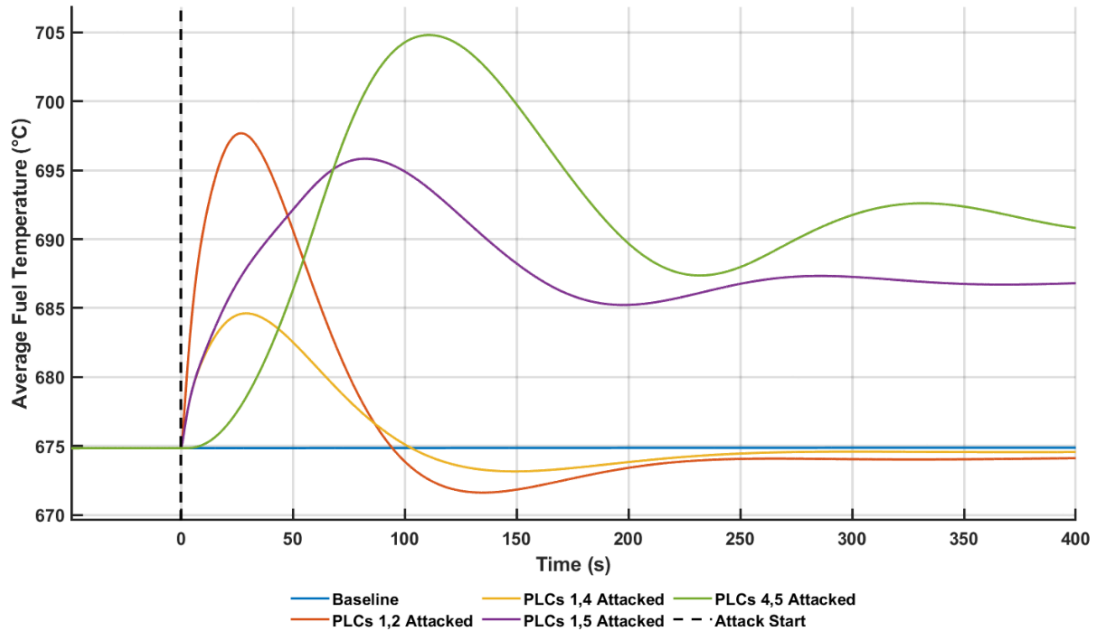
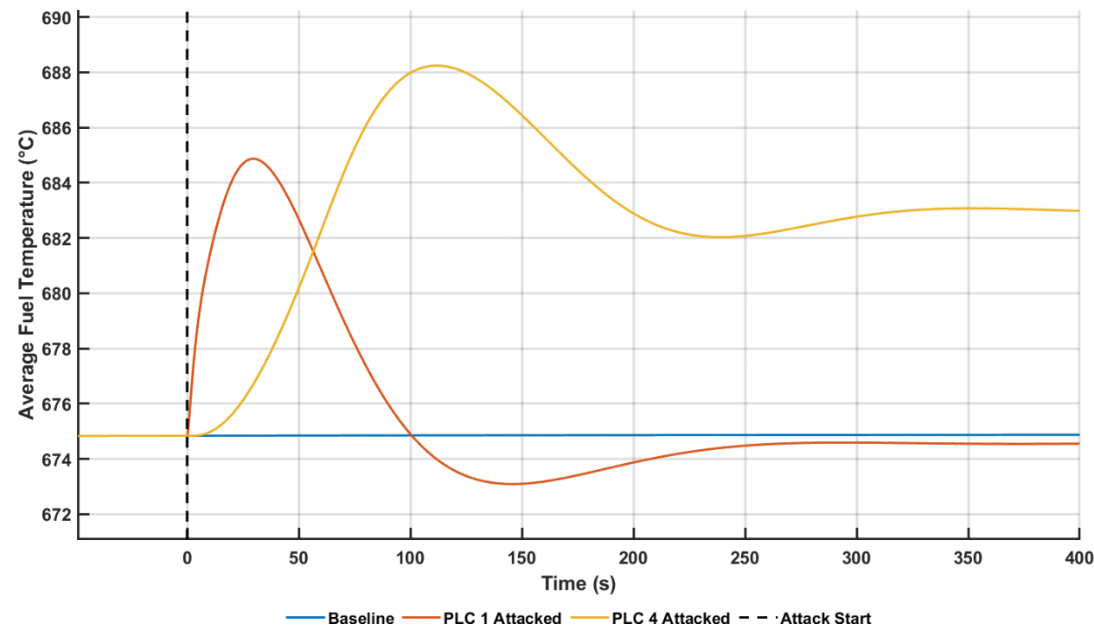
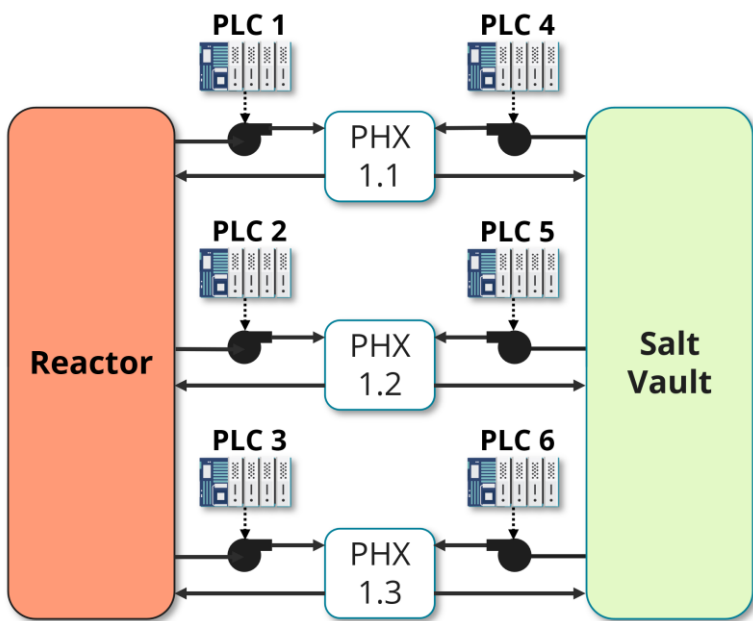


# SLDA | PRELIMINARY ANALYSIS





# SLDA | PRELIMINARY ANALYSIS





# SLDA | PRELIMINARY ANALYSIS

