Joint Use Modular Plant Program Research, Development & Deployment Activities

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23 January 2019

LINE Commission Briefing
Boise, ID

www.inl.gov

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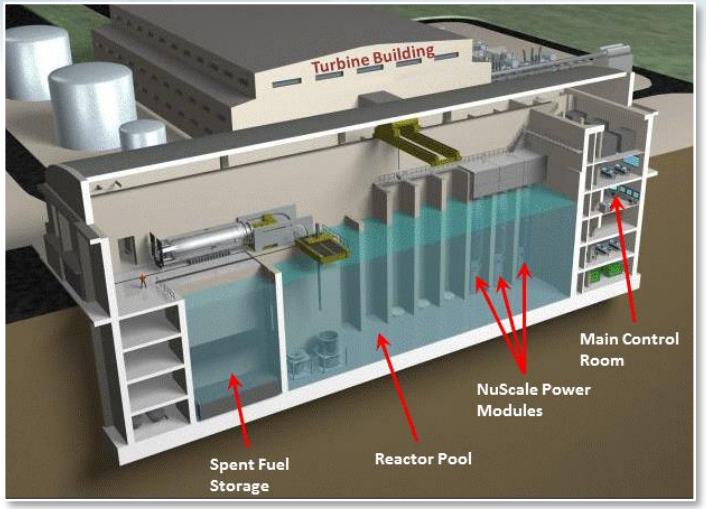
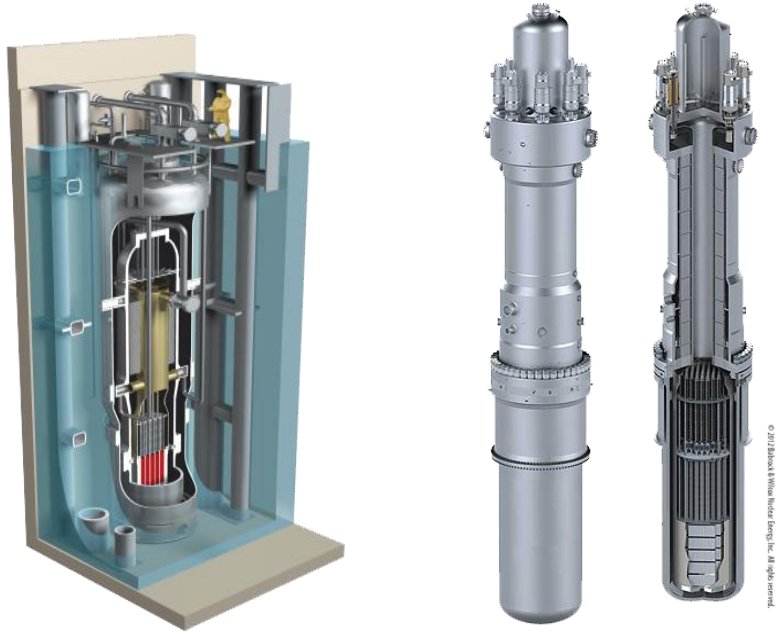
Joint Use Modular Plant (JUMP) Program

- The JUMP Program, based at INL and coordinated with the operating utility, UAMPS, and the plant vendor, NuScale, will:
  - Provide a unique opportunity to conduct research within an operating commercial reactor environment
  - Support demonstration of the use of nuclear energy beyond the electricity sector
  - Provide abundant data for model verification and validation (V&V), design refinement
  - Support development and demonstration of innovative nuclear technologies (fuels, materials, sensors, etc.)
- Includes RD&D activities *and* commercial use within a single multi-module nuclear plant, wherein a specific module is allocated to RD&D
- JUMP is a key aspect of the Carbon Free Power Project (CFPP)
  - The first plant module would be designated for JUMP; anticipated operational date of 2027

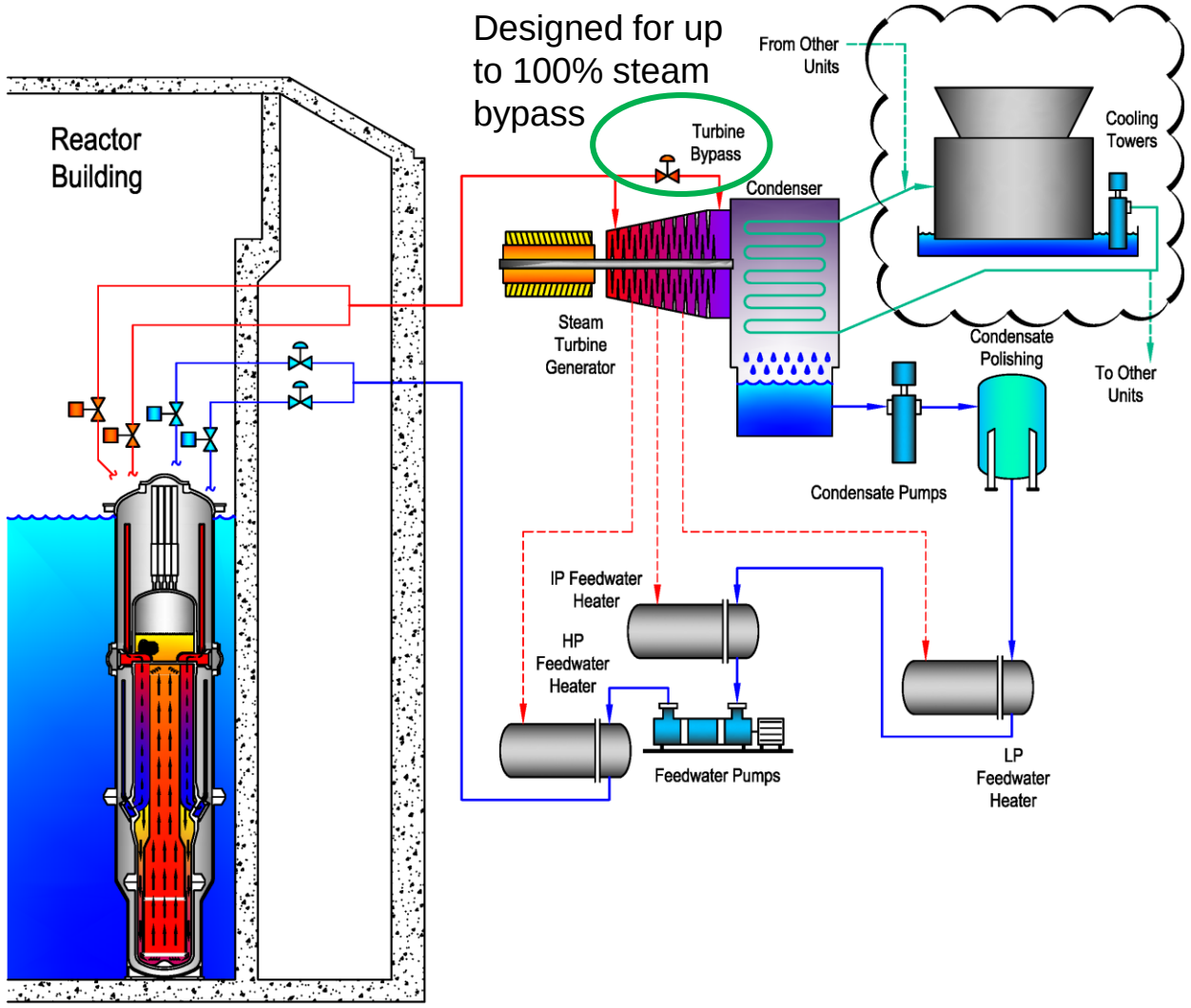


3-D view of Six NuScale Modules



Constraints on JUMP RD&D

- Consider potential impacts on regulatory processes
- Should not require significant modification of the nuclear island within the standard plant design
  - Most RD&D projects are likely to require license amendment
  - Potential licensing impacts will be identified and evaluated
  - Alteration of the secondary side systems may require addition of a transition heat exchanger to decouple the RD&D components from the NuScale Power Module secondary coolant system
- Module must be able to return to standard electricity production service at the end of the contractual agreement



Key Research Priority: Integrated Energy Systems

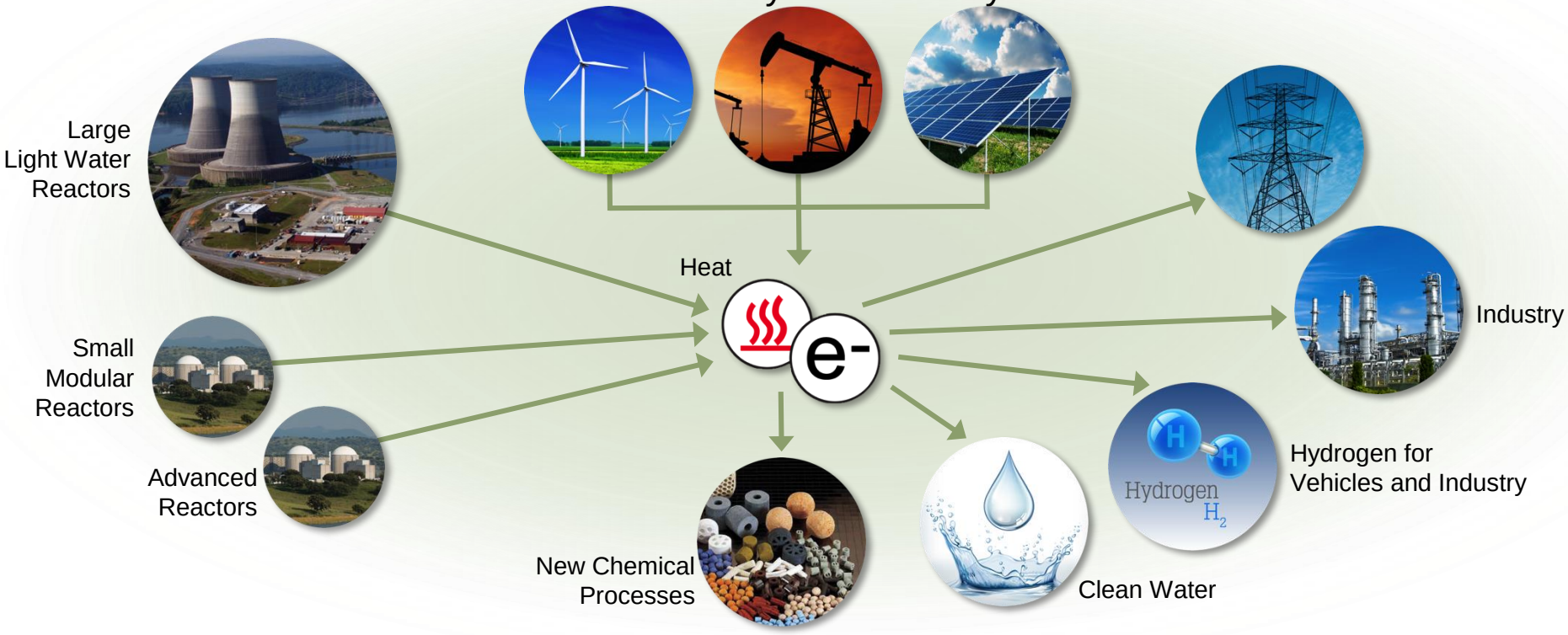
- Tighter coupling of nuclear plant output required to achieve highly efficient integrated energy systems
- JUMP provides opportunity to measure energy transport phenomena for non-steady-state process operations

Today

Electricity-only focus

Potential Future Energy System

Integrated grid system that leverages contributions from nuclear fission beyond electricity sector



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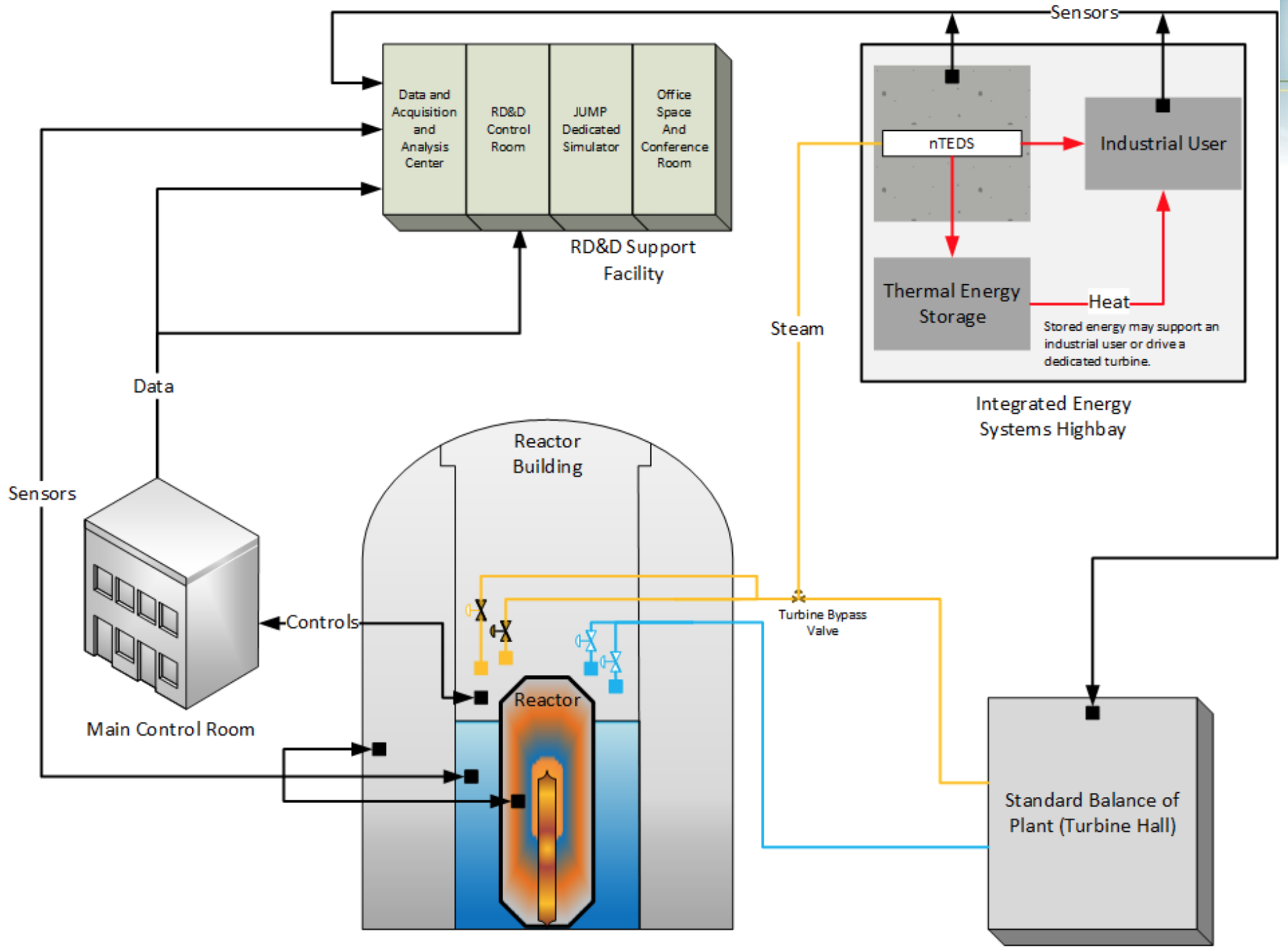
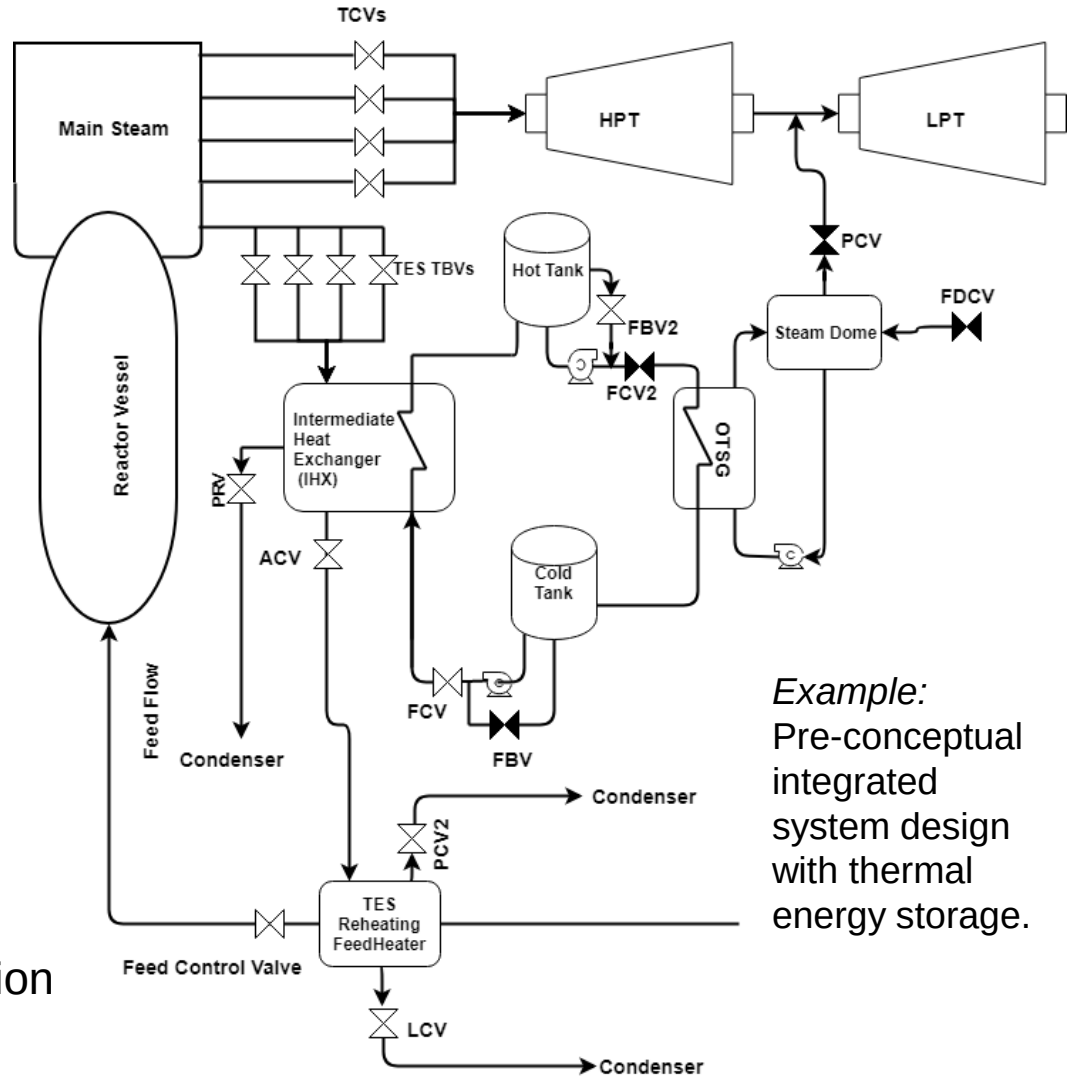
Overview of the JUMP concept relative to the NuScale module in the UAMPS commercial facility



Integrated Energy System Concepts

JUMP provides a platform for demonstration of:

- Coordinated operation with nearby renewable installations
- Front-end control approaches, communications standards, control reliability
- Data collection and analytics to maintain process stability
- Thermal and electrical energy delivery system effectiveness
- Physical feedback in the system
- Multiple energy users/industrial applications:
  - Energy storage (electrical, thermal, chemical)
  - Industrial process pilot scale demonstration:
    - Hydrogen generation, desalination, carbon conversion, etc.
    - Verify process chemistry, operational stability
  - Grid emulation environment to replicate arbitrary grid conditions relative to integrated system operations, measure process response characteristics
- Demonstrate human factors aspects of integrated system operation
- Exercise new regulatory approaches



Example: Pre-conceptual integrated system design with thermal energy storage.

Innovative Technologies and Approaches

Advanced Instrumentation and Model V&V

- Test and demonstrate advanced instrumentation and sensor technologies in relevant reactor conditions
- Collect valuable data for system characterization, model development and V&V; reduce design conservatisms

Fuels and Materials Testing, Characterization

- Provide prototypic commercial operating conditions
- Characterize materials as a function of design, fabrication methods, operating parameters, load cases
- Test advanced fuels under various operational conditions; leverage module ability to accept full assemblies
- Provide data to support licensing

Human Factors

- Measure and evaluate human performance via a realistic operational environment
- Inform future control rooms and training simulator designs, increase reliability of safety critical systems, and increase operator awareness in unfamiliar operating environments

Cybersecurity

- Demonstrate operator situational awareness in cyber-attack scenarios
- Evaluate supply chain security

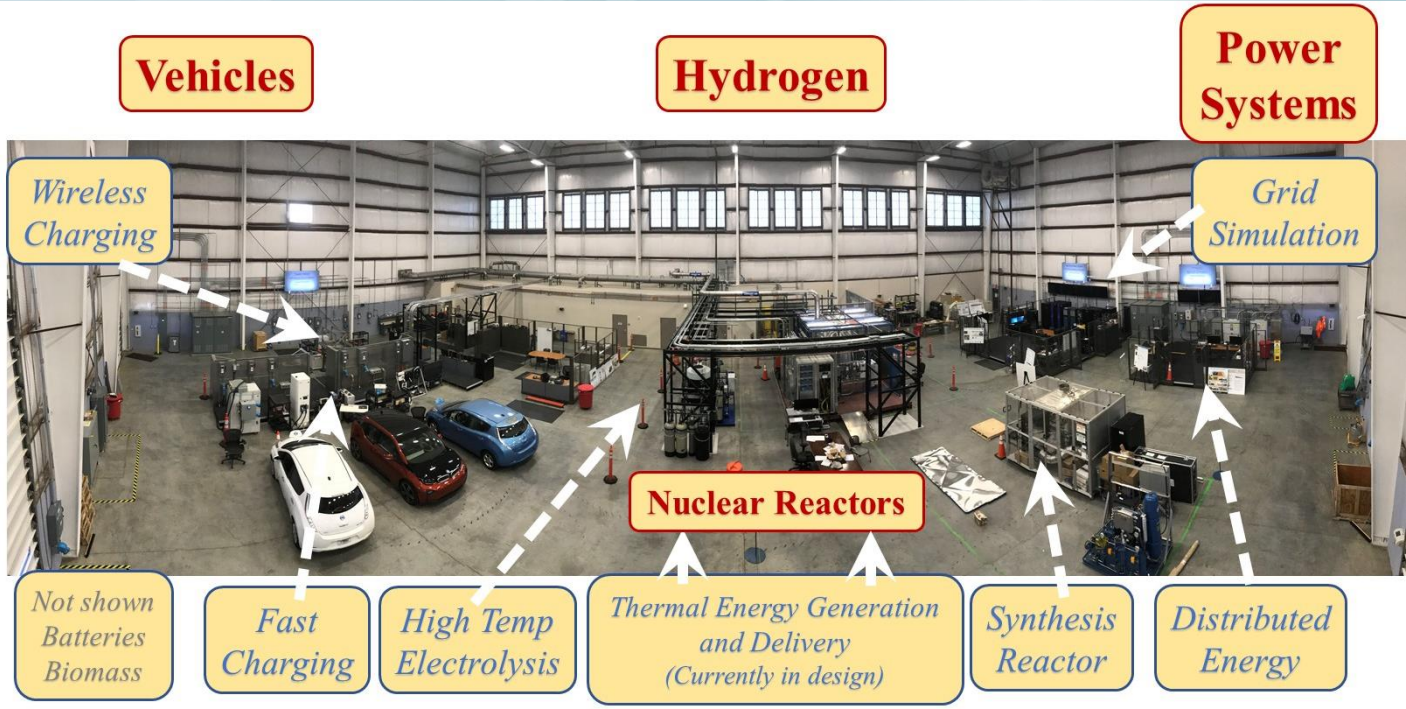
Regulatory Research

- Inform regulatory approach for fully digital instrumentation and control
- Exercise specialized licensing paths for non-traditional applications

Image taken from June 2018 NuScale Power advanced technology presentation available at https://gain.inl.gov.

Leveraging Relevant Facilities in the DOE Complex

- Systems Integration Laboratory
- Human Systems Simulation Laboratory
- Fuels and Materials Development and Testing
- High Temperature Test Laboratory (sensor development and testing)



INL Systems Integration Laboratory

INL Materials and Fuels Complex

High Temperature Steam Electrolysis Test Platform

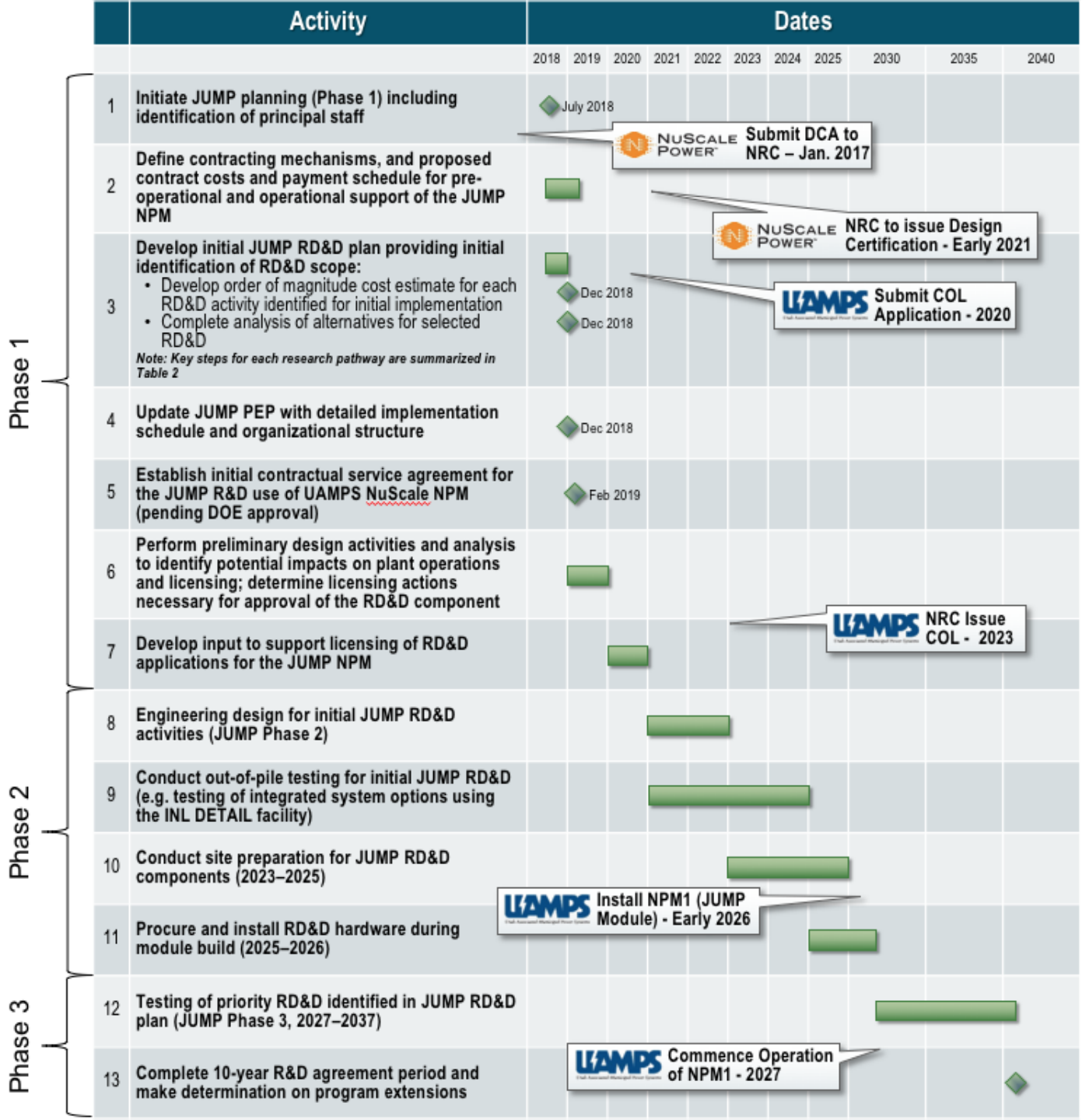
INL Human Systems Simulation Laboratory

Process to Determine JUMP Research Prioritization

- Collect RD&D proposals in multiple focused brainstorming sessions with DOE programmatic leads and RD&D thought leaders
- Screen concepts for preliminary licensing feasibility with subject matter experts and plant designers
- Review programmatic and other stakeholder interests
  - Gauge overall support within DOE research programs
  - Obtain vendor (NuScale) input on RD&D concept and high-level design
  - Establish preliminary prioritization
- Assess complementary RD&D activities that can be coupled or conducted in parallel
- Evaluate alternatives available to achieve the desired RD&D results
- Develop order-of-magnitude cost estimates for high-priority activities
- Review concepts with DOE and other stakeholders – select options to proceed to detailed design

Schedule and Task Summary

- ***Phase 1 (2018–2021): Planning***
  - Develop detailed program plan, RD&D plan, schedule and budget, analysis of alternatives
  - Establish contractual agreements
  - Conduct preliminary JUMP RD&D hardware design activities
  - Assess licensing impacts and development of inputs to licensing (engage NRC staff)
- ***Phase 2 (2021–2026): Precursor Activities, Hardware Installation & Pre-Op RD&D***
  - Modeling, benchtop testing, and scaled non-nuclear demonstrations for the selected RD&D activities
  - Final design of JUMP hardware, infrastructure
  - NRC engagement; submit license amendments
  - Procure and install JUMP-related hardware and infrastructure
- ***Phase 3 (2027–2037): Post-Op JUMP RD&D***
  - Initial testing of hardware
  - Execute JUMP RD&D plan
  - Assess and plan for future use of JUMP



Memorandum of Understanding (signed December 2018)

- Parties:
  U.S. Department of Energy, Utah Associated Municipal Power Systems (UAMPS), Battelle Energy Alliance

- Scope:
  - Contemplate the licensing, construction, and operation of a first-of-a-kind SMR at INL
  - One module would be dedicated to research, development, and demonstration (RD&D) under the JUMP program
  - One module would be used for power production to support INL energy needs (via Power Purchase Agreement [PPA])
  - Includes collaboration during pre-construction, construction, and licensing periods

- JUMP Agreement Scope
  - UAMPS to work with the U.S. Nuclear Regulatory Commission (NRC) to develop a licensing approach to include RD&D activities
  - Anticipated 15-yr term w/potential for 15-yr renewal

Questions?

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