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ESIG
NuScale SMR Design

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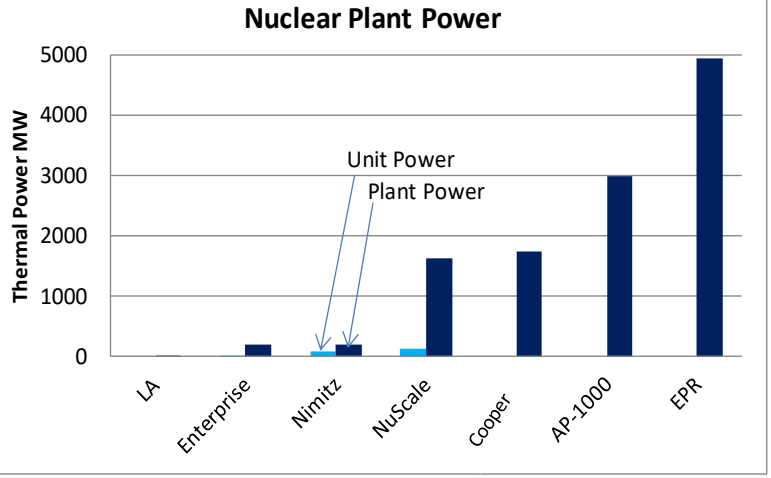
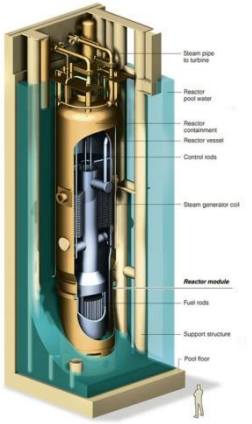
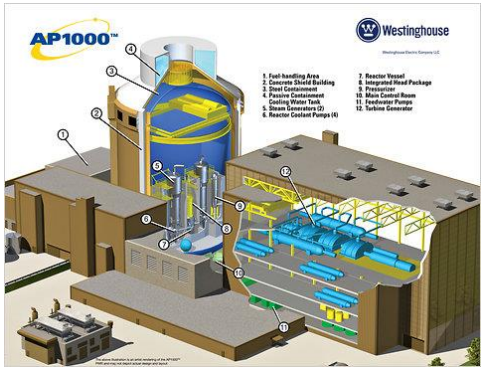
Reactor Power

Micro-reactor ~5MW
Los Angeles Class Submarine ~26 MW
Enterprise Class Aircraft Carrier 8x
Nimitz Class Aircraft Carrier 2x97MW, 194MW
NuScale Reactor 12 x 60MW, 720MWe
Cooper BWR, 800MWe
Westinghouse AP-1000, 1000MWe
European Pressurized Reactor, 1650MWe







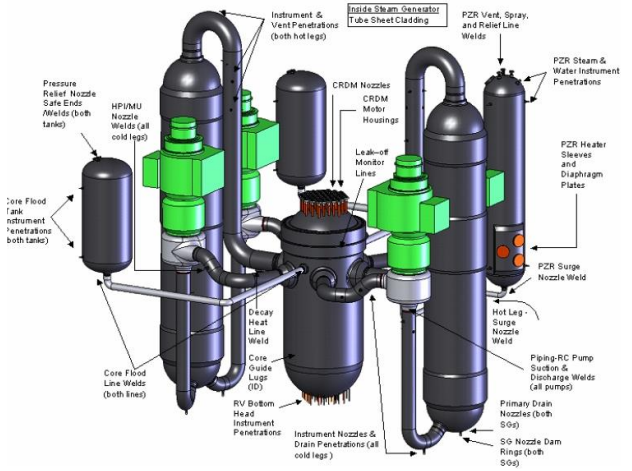
Integrated Reactor

SMR reactor and full primary system in one vessel

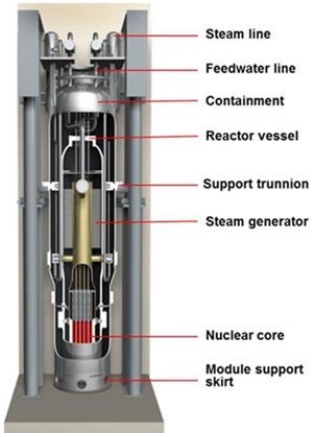
Simplified systems

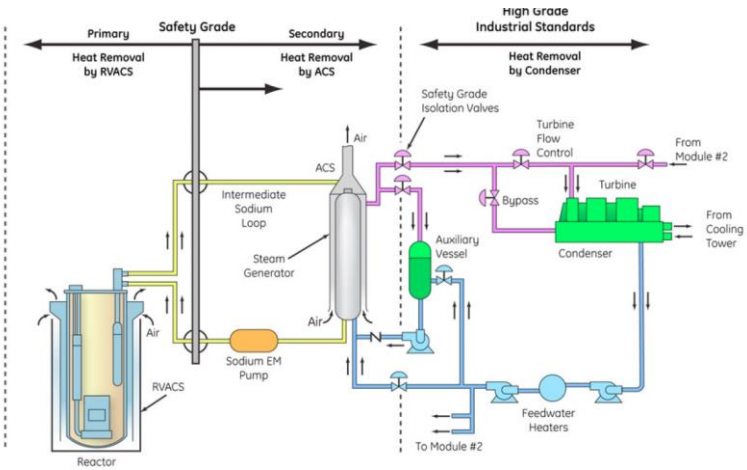
Fewer Failure Modes

Westinghouse ~integrated
Transatomic component/gas
NGNP Alliance component/gas
FliBe Energy – component
GEH Prism – component
Elysium – component
Terrestrial – integrated
TerraPower – component
GA EM2 – component/gas
Holtec – integrated
X-Energy – component/gas



Westinghouse SMR and PWR





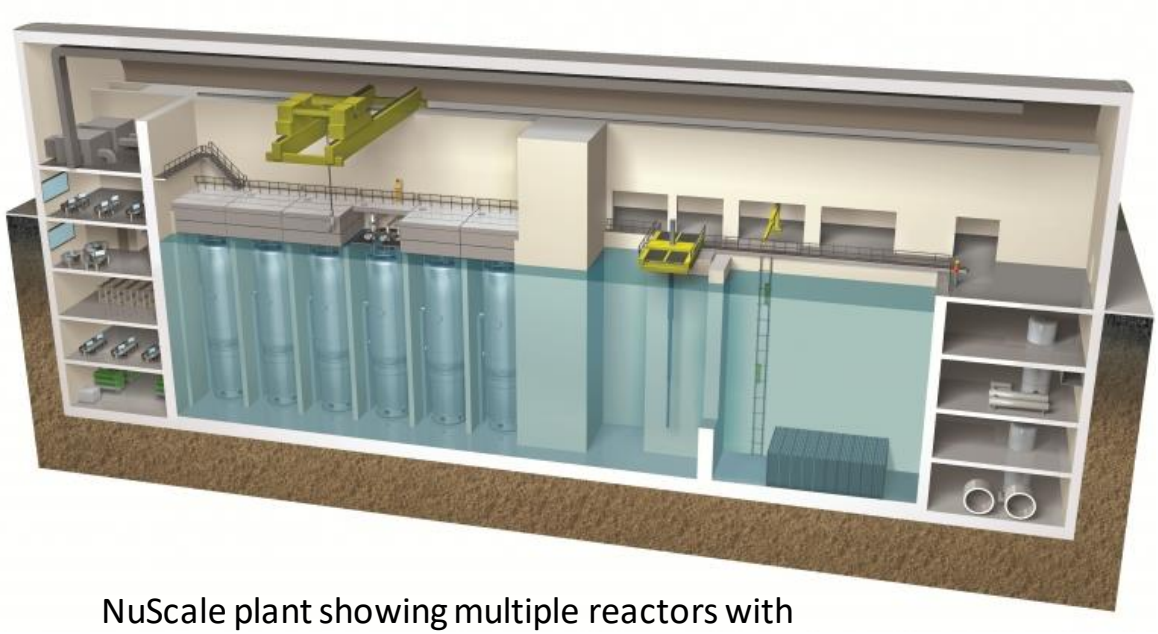
NuScale

Single unit

- 160 MWt, 60 MWe, 28% efficient

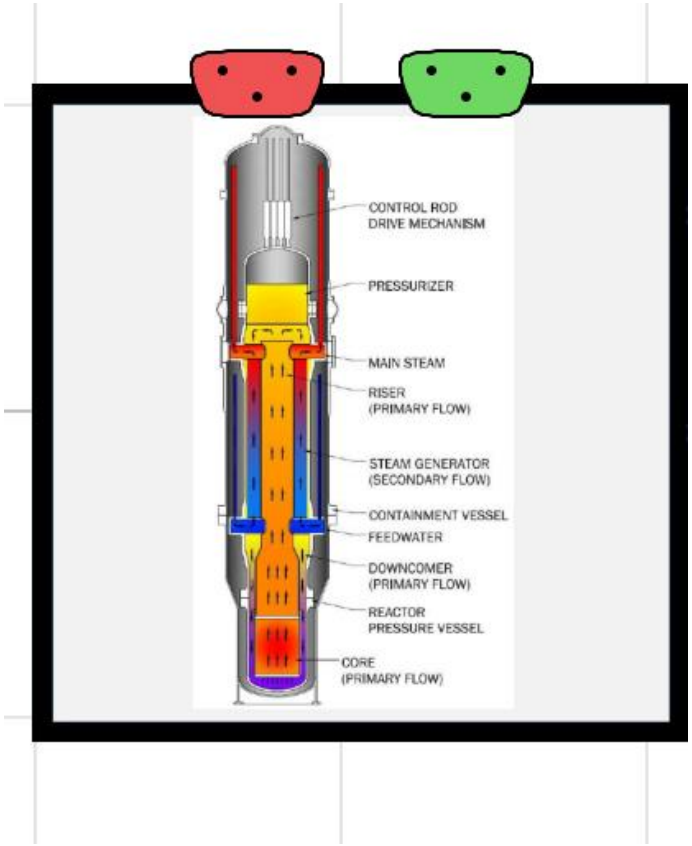
12 units per plant planned 540 MWe total

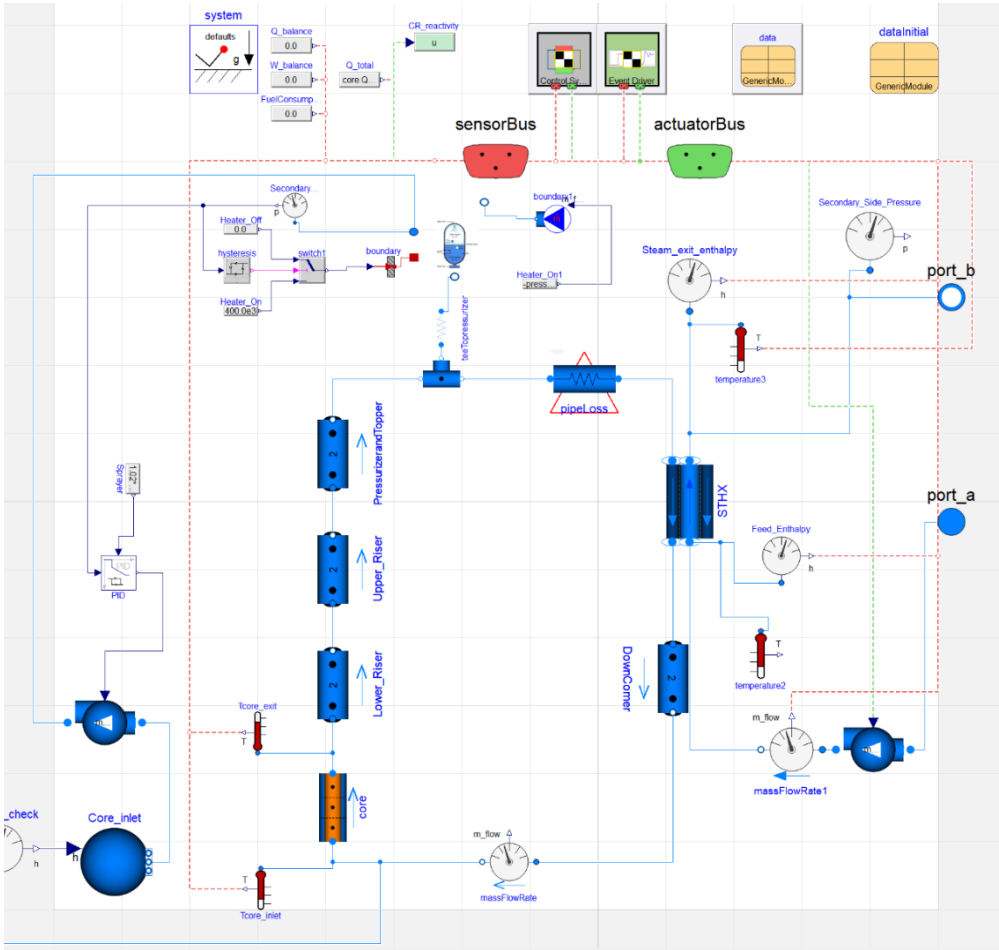
- Vessel 2.7m diameter, 20m high, 264t
- Rail, truck or barge shipping
- Natural circulation operation
- ECCS is passive and depends on natural circulation
- 365 Staff



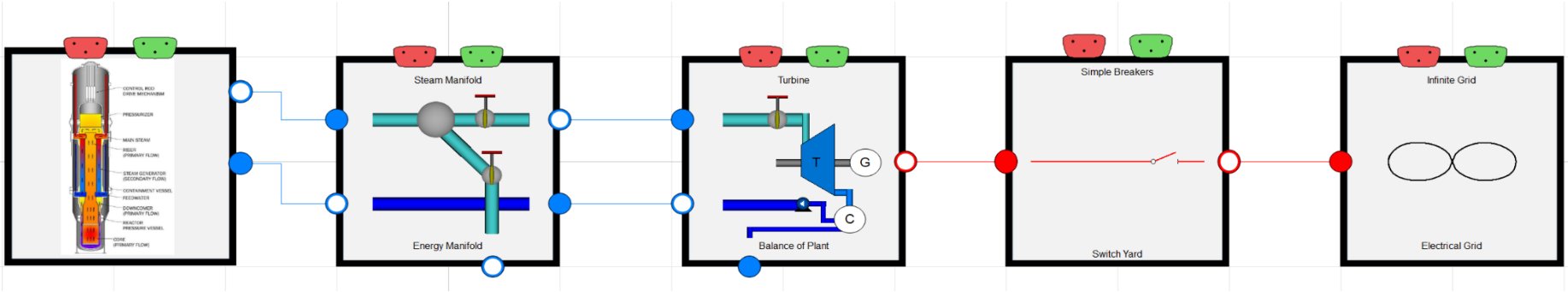
NuScale plant showing multiple reactors with largely below grade construction

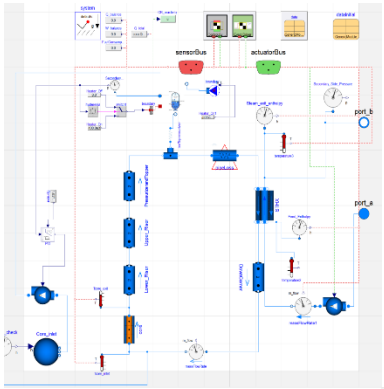
Transient NuScale Model in the Modelica Language

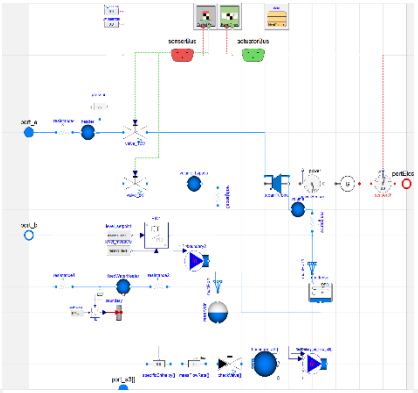


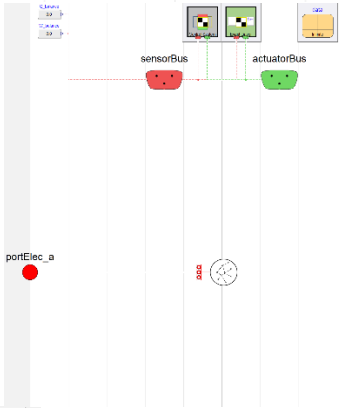


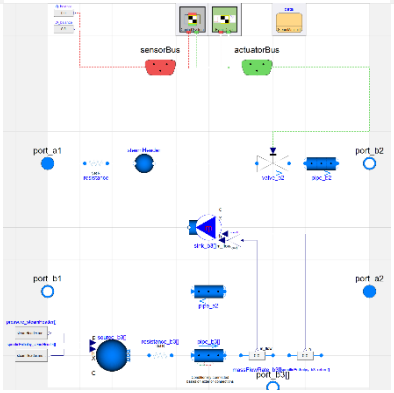
Modelica Eco-System allows the interconnection of Systems

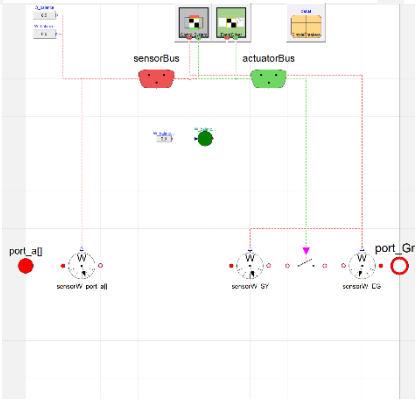






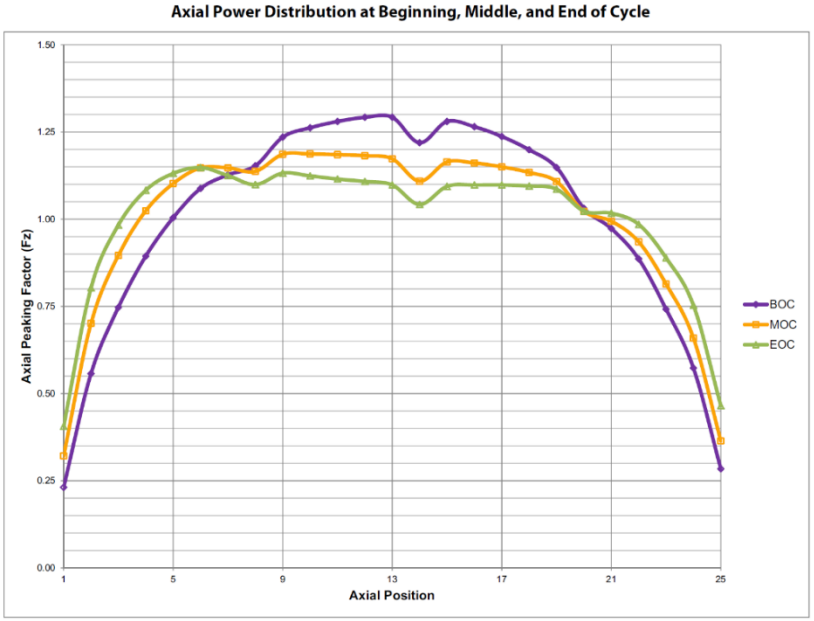






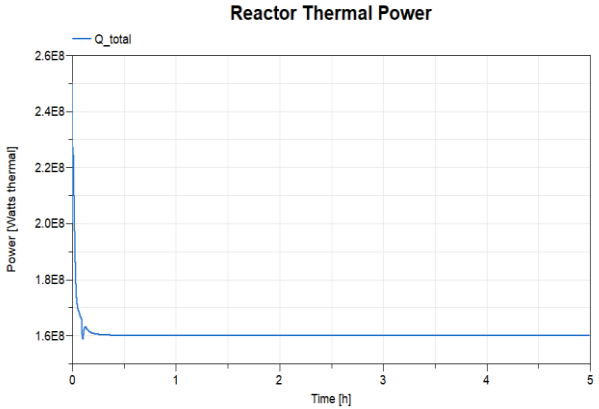
Implemented Calculations

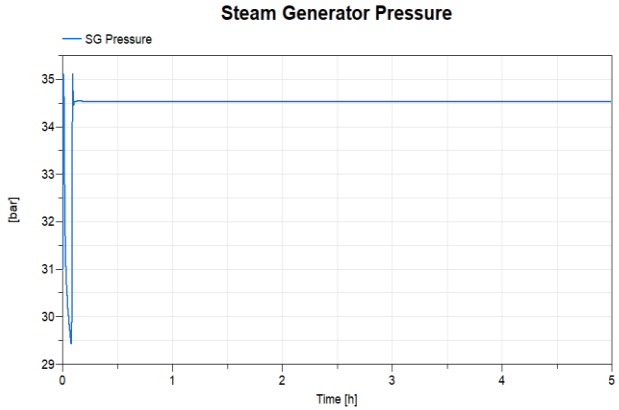
- Hot Channel Calculations
  - Peaking Factors (radial and axial)
  - Bulk Fluid Temperature
  - Outer Clad Temperature
  - Fuel Centerline Temperature
  - Departure from Nucleate Boiling Ratio (DNBR) (EPRI based)
- Pressurizer
  - Heaters
  - Sprays
- Reactivity Control
  - Standard Feedback Mechanisms
    - Boron, fuel temperature, moderator temperature, xenon
  - Control Banks
  - Beginning, Middle, and End of Cycle Feedback mechanisms can be simulated.

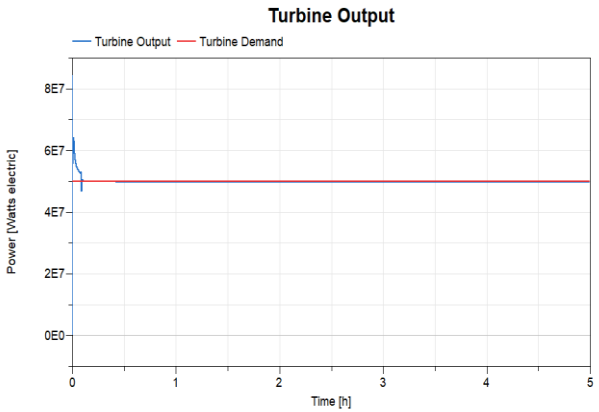


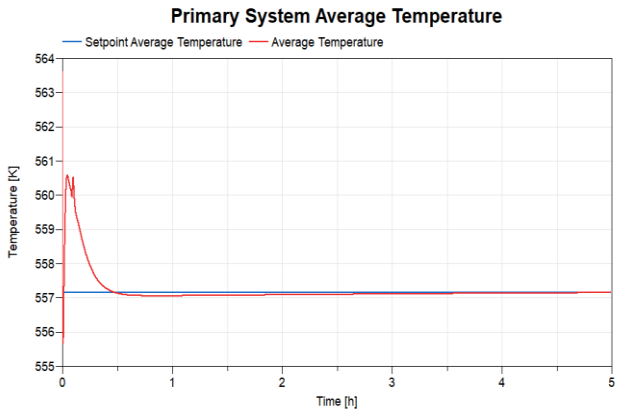
NRC Design Certification Matching

- 50MWe/160MWt
- Uprated to 60MWe
- SG Pressure remains constant
- Turbine Output Matches Turbine Demand
- Primary System Flowrate is within 0.4% of design certification quotes.
- All temperatures and pressures maintained within design limits.





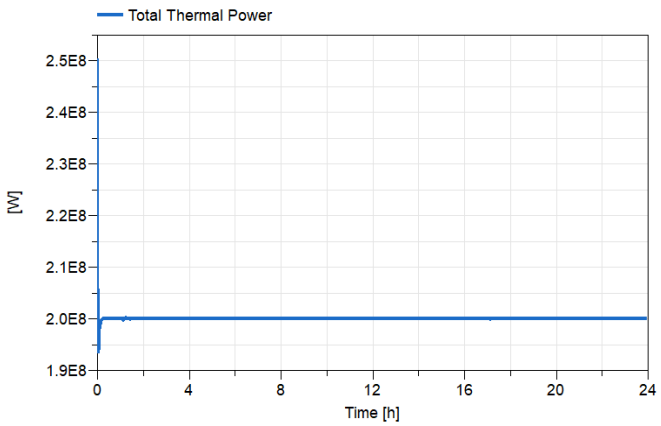


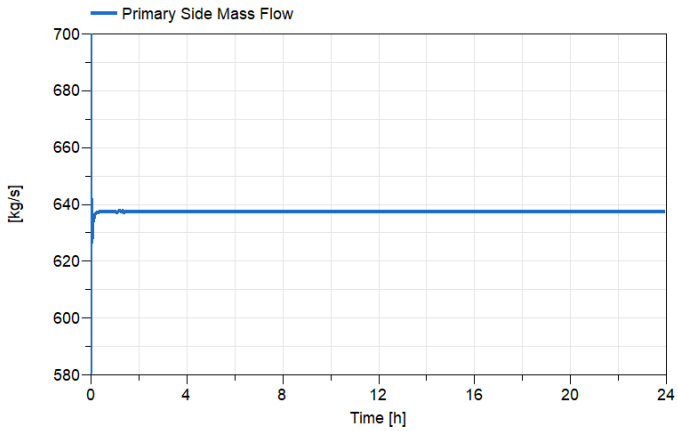


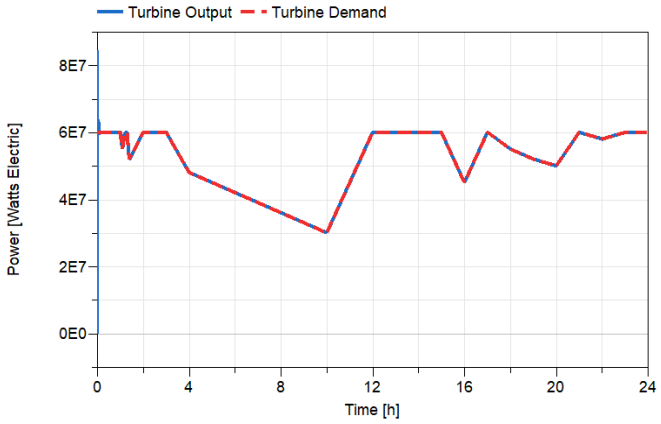
Load Follow Operation

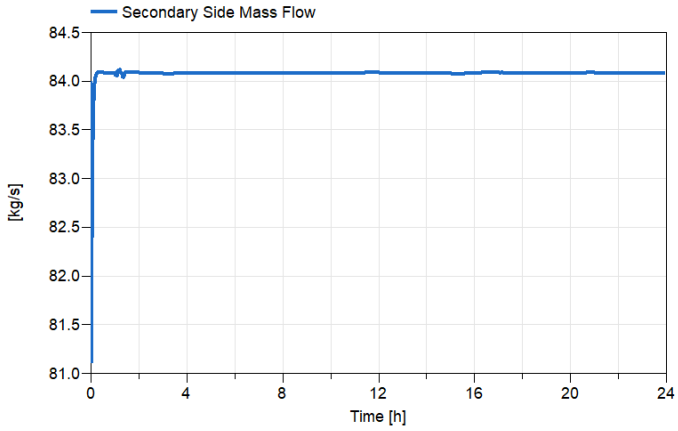
- 60MWe/200MWt
- SG Pressure remains constant
- Turbine Output Matches Turbine Demand over 24 hour period.
- Control Actions are able to maintain temperatures, pressures, power outputs at safe levels.

- **Measures of ramp rate**
- 100%-20%-100% in 24 hours
- 40%/hr ramp rate
- 20% step in 10 minutes
- Bypass to condenser for faster ramps (Seconds-minutes)
- Meets California Duck curve requirements



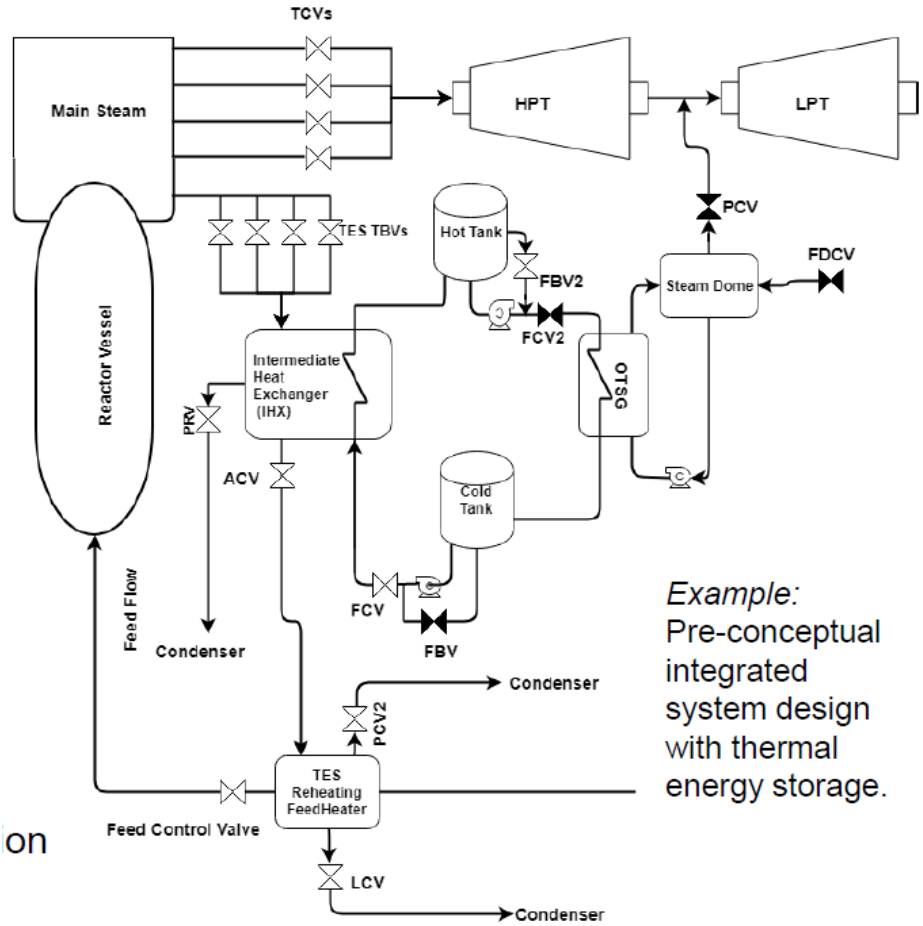






Conclusions

- NuScale is an advanced design to address issues with building an deploying nuclear power plants.
- NuScale can operate in different modes with modules and load following.
- SMRs can address different markets
- Models have been made that include hot channel calculations, reactivity feedback mechanisms, control rods, system geometries, and associated control systems.
- Models will be integrated with existing and new models (thermal storage, HTSE, RO, etc…)



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