

Small-Scale Pumped Heat Energy Storage Demonstration

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Panel: System, heat exchangers, and TES Technoeconomics

SETO PTES Workshop

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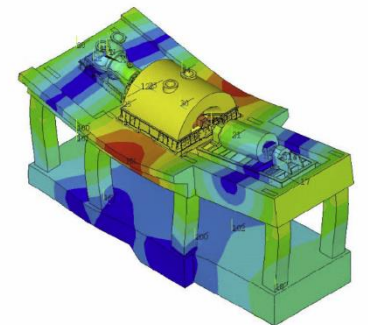
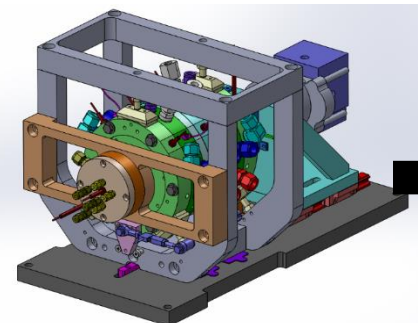
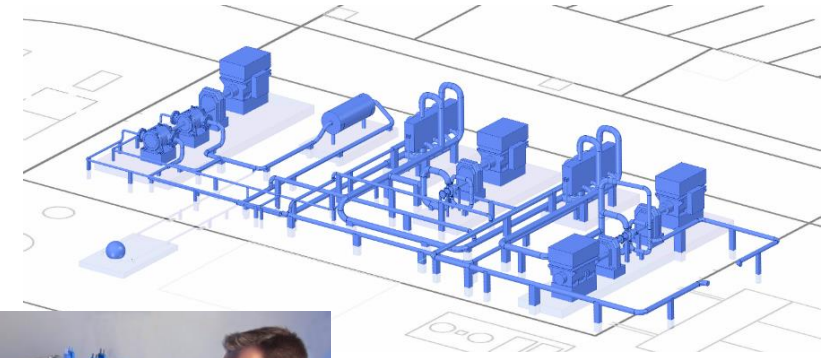
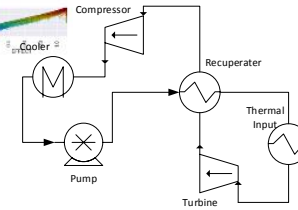
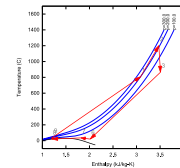
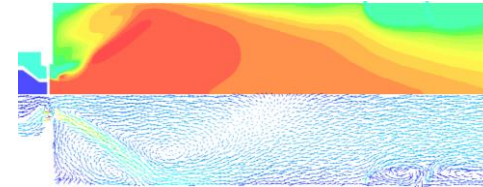
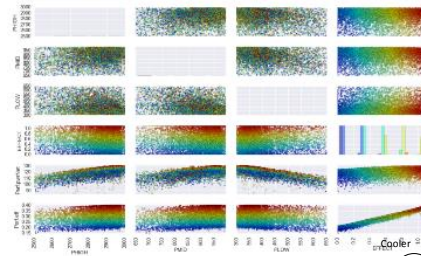
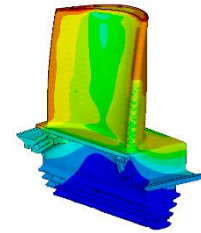
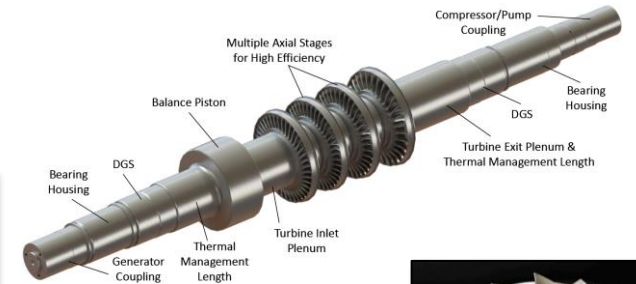
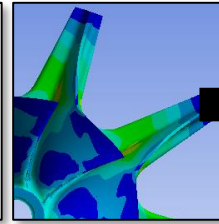
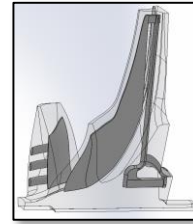
Applied Research centered around Rotating Machinery and associated systems for

- Oil & Gas
- Aviation
- Liquid Propulsion
- Power Generation

Specialize in developing technologies and prototype demonstration

- Support OEMs in transitioning new technologies to products

Including energy storage & sCO2 technology development



SwRI Small-Scale PHES Demonstration

Funded by



Project team of



Project Description:

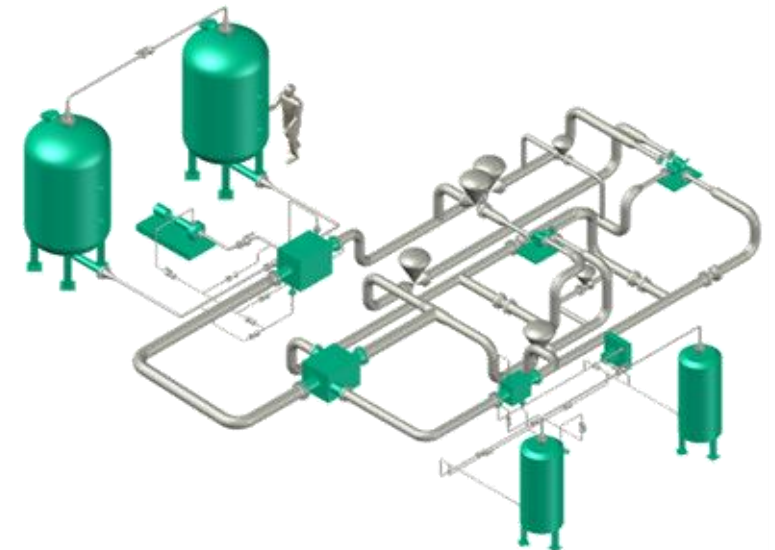
Demonstrate operation of a Air Brayton PHES at **laboratory scale to verify system control strategies**. Address first implementation challenges and reduce the number of unknown unknowns.

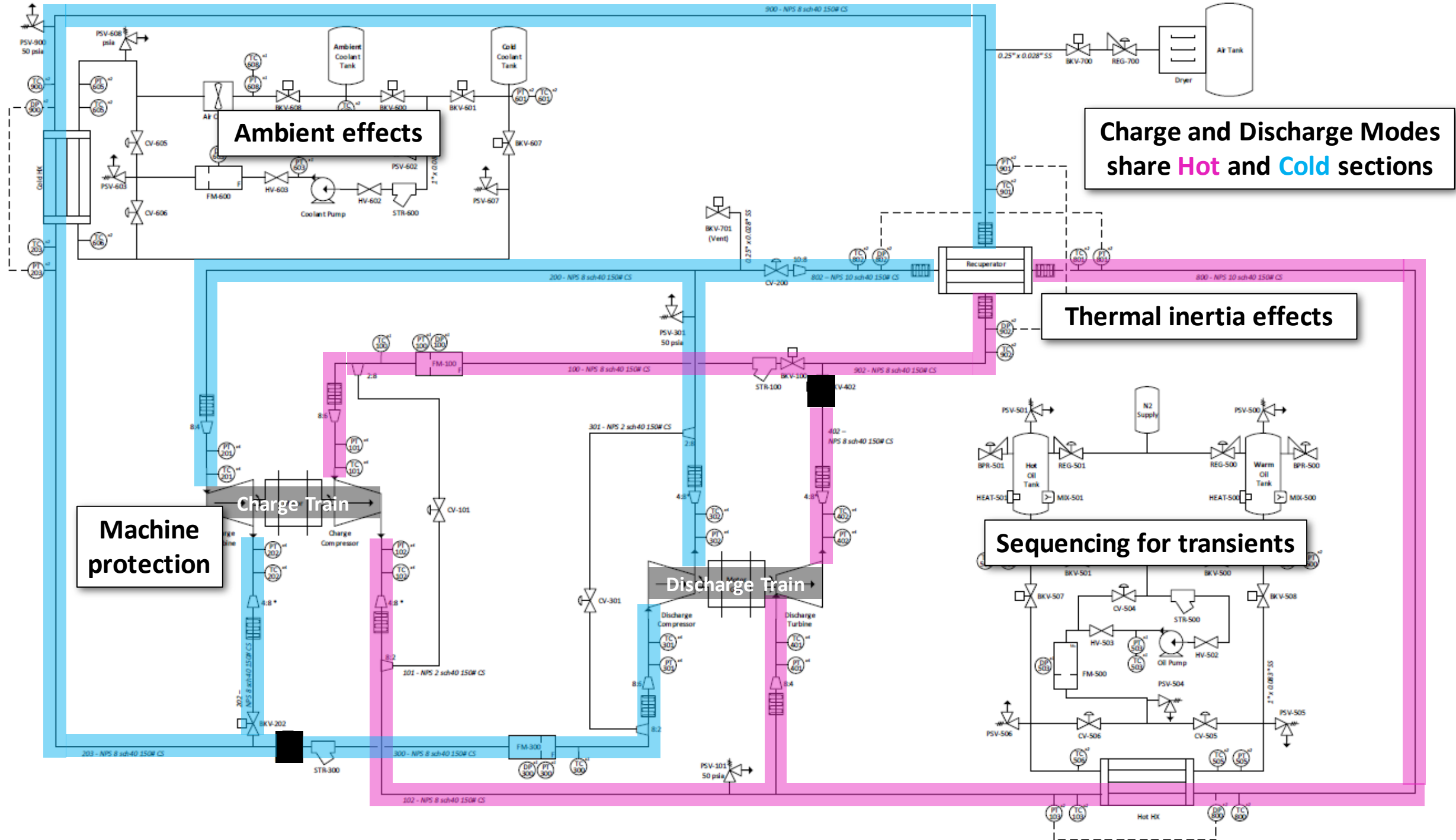
Main Outcomes:

- Data from transient and steady state operation
- Verification of control strategies
- Address first implementation challenges
- Reduced risk for full-scale implementation

Project Timeline:

- Design Complete – August 2020
- Hardware Procurement Complete – February 2021
- Assembly & Commissioning Complete – September 2021





Ambient effects

Charge and Discharge Modes share Hot and Cold sections

Thermal inertia effects

Machine protection

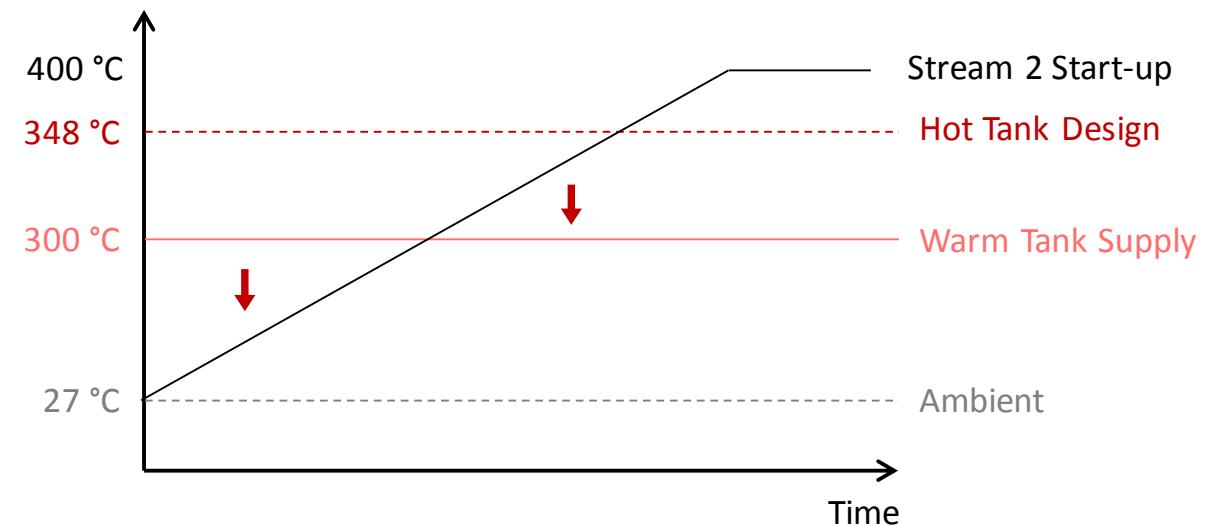
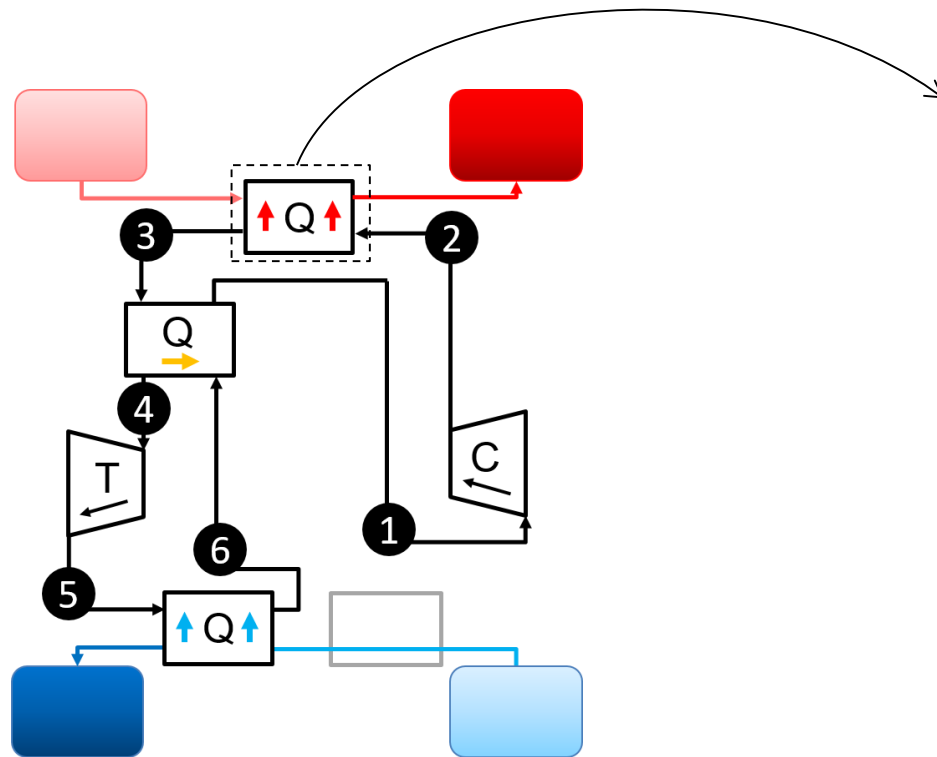
Charge Train

Discharge Train

Sequencing for transients

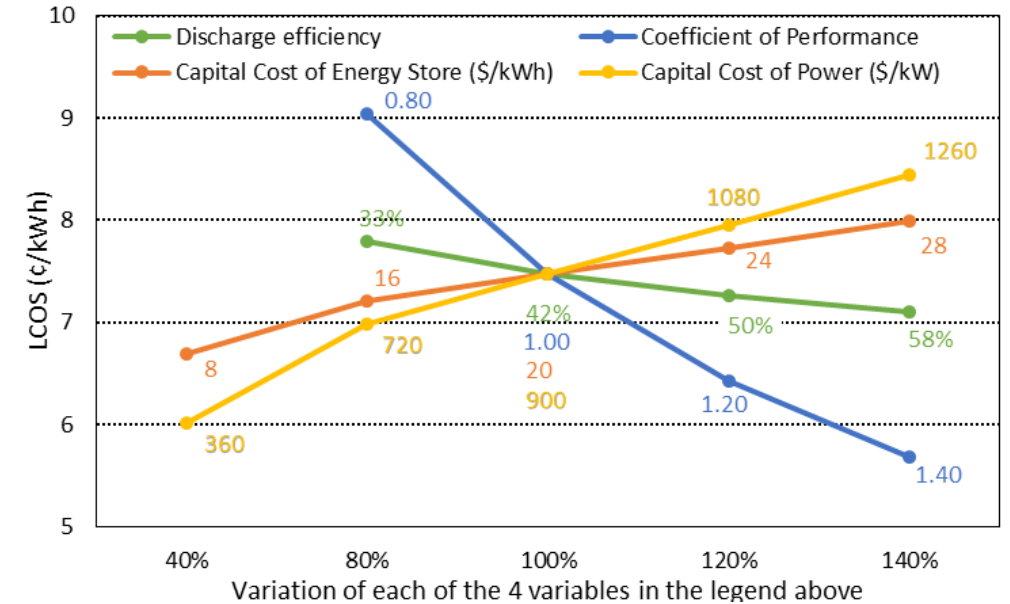
Charge Mode Cold Start

- Direction of heat transfer in Hot Heat Exchanger switches during Charge Mode start-up
- Controls & sequencing to balance
 - Thermal ramp rate,
 - Storage media management,
 - System complexity, etc.



The path forward for PTES

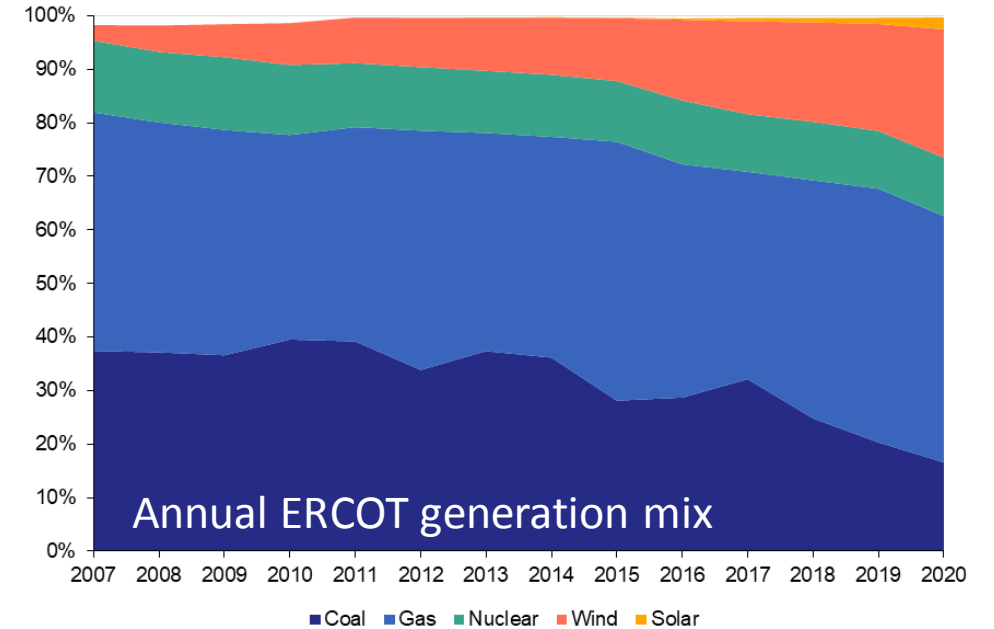
1. What are the key metrics to enable deployment of PTES?
 - \$\$\$
 - *Commercial readiness is a function of temperature and scale. Key Hardware: Compressor, HX, valves*
 - *Systems capable of integrating with various use cases and existing infrastructure will be critical to success. Think Legos, not single package.*
2. What is the ideal PTES configuration?
3. What heat exchangers exist or can be developed for 550 °C+?
 - Thermal transient capability (Mechanical integrity and thermal inertia)
 - Bidirectional
 - ARPA-E HITEMMP
4. Beyond component development, what can enable PTES deployment?



Clearly, these are all important factors, and an optimal balance will arise, but this might not look the same for all use cases.

The optimal architecture & integration?

- Use case and integration case specific, even within hybrid CSP applications
 - Existing infrastructure
 - Local energy market, other renewables or fossil assets
- PTES has natural synergy with CSP applications



Air PTES

- Lower pressure conditions
 - Thinner-walled hardware
 - Higher sensitivity to pressure loss
 - Generally, larger pipe size
- Make-up air readily available

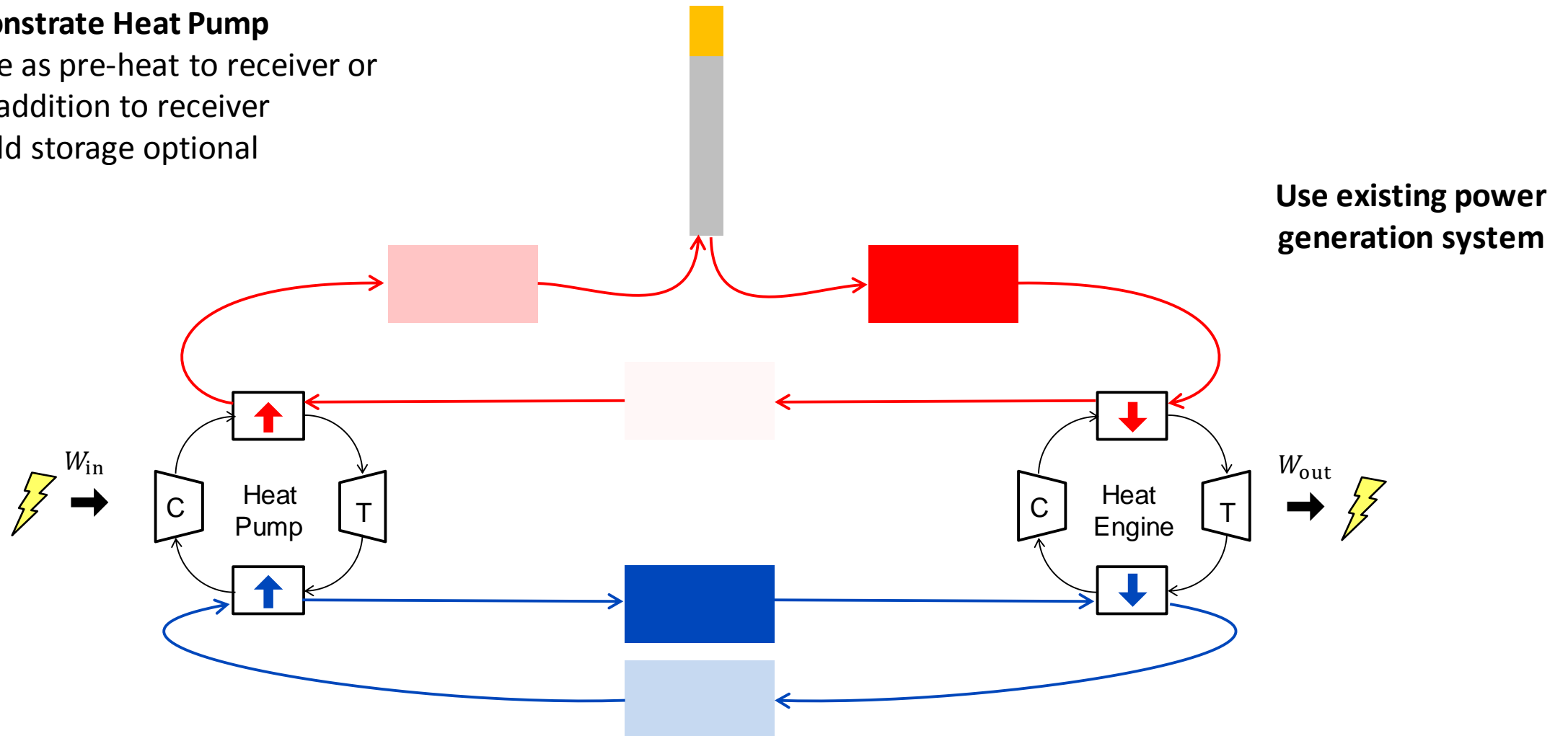
sCO₂ PTES

- Higher pressure
 - Compact pipe and hardware sizes
 - Thermal masses due to thick walls would likely still be high
- Mates well with no cold storage options, however maybe not optimal

Possible first implementation

Demonstrate Heat Pump

- Use as pre-heat to receiver or in addition to receiver
- Cold storage optional



Use existing power generation system

What else for PTES deployment?

- R&D: Operation & controls considerations
 - Charge mode surge protection
 - Storage media management for optimal performance
 - Controls sequencing for fast transients
- Non R&D: Asset-owner buy-in
 - Regulatory implications
 - PTES needs to out-perform
 - Peaker units
 - Batteries
 - More instances of thermal storage

