# Small-Scale Pumped Heat Energy Storage Demonstration

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Industry Panel
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# About Southwest Research Institute (SwRI)

- Applied Research and Development
  - 501 (c)(3) nonprofit corporation
  - $600M 2018 revenue is based on Contract R&D
- San Antonio location
  - Over 2,600 employees
  - 1,200-acre facility
  - 2.3 million square feet of laboratories & offices
- More than 1,300 patents
  - Resulting from Client sponsored and Internal Research

Benefiting government, industry and the public through innovative science and technology

- Applied Physics
- Intelligent Systems
- Fuels & Lubrication
- Powertrain Engineering
- Mechanical Engineering
- Defense & Intelligence Solutions
- Space Science & Engineering
- Chemistry & Chemical Engineering

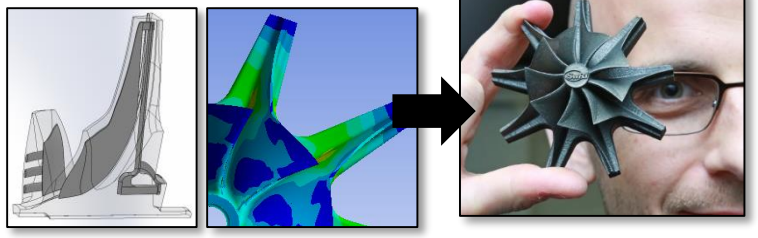
# SwRI Machinery Department

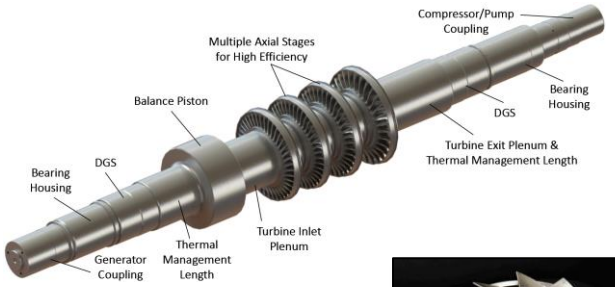
Applied Research centered around Rotating Machinery and associated systems for

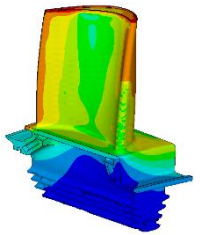
- Oil & Gas
- Aviation
- Liquid Propulsion
- Power Generation

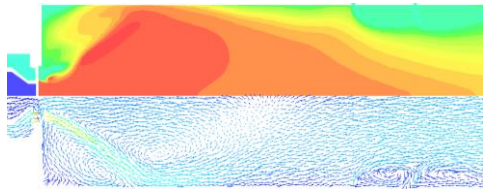
Specialize in developing technologies and prototype demonstration

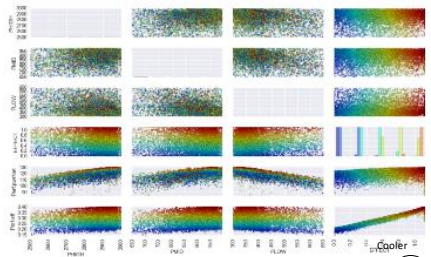
- Support OEMs in transitioning new technologies to products

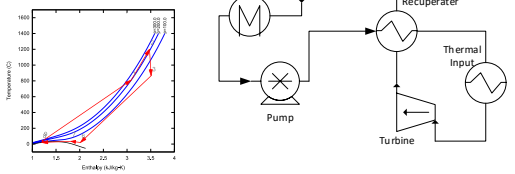


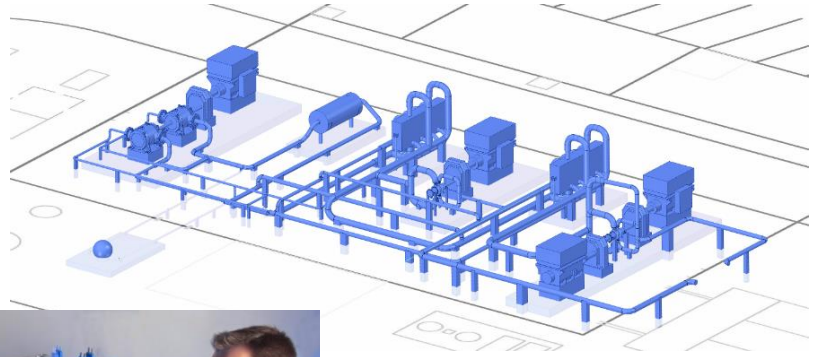


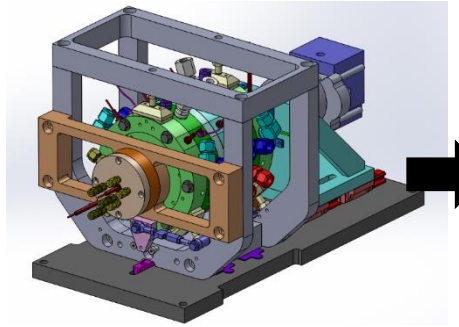



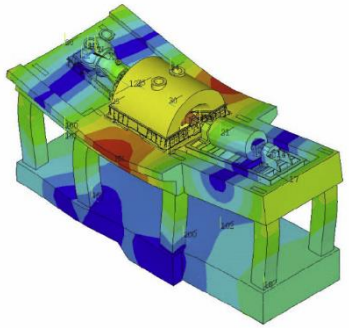










# End-user Tech Requirements = The ES Dream

- RTE **as high as possible**
- **Low** thermal loss
- Modularity and scalability
- Cycling capacity
- Compactness and affordability of storage media
- **Low** CAPEX for energy conversion system
- **High** flexibility during charge phase
- Flexibility in discharge **as close as possible** to a gas turbine
- Compatibility for retrofitting existing plant
- Compatibility with direct heating and cooling
- Safety and chemical hazard

Several technologies both high and low TRL could potentially meet these requirements

- Liquid Air, Compressed Air, Pumped Heat

Different implementations of the technologies could serve for different use cases.

- Each implementation will have different optimal layouts and limitations

If you truly want all of **these** outcomes, R&D is necessary.

# SwRI Small-Scale PHES Demonstration

Funded by arpa·e CHANGING WHAT'S POSSIBLE

Project team of SwRI® MALTA

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.

Operational Modes of Interest:

Startup, shutdown, mode switch, and steady state operation

- Validates approach to full scale system
- Understand limitations

Approach:

Cycle from literature → Implement with COTS hardware → Evaluate effectiveness of control schemes for various operational modes

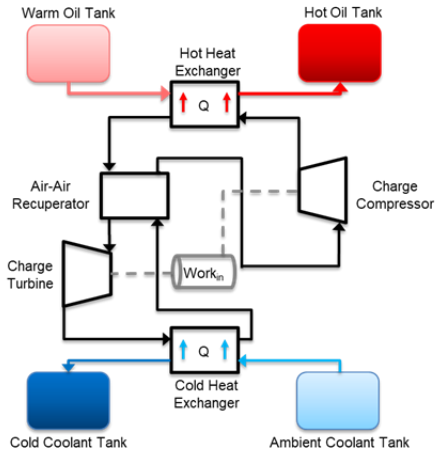
**Cycle**
Definition from literature
Evaluation
Optimization for COTS hardware

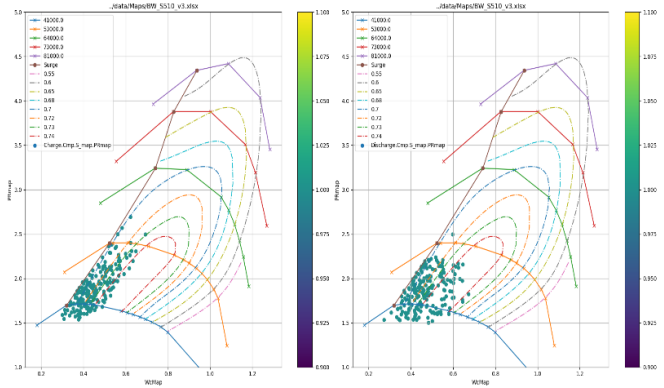
**Component Selection**
Turbomachinery
Heat exchangers
Thermal storage systems

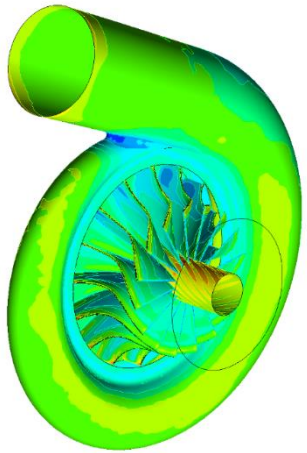
**COTS Hardware Modification**
Turbomachinery Aero and Mechanical

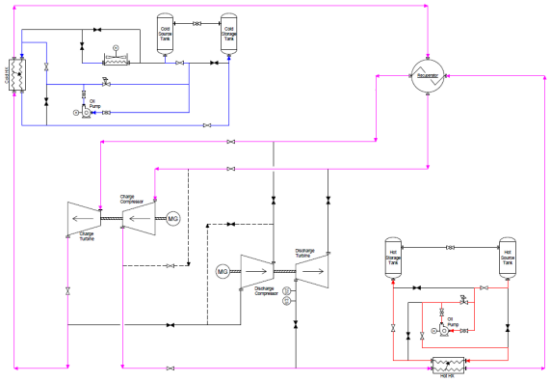
**Controls Strategy**
Component interactions
Startup and shutdown
Mode switch

### Charge Mode: Heat Pump

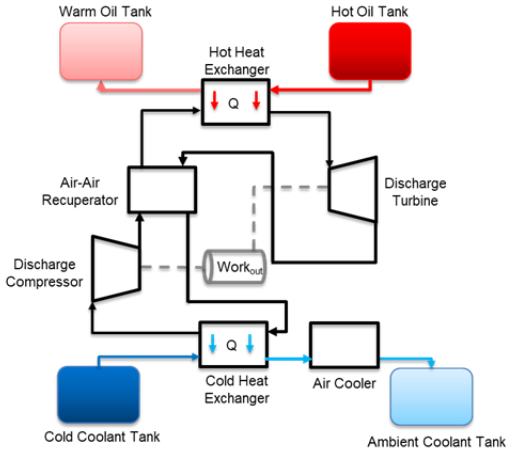


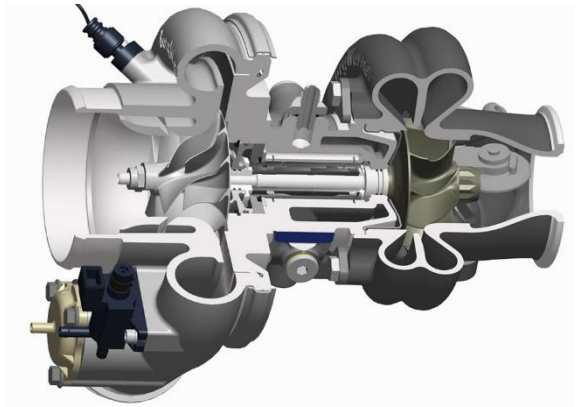



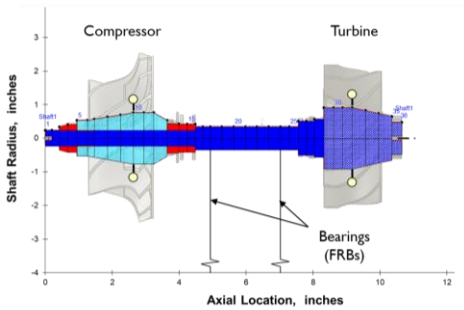


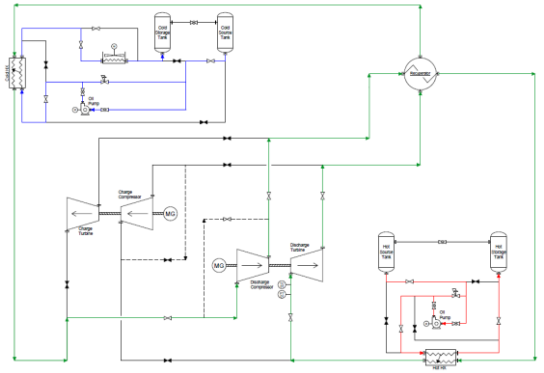


### Discharge Mode: Heat Engine

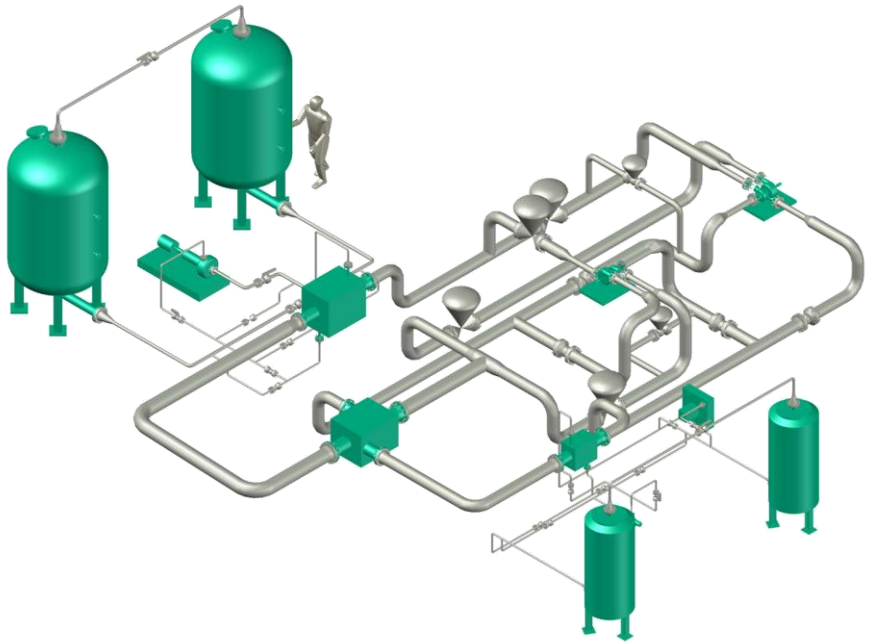




**Facility Development**
Layout and piping
Balance of plant



**Energy Storage Test Facility**
» Developed for Air Brayton demonstration
» Extendable to other technologies to leverage thermal storage media and balance of plant

# Small-Scale Pumped Heat Energy Storage Demonstration at SwRI

Status:
Progressed to BP2
Procuring hardware and finalizing design
Operational by end of 2020

Main Outcomes:
Data from transient and steady state operation
Verification of control strategies
Reduced risk for full scale implementation