Commercial Design and Deployment Plans for a Transcritical CO_2 Pumped Thermal Energy Storage (PTES) System

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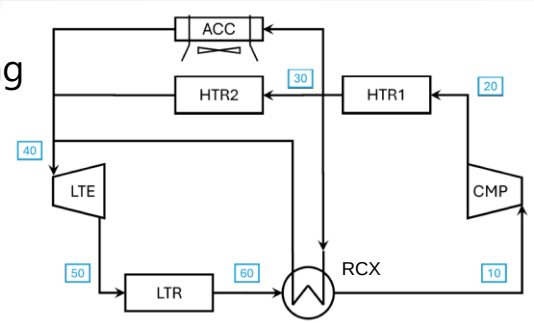
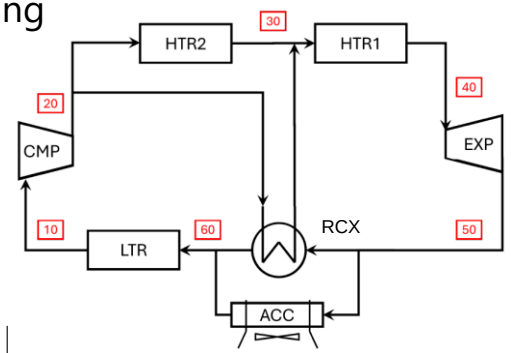
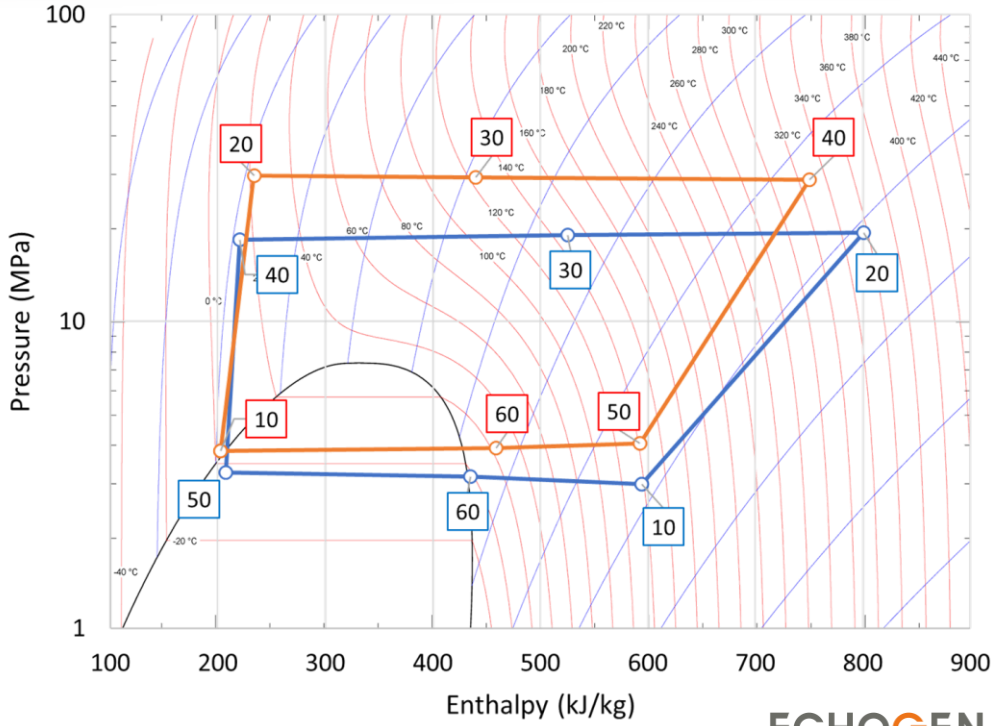
Pumped Thermal Energy Storage basics

Charging



Generating





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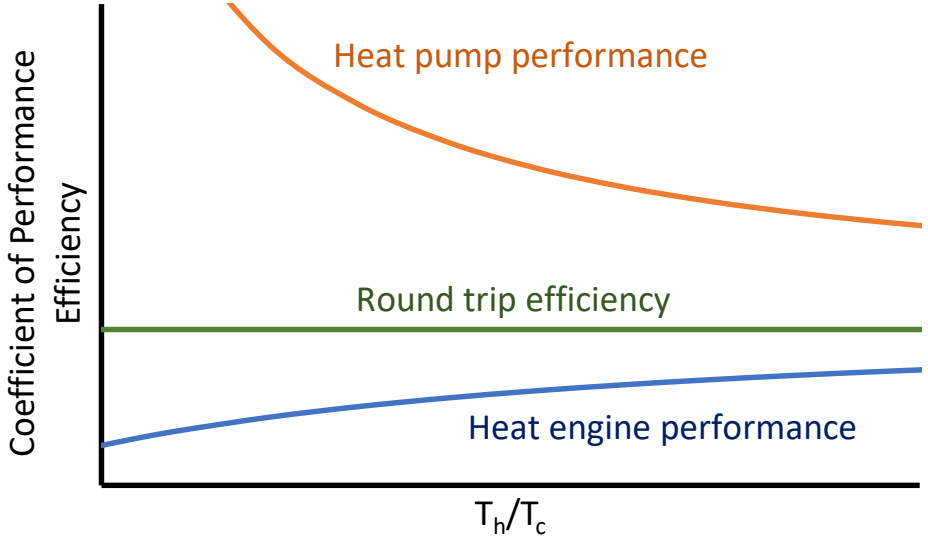
PTES provides good round-trip efficiency (RTE) at modest temperatures



Heat pumps get more efficient at low temperature ratio (T_h/T_c)

RTE is mathematical product of heat pump and heat engine performance

Heat engines get more efficient at high temperature ratio

… so good RTE (~60%) can be obtained at moderate temperature ratio

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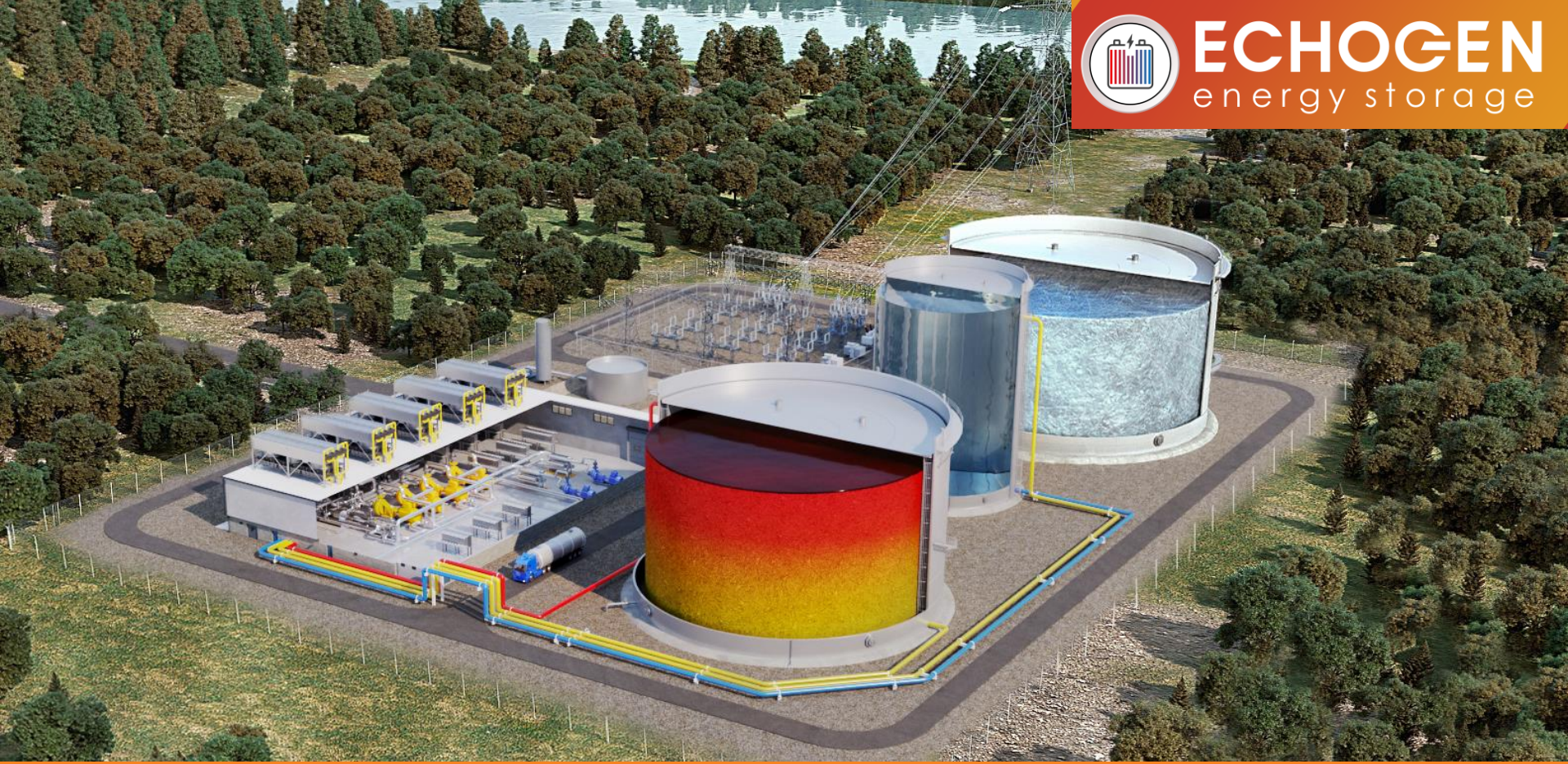


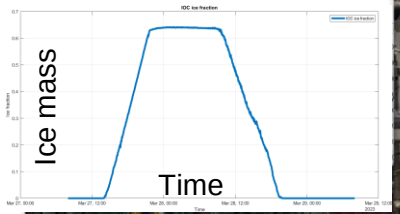
Pumped Thermal Energy Storage (PTES)

Low-cost, safe and environmentally-responsible electrical energy storage anywhere

From Concept to Prototype: ARPA-E DAYS Program

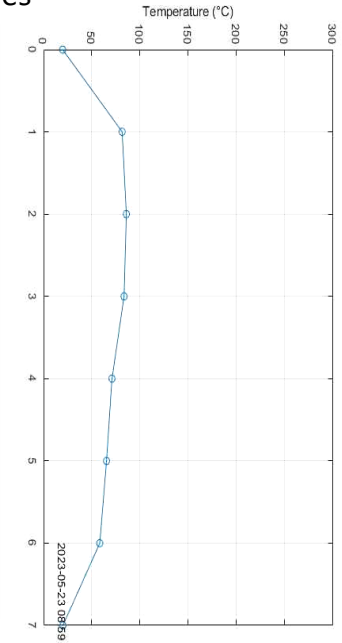
~100 kWth system, including both charging and generating cycles

Low-Temperature Reservoir (LTR)



CO_2 heat pump & power cycle

High-Temperature Reservoir (HTR)



Charge/gen cycle

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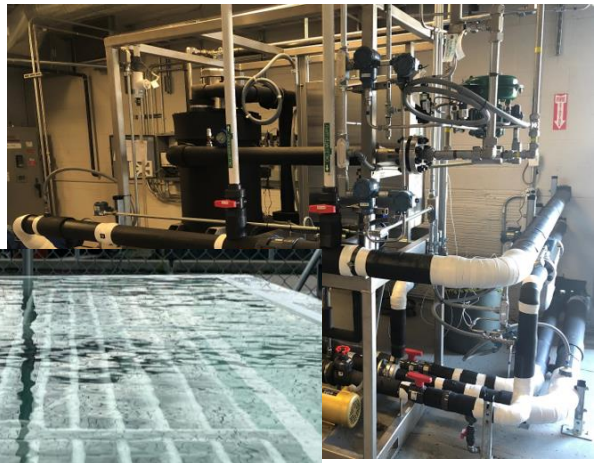
Passive Ice/Water mixture generation

- Mechanically scraped-surface ice slurry generator tested successfully
- Developing/testing three non-mechanical ice/water systems
- DOE EERE-funded with technology partners Shift Thermal & SPF



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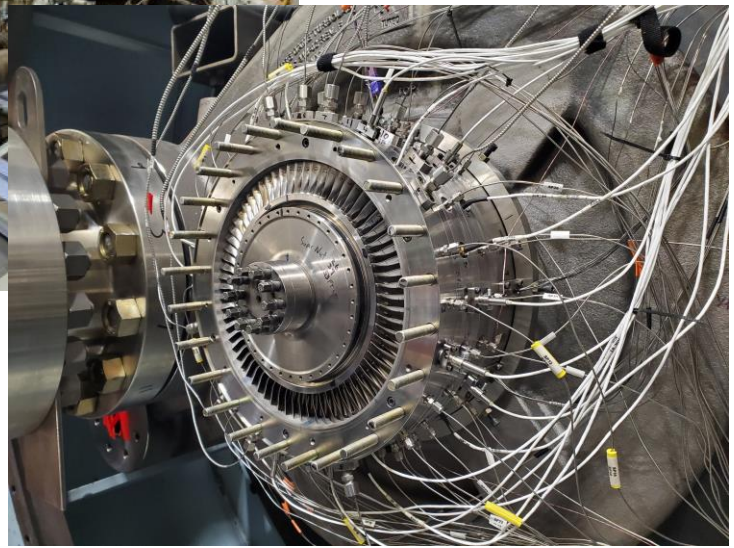
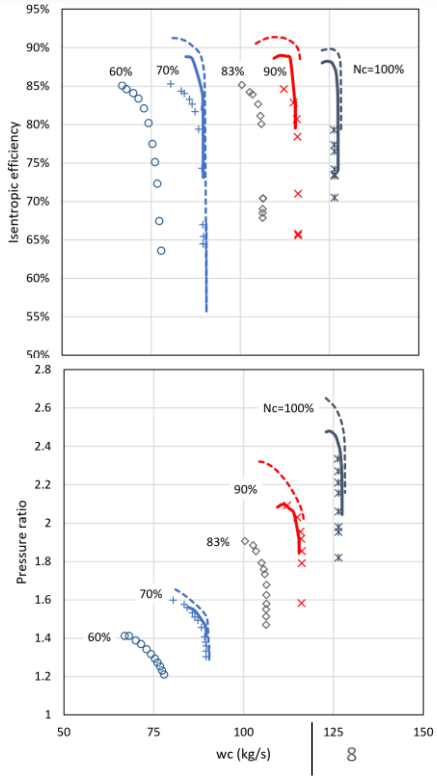
9 MW closed-loop CO_2 testing at NDTL Propulsion & Power provided first test data for a CO_2 axial compressor





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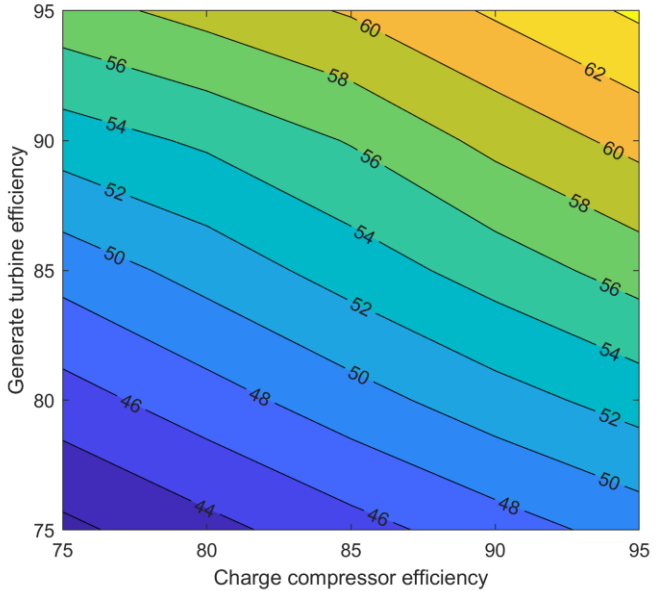
Compressor vs turbine losses – reality is more complex!

- Compression anisentropic losses = higher discharge temperature for the same pressure ratio
- System constrained on compressor discharge temperature
- Lower isentropic efficiency achieves same exit temperature at lower pressure ratio

Both turbine and compressor efficiency are important
Turbine efficiency larger influence than compressor



Lab/pilot-scale PTES system developed as part of ARPA-E DAYS program provided key validation data and operational experience

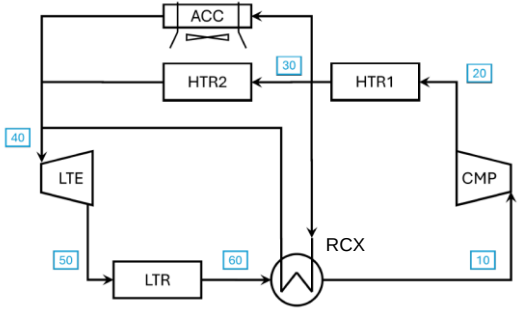
Compressor

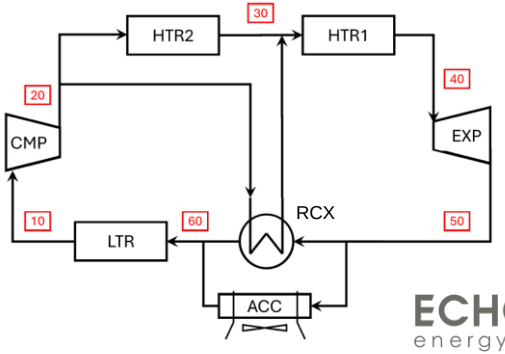
Pump

HTR

LTR

RCX





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Echogen PTES technology - $50 MM federal award in DOE OCED Energy Storage Grand Challenge

- Prime: Westinghouse Electric
- Technology Provider: Echogen
- Project Partners:
  - Golden Valley Electric Association
  - Arctic Slope Regional Corporation
  - EPRI
  - Shell
- 50 MWe X 24 hours duration
  - Firm/support new wind generation
- High turndown charging and generating requirements

ECHOGEN power systems

Golden Valley Electric Association has challenging future power generation needs

- Current generation mix
  - Coal
  - Small wind farm
  - ULSD-fired frame SCGTs
  - Limited ability to import power along 80 MW “inter-tie”
- Future scenario
  - One of two coal-fired generators at Healy to be retired soon
  - Replace capacity with wind + storage
  - Li+ too expensive, difficult to operate in arctic environment
  - PTES offers lower cost energy storage, adds needed VAR support and natural grid inertia, but at lower RTE and with longer response times than Li+-
  - Hybrid solution with wind + PTES + smaller duration Li+ best fit for customer’s needs

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Office of Clean Energy Demonstrations (OCED)

1.2 GWh PTES system

Healy, Alaska

FEED Study	Proj Dev	Construction	Operations
2024	2025	2026	2027	2028

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