Supercritical CO_2-Based Long-Duration Electrical Energy Storage

Echogen overview

- Founded in 2007
- Mission: To develop and commercialize a better exhaust and waste heat recovery power system using CO_2 as the working fluid

sCO_2 power cycle commercial activity

- Key partnerships – Siemens (Oil & Gas), GE (Marine)
- First commercial article (EPS100 – 7.5 MWe) designed and built by Echogen, tested at Siemens
- First commercial sale (EPS120 – 9.5 MWe) announced in March 2019 by Siemens to TransCanada

TransCanada

SIEMENS

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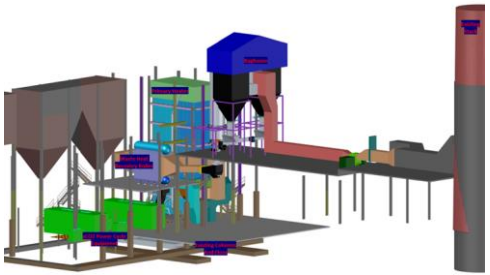
Ongoing Echogen projects

- Leading multiple DOE- and industry-funded projects in:
  - Nuclear – Micro-reactor power plant, others
  - Fossil – 10 MWe indirectly-fired power plant (FE)



  - Solar – thermochemical energy storage (SETO)
  - Energy Storage – (ARPA-E)
  - Thermal power plant integration with ETES (Coal FIRST)
  - Large-scale (100 MWe+) CO_2 compressor technology development (SETO)

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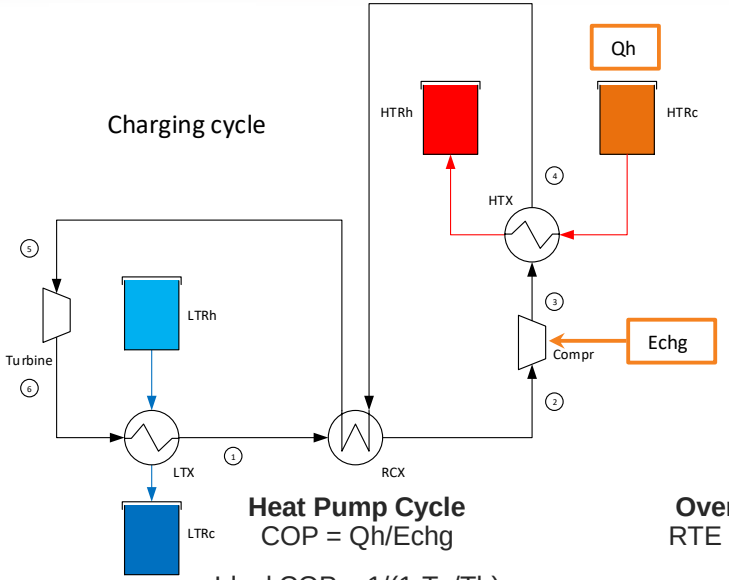
ETES (or TEES, or PTES, or Carnot Battery) storage

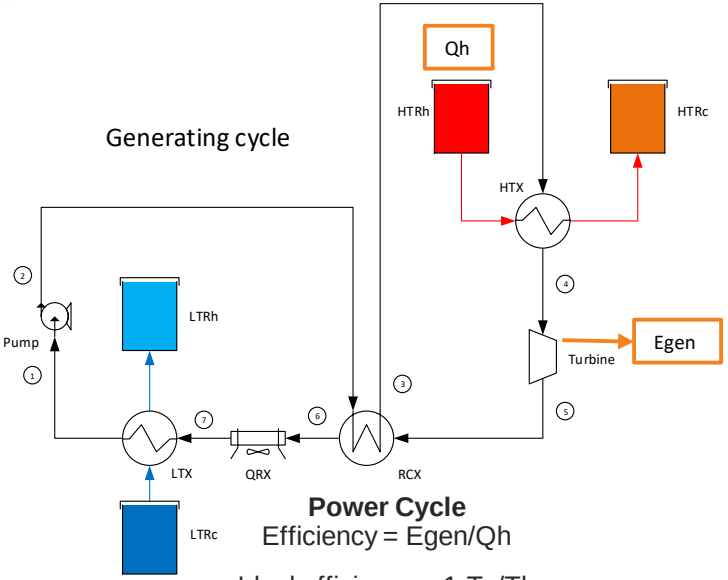


Heat Pump Cycle
COP = Qh/Echg

Ideal COP = 1/(1-Tc/Th)

Overall Process
RTE = Egen/Echg

= COP x Efficiency



Power Cycle
Efficiency = Egen/Qh

Ideal efficiency = 1-Tc/Th

Ideal cycle RTE = COP_{Carnot} x η_{Carnot} = 100%

Non-ideal processes result in RTE ~60%, even at modest temperature ratio

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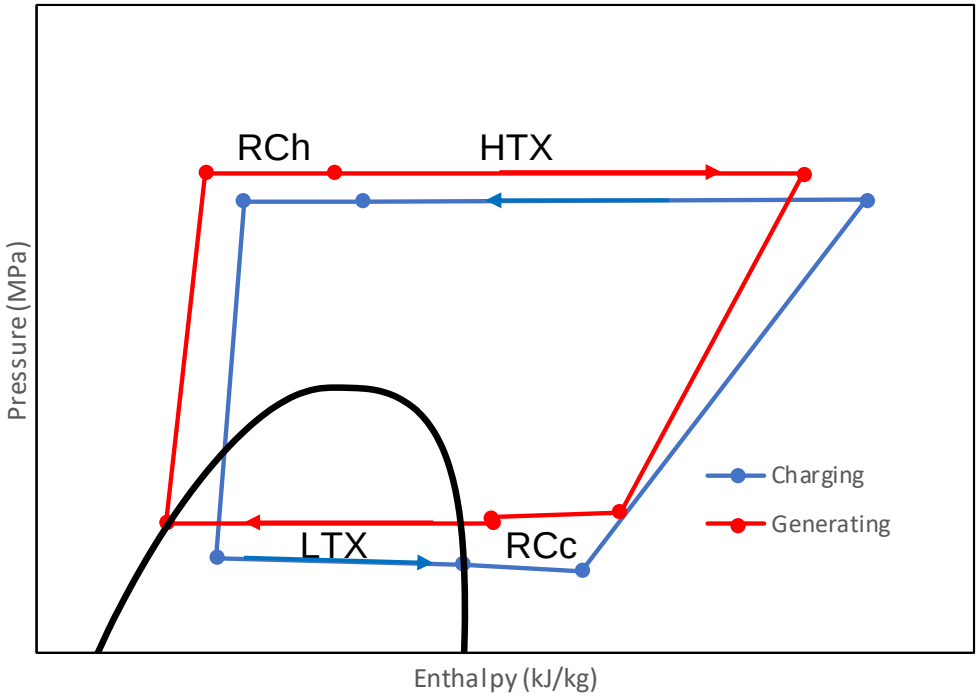
Cycles on a PH diagram

HTX heat transfer is supercritical - sensible enthalpy transfer interaction with HTR

LTX is subcritical – condensation and evaporation - ~ constant temperature interaction with LTR



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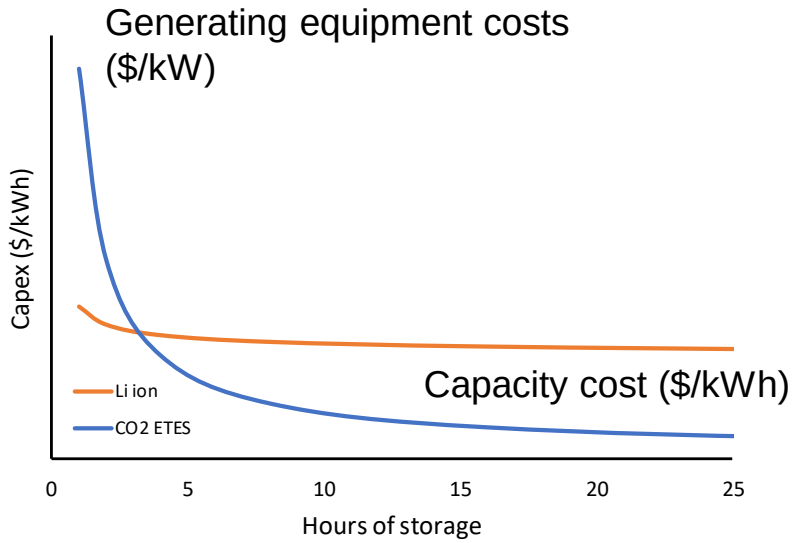
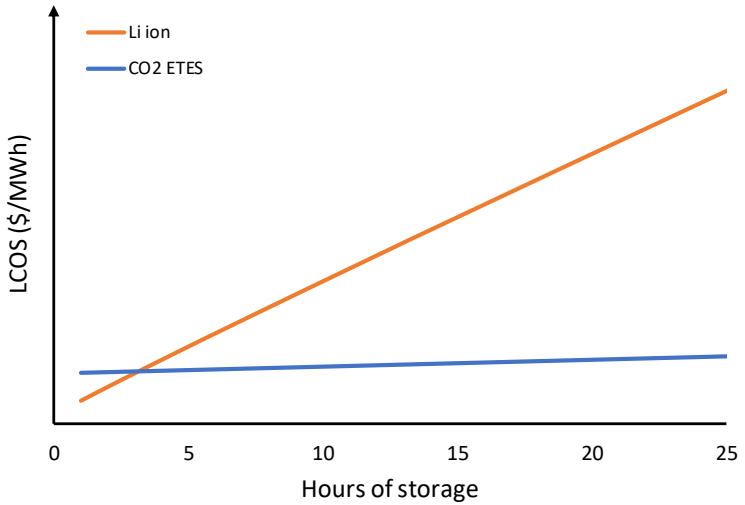
Longer Duration = Lower Capex/kWh = Lower LCOS





Lower Capex => Lower LCOS

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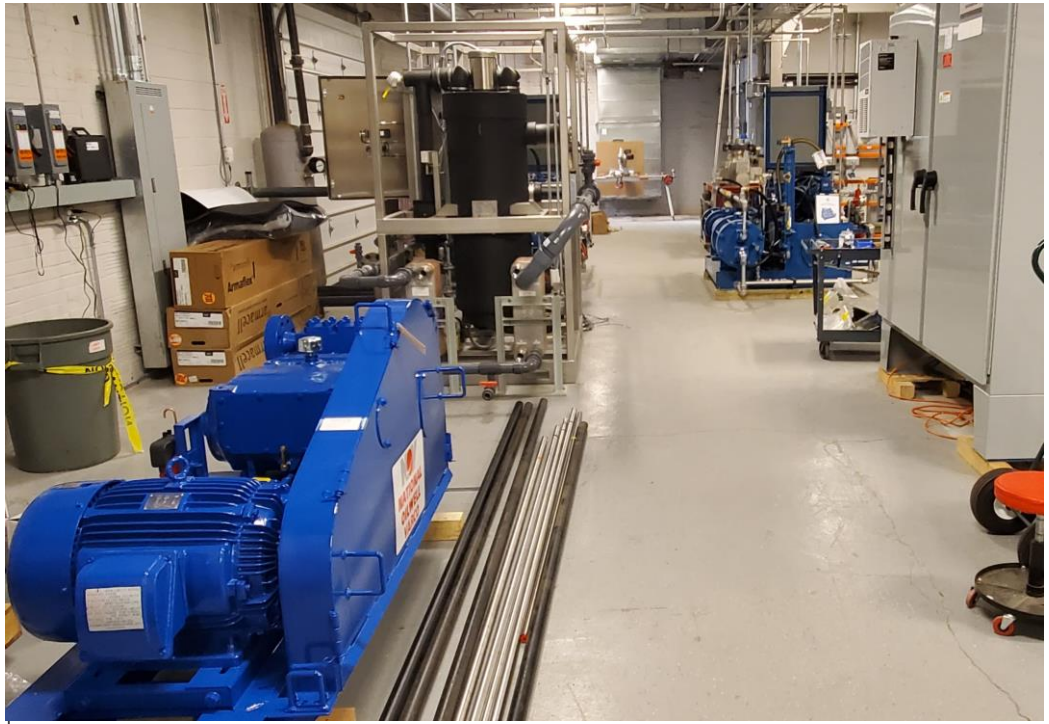
ETES lab-scale system



ARPA-E funded project

~200 kWth system, including both charging and generating cycles

Focused on reservoir and heat exchanger development and TEA

Operation and controls development

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Capability matrix for discussion

Services :

Arbitrage	– Yes (if economics support)
RES smoothing	– ”
Peak capacity	– ”
Seasonal storage	– No

Technical requirements

Round trip efficiency as high as possible - $ vs RTE trade
Low thermal loss – Small ΔT to environment
Modularity and scalability – Yes – 10-100 MWe blocks
Cycling capacity => small degradation during lifetime – Typical power plant
Compactness and affordability of storage medium – Very
Low CAPEX for energy conversion system – Yes at longer durations
High flexibility during charging phase – TBD
Compatibility for retrofitting existing plant – Yes
Compatibility with district heating and cooling – Yes
Safety and chemical hazard – Excellent

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