CO_2-Based Pumped-Thermal Energy Storage Technical Overview & Status

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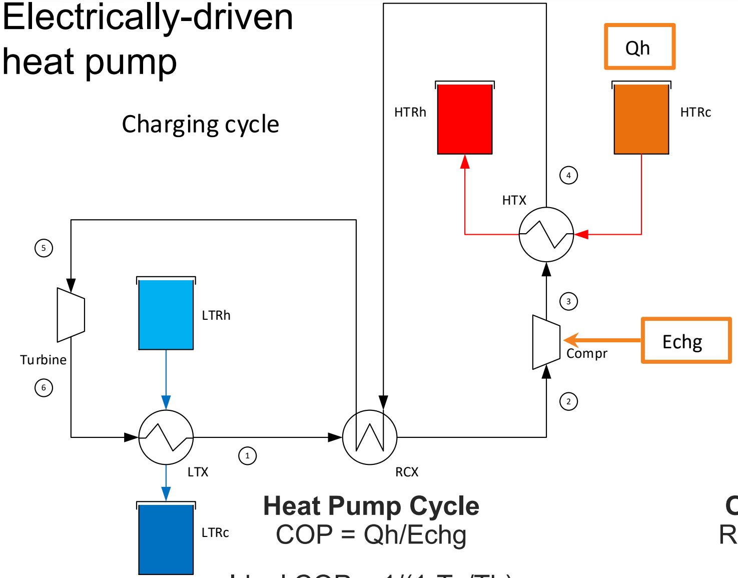
PTES in a nutshell

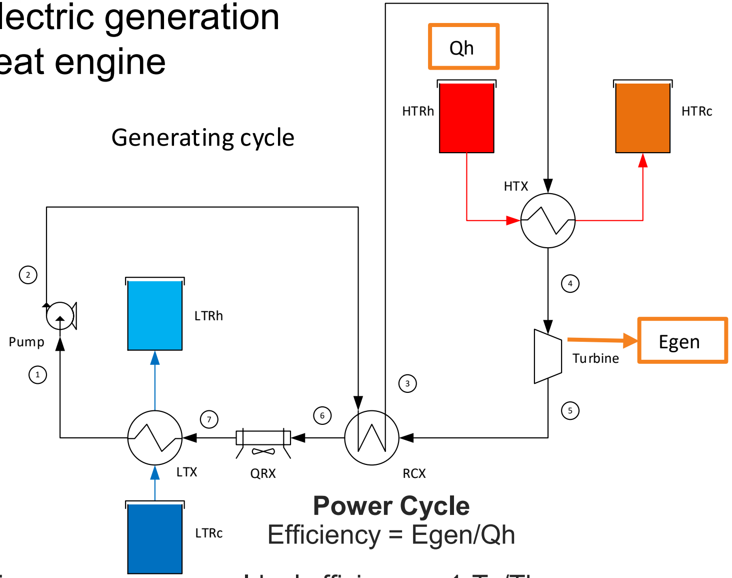
Electrically-driven heat pump

Charging cycle



Electric generation heat engine

Generating cycle



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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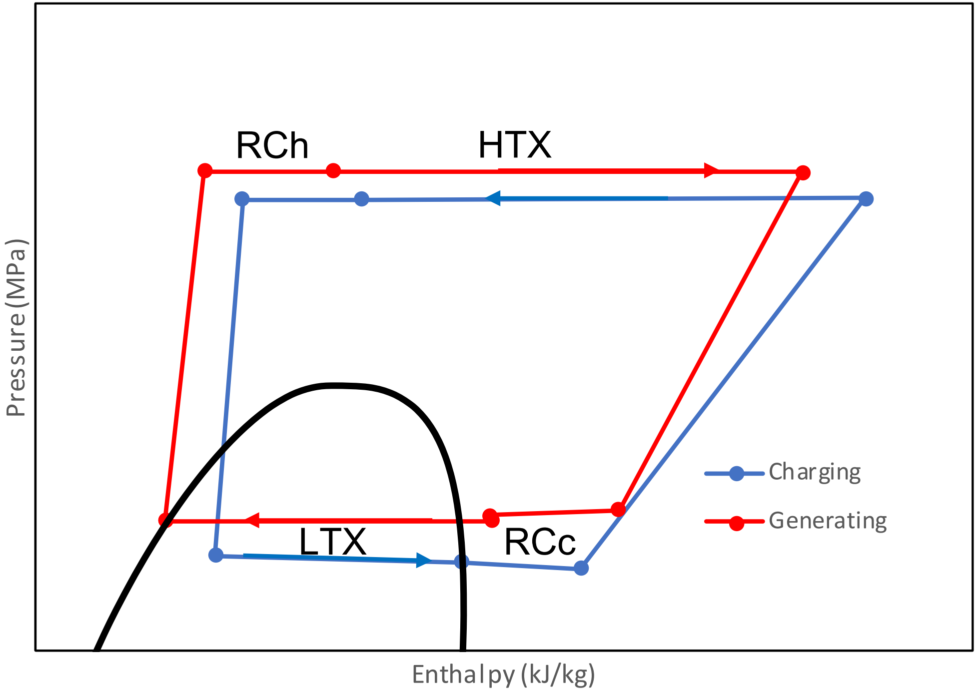
Cycles on a PH diagram

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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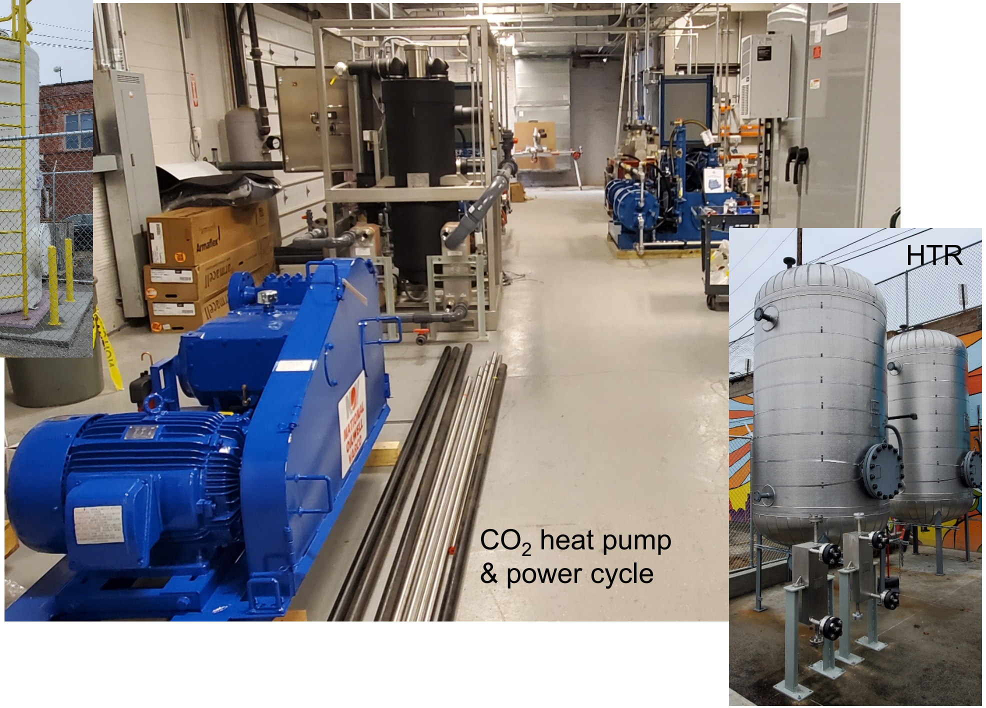
ARPA-E DAYS Program – PTES lab system



~200 kW_{th} system, including both charging and generating cycles

Operating for ~ 6 months, repeated charge/generate cycles

Basic cycle and thermal reservoir experience and data

Operation and control methodology development and optimization

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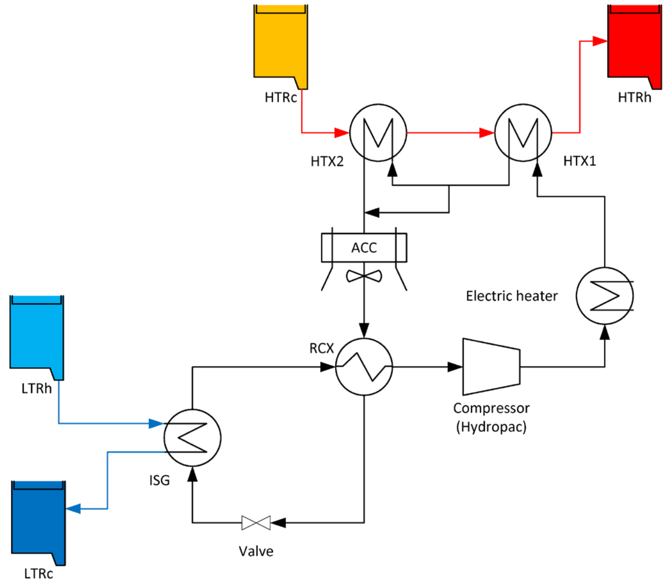
Lab-system configuration – Charge cycle



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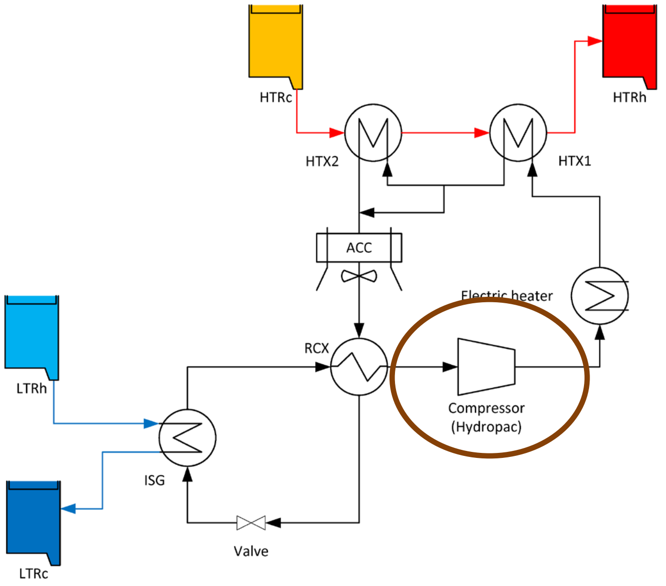

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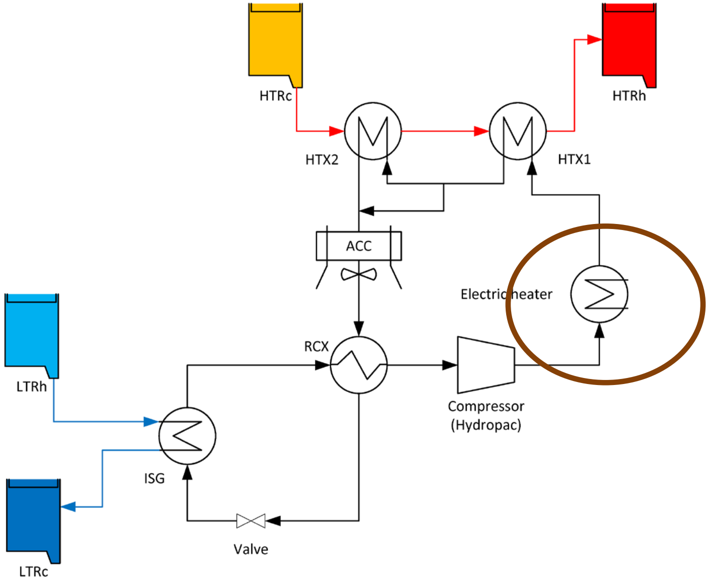

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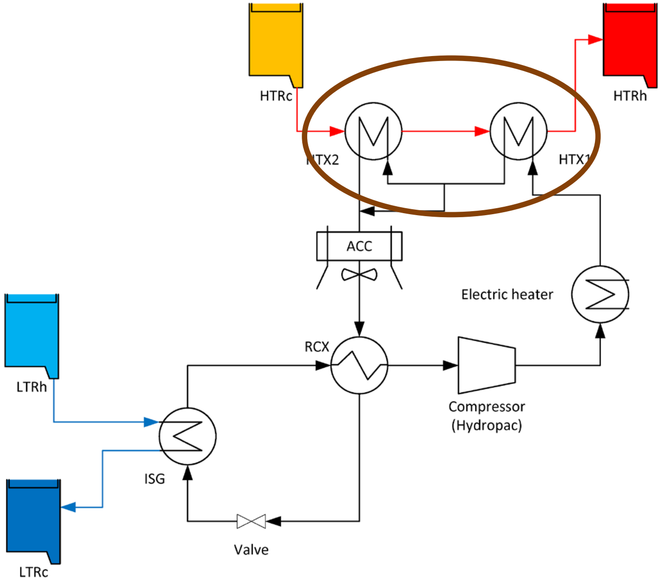

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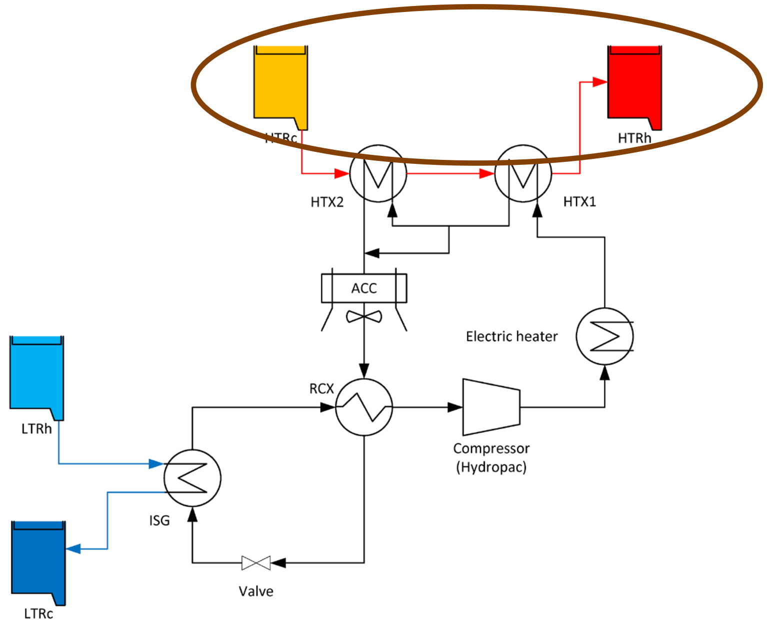

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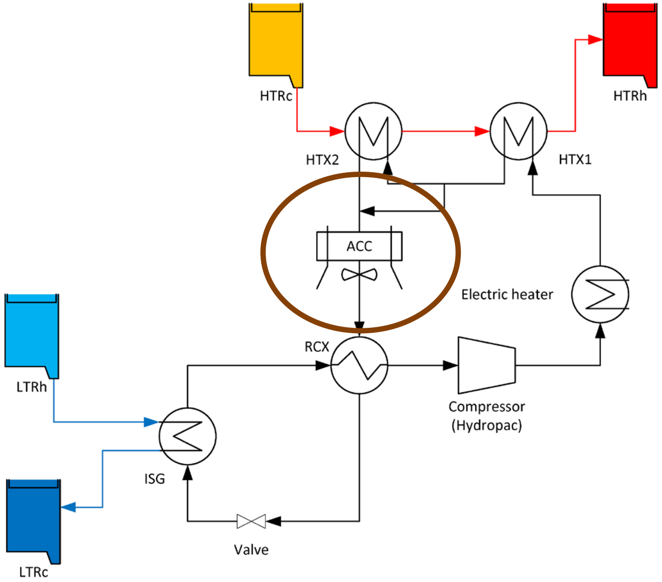

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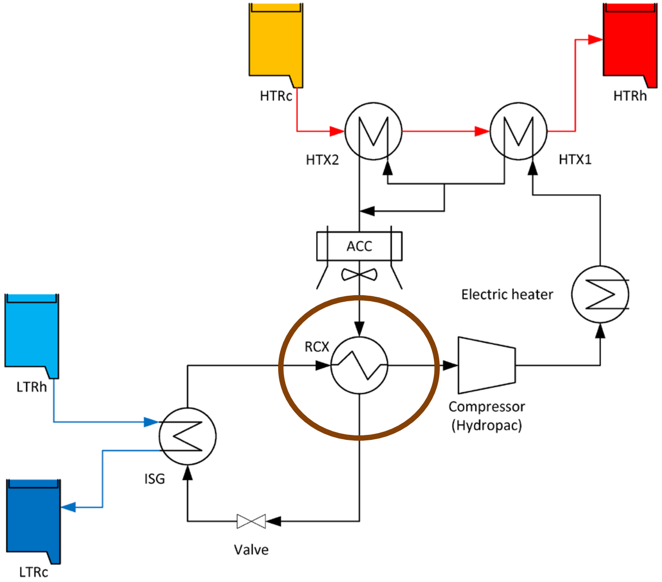

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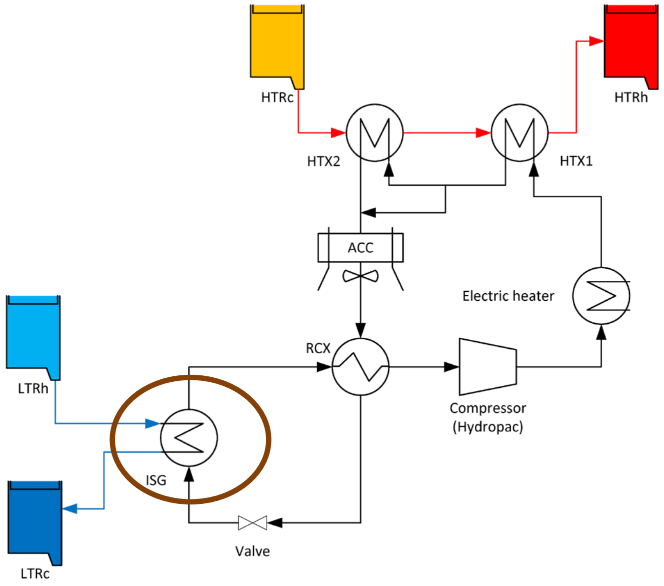

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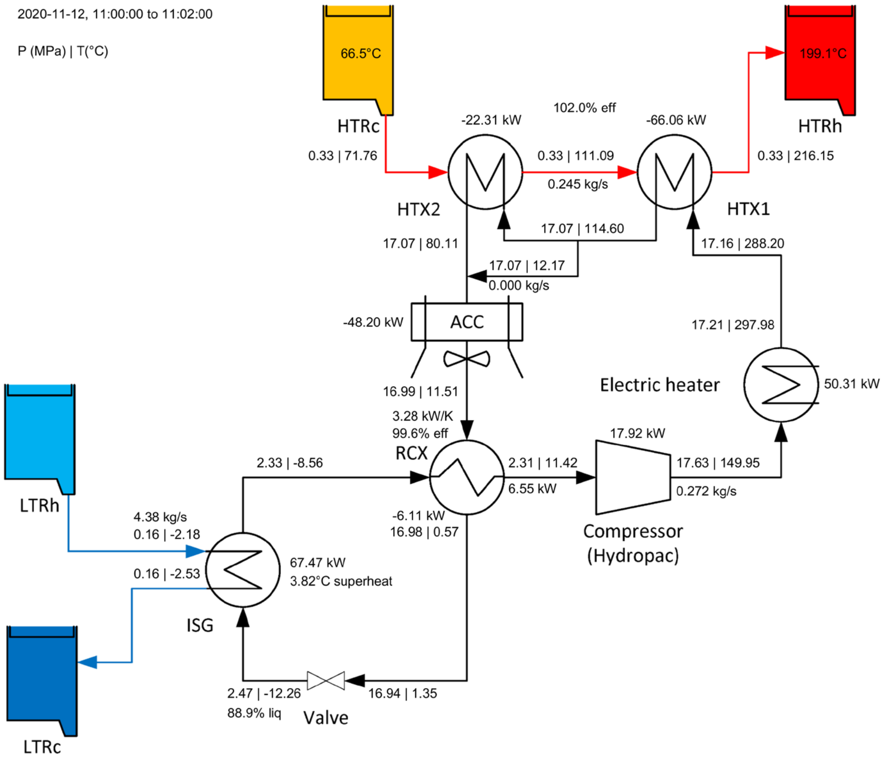

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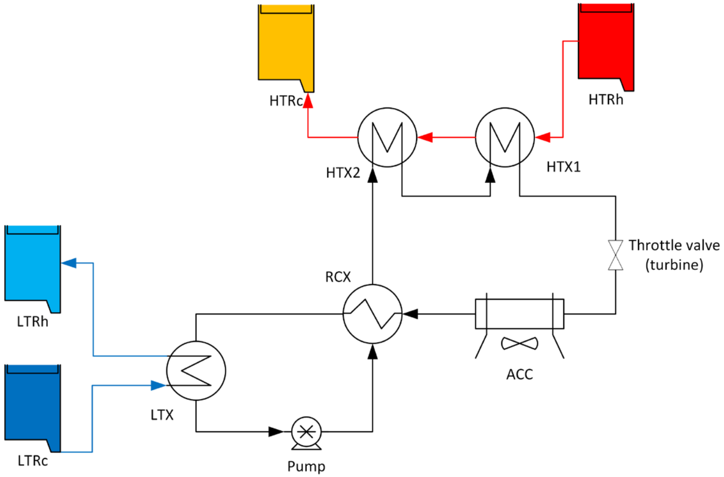
Lab-system configuration – Generate cycle



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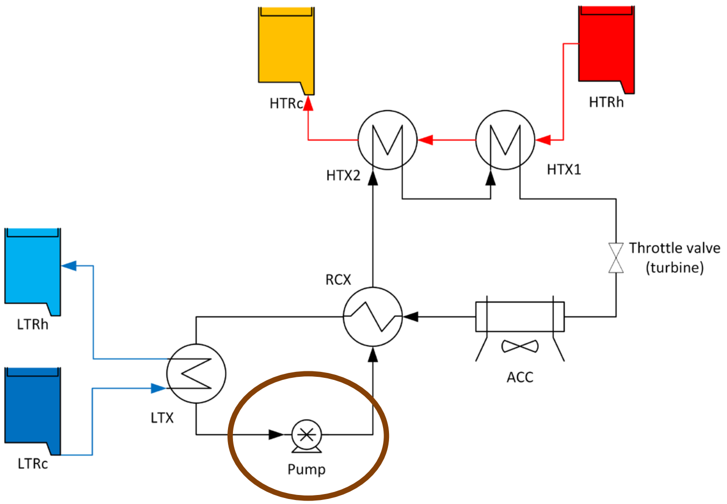

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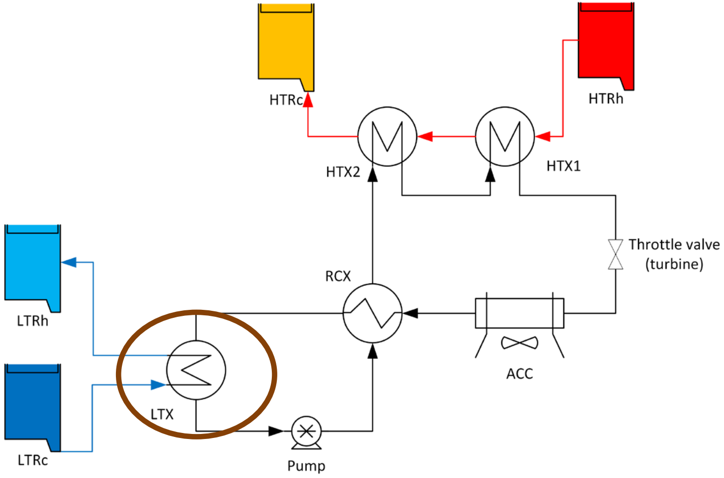
Lab-system configuration – Generate cycle



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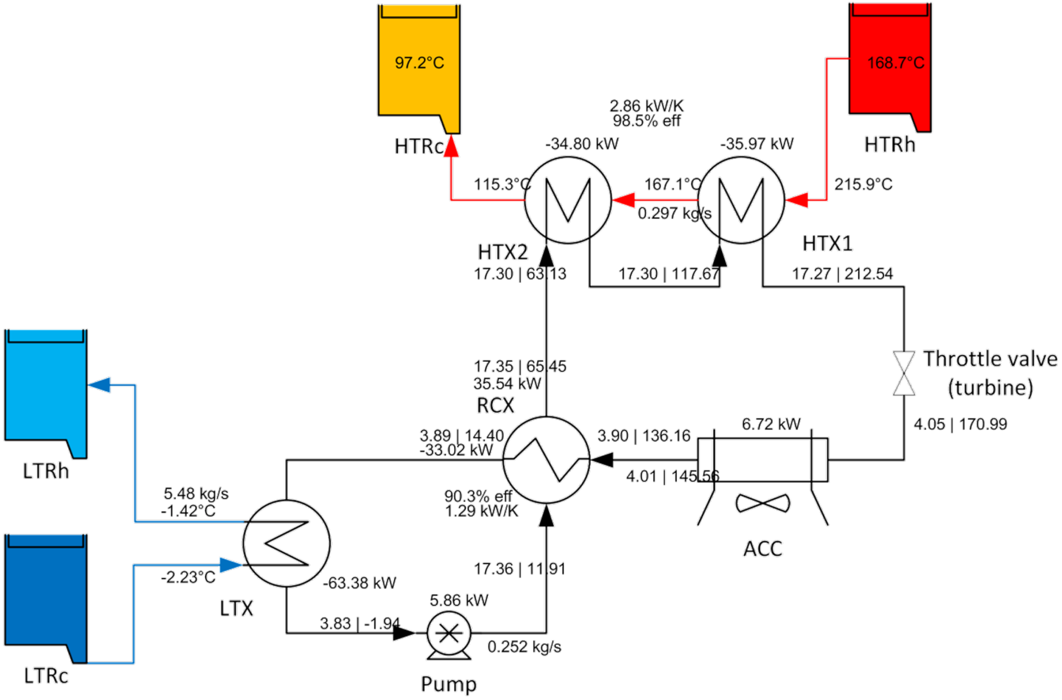
Lab-system configuration – Generate cycle

2020-11-12, 14:00:00 to 14:02:00

P (MPa) | T(°C)



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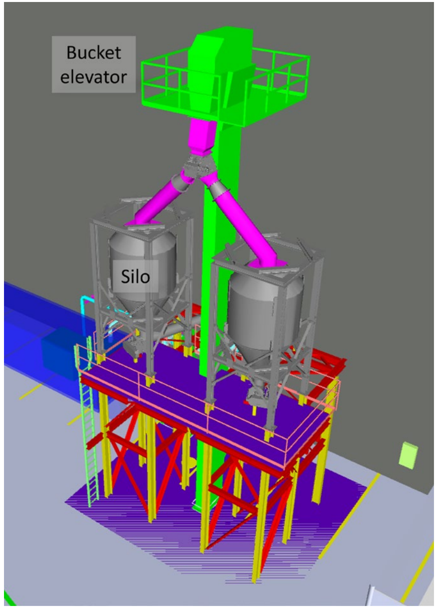
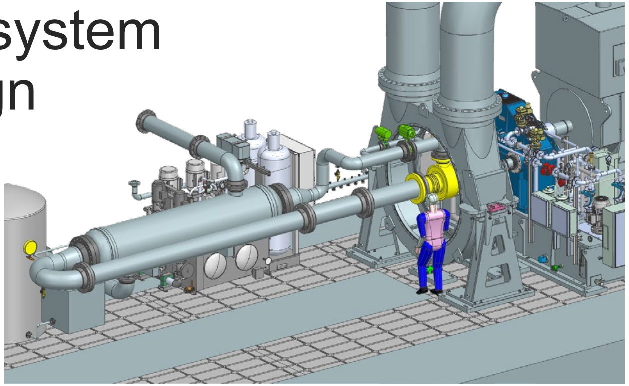
Work in progress & next steps

- HTR – Sand-based reservoir installation
- HTX – Fluidized bed heat exchanger
- IOC – Ice-on-coil LTR
- Axial compressor (100+ MW)
- 25 MW / 8-hour system preliminary design





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