Low-cost, long-duration electrical energy storage using a CO$_2$-based Electro Thermal Energy Storage (ETES) system

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Team Members: EPRI, Liquid Ice Technologies, Louis Perry Group, Solex Thermal Sciences, TU Wien, Westinghouse

Project Vision

Delivering long-duration electrical energy storage with cost effective, environmentally friendly and intrinsically safe materials assembled into a high-tech system

<table>
<thead>
<tr>
<th>Total project cost:</th>
<th>$4.2M</th>
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<td>Length</td>
<td>30 mo.</td>
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The Concept

Charging

Generating

The low and high-temperature reservoirs (HTR) and heat exchangers (HTX) are the main focus of the technology development plan.

Low Temperature Reservoir
- Uses water-ice slurry as cold storage. Ice slurry generator + Shell and Tube or plate heat exchanger

High Temperature Reservoir Options:
- Heat transfer fluid (HTF) with “conventional” PCHE (economic and performance baseline)
- HTF + concrete and Printed Circuit Heat Exchanger (PCHE)
- Sand + Moving Packed Bed Heat Exchanger (MBHE)
- Sand + Fluidized-Bed Heat Exchanger (FBHE)
The Team

**Echogen (EPS) - Prime contractor**
Develop and commercialize large (~ 10MW+) sCO₂ power cycles

**Electric Power Research Institution (EPRI)**
Economic modeling, market research and voice of the customer

**Liquid Ice Technologies (LIT)**
Ice slurry generator design and commercialization

**Louis Perry Group – A CDM Smith Company (LPG)**
EPC, detailed mechanical / electrical design of sCO₂ power cycles

**Solex Thermal Science (STS)**
Moving bed heat exchanger (CO₂-sand)

**Technische Universität Wien (TUW)**
Fluidized bed heat exchanger (CO₂-sand)

**Westinghouse Electric Corp (WEC)**
Modular concrete-based thermal energy storage modules
**Project Objectives**

### Y1
- Design definition, application and market studies
  - *EPS, EPRI*
- Lab-scale prototype design, fab & commission
  - *EPS, LIT*
- HTR/HTX prelim design & costing, lab-scale (100kW) and full-scale (10-100 MW)
  - *STS, TUW, WEC → LPG*

### Y2
- Techno-economic analysis and optimization (full-scale, 10-100 MW, 10-100 hours)
  - *EPS, EPRI, LPG*
- System testing (HTF HTR)
  - *EPS*
- HTR/HTX final design & fab
  - *TBD*

### Y3
- System testing (final HTR/HTX)
  - *EPS*

**Primary program objectives:**

- Demonstrate operation and control of a lab-scale CO$_2$-based ETES system
  - Designed for 0.5 kg/s CO$_2$ flow
  - 200 kW$_{th}$ of heat for 2 hours generating
  - 120 kW$_{th}$ of cooling for 2 ½ hours charging
- Develop improved HTR/HTX designs (performance and cost) and down select to most promising commercial HTR/HTX
- Design and test lab-scale HTR/HTX prototype
Challenges and Potential Partnerships

- Long-duration storage requires:
  - High round-trip efficiency, Low equipment and storage media cost

- HTR/HTX challenges
  - HTF + concrete and Printed Circuit Heat Exchanger (PCHE)
    • Performance due to intermediate HTF between storage media and CO₂
  - Sand + Moving-Bed Heat Exchanger (MBHE)
    • Cost and size of particle to CO₂ heat exchanger, parasitic loads and heat loss
  - Sand + Fluidized-Bed Heat Exchanger (FBHE)
    • Cost of installed system, heat loss and parasitic loads due to particle “fluidization”

- LTR/LTX challenges
  - Water-Ice slurry to CO₂ heat exchanger performance
  - Parasitic load requirements
  - Commercial cost

- Potential partnerships
  - End-use customers – define applicable use cases, better define commercial value proposition and applications for long-duration storage
  - OEMs & financial institutions – deployment of practical scale ETES systems will be capital-intensive, require balance sheet / commercial guarantees