Liquid Air Combined Cycle (LACC) for Power and Storage

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DOE: $250,000
Non-DOE: $69,120
Total: $319,120

Southwest Research Institute
San Antonio, TX

Pintail Power LLC
Palo Alto, CA
LACC can be applied to existing or new combustion turbine assets

• Advantages
  – Any CT
  – Site anywhere
  – High-TRL components
  – Valuable at large scale
  – Lower CAPEX

• Project objectives
  – Identify application
  – LACC conceptual design
  – Demo-scale LACC
Feasibility calculations have demonstrated preliminary performance

**Charging**
- 400 kWh/m.t.

**Discharging**
- Net power
  - SC: 54 MW
  - CC: 77 MW
  - LACC: 104 MW
- Fuel heat rate
  - SC: 8,725 Btu/kWh
  - CC: 5,993 Btu/kWh
  - LACC: 4,532 Btu/kWh
- Primary (electric) energy rate
  \[
  \frac{\text{Charge energy}}{\text{Discharge energy}} = 1.04
  \]
- Liquid air rate = 2.6 kg/kWh
Key commercialization/market considerations for LACC are...

• Cryo liquefaction is capital intensive
  – LACC reduces Liq. Air consumption
  – Zero cost storage medium offsets CAPEX
  – Benefits from economy of scale

• Coupling opportunities
  – Fuel security (co-liquefy natural gas)
  – H\textsubscript{2}, Renewable fuel cost savings via low heat rate
  – Oxy combustion for carbon capture

Best suited for long duration

78 GWh-AC
What is needed to be able to pilot a demo LACC plant by 2025?

• ORC Turbo-machinery selection/design
  – Multiple Radial flow Generator-loaded-expanders (repurposed from LNG)
  – Axial flow high pressure ratio expander

• ORC Heat Exchanger design
  – Recuperator (Δp, effectiveness, cost)
  – LA regasifier/ORC condenser
Storage economics driven by total CAPEX and capacity factor

• Total CAPEX
  – Mature discharge equipment ➔ increase $/kW_{\text{discharge}}$
  – Air is free, tanks have modest cost $/kWh_{\text{storage}}$
  – Leverage LNG experience to reduce $/kW_{\text{charge}}$

• Discharge capacity factor is limited by charging hours
  – Faster charging
    • Charge Power > Discharge Power
      – Optimal ratio depends on wind/solar over-generation duration
    • Charge Energy < Discharge Energy
      – Reduce liquid air rate
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