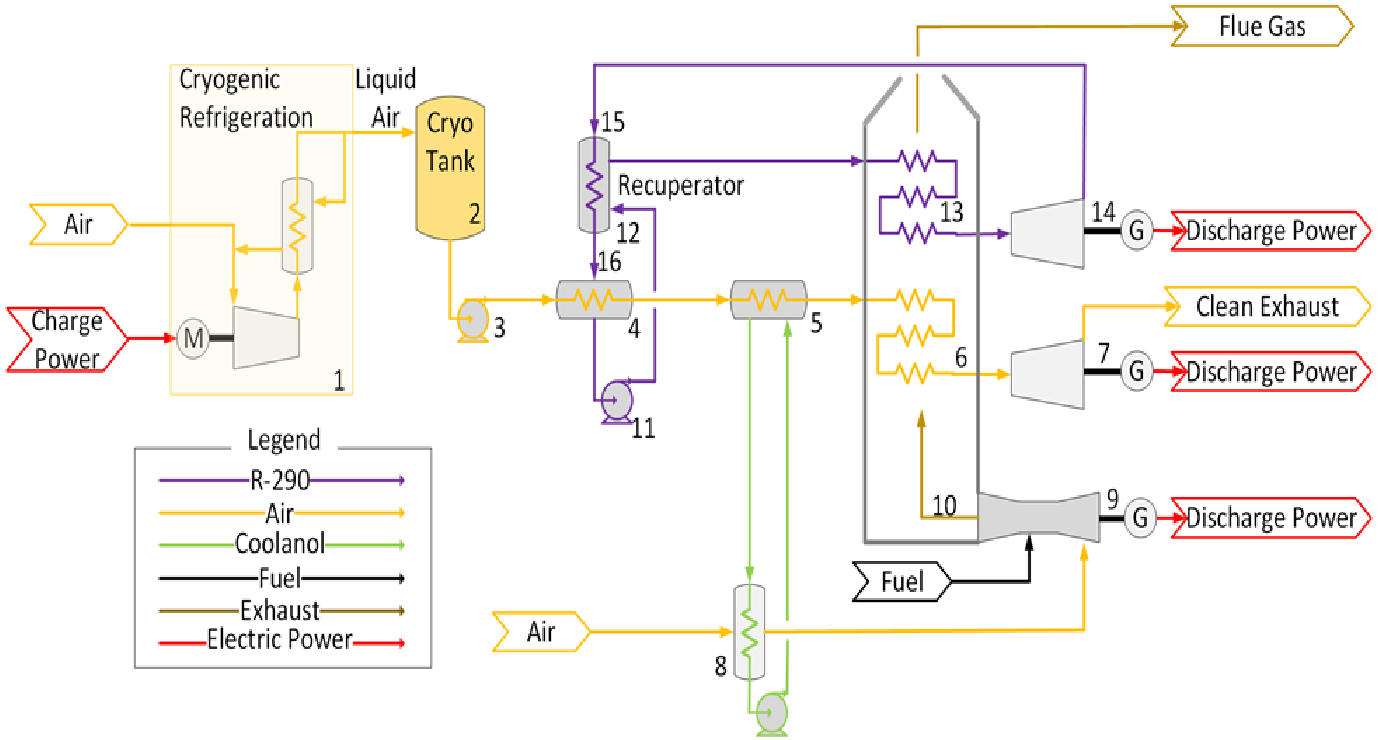
Liquid Air Combined Cycle (LACC) for Power and Storage

Award No. DE-FE0032002

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



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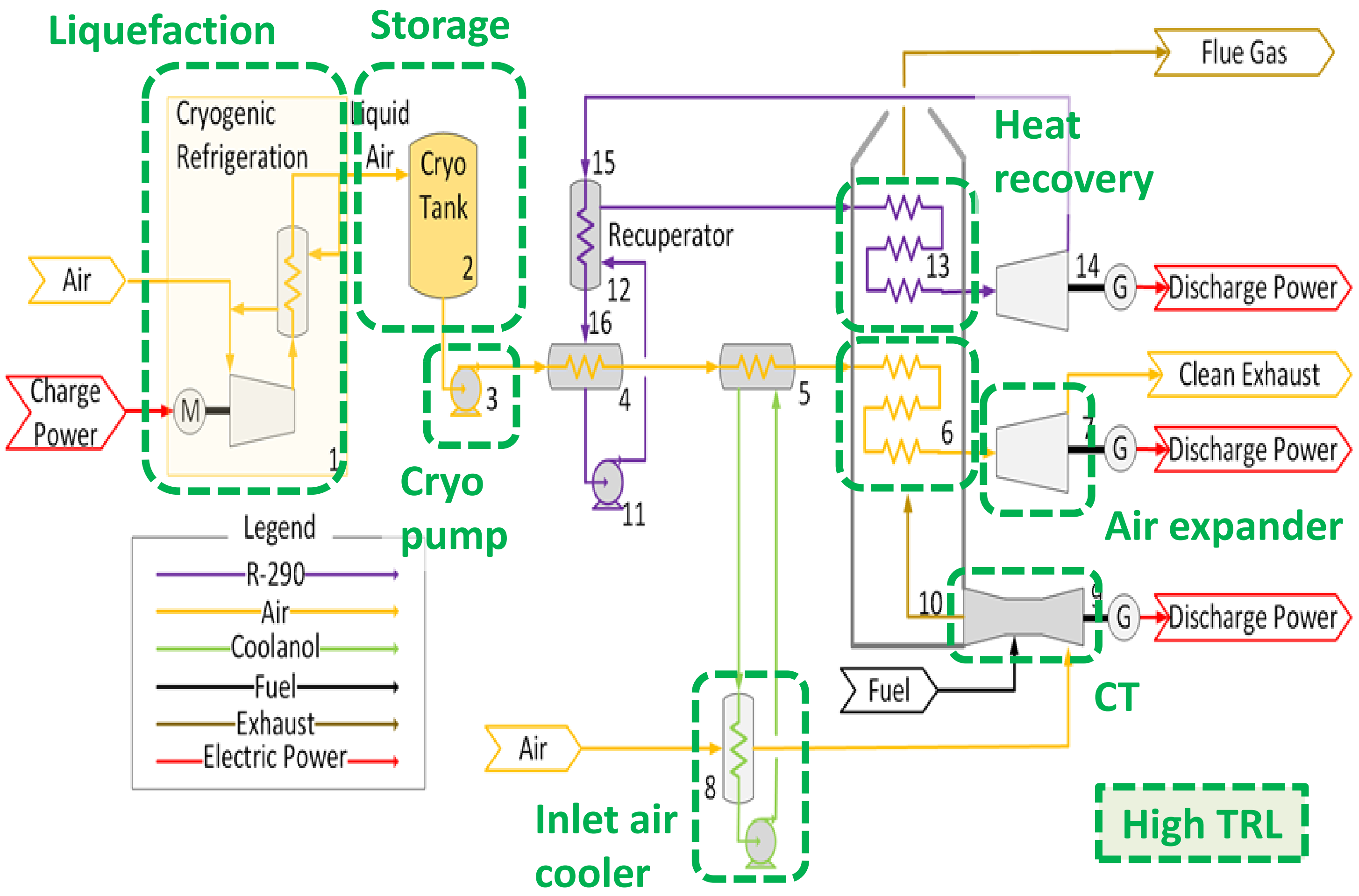
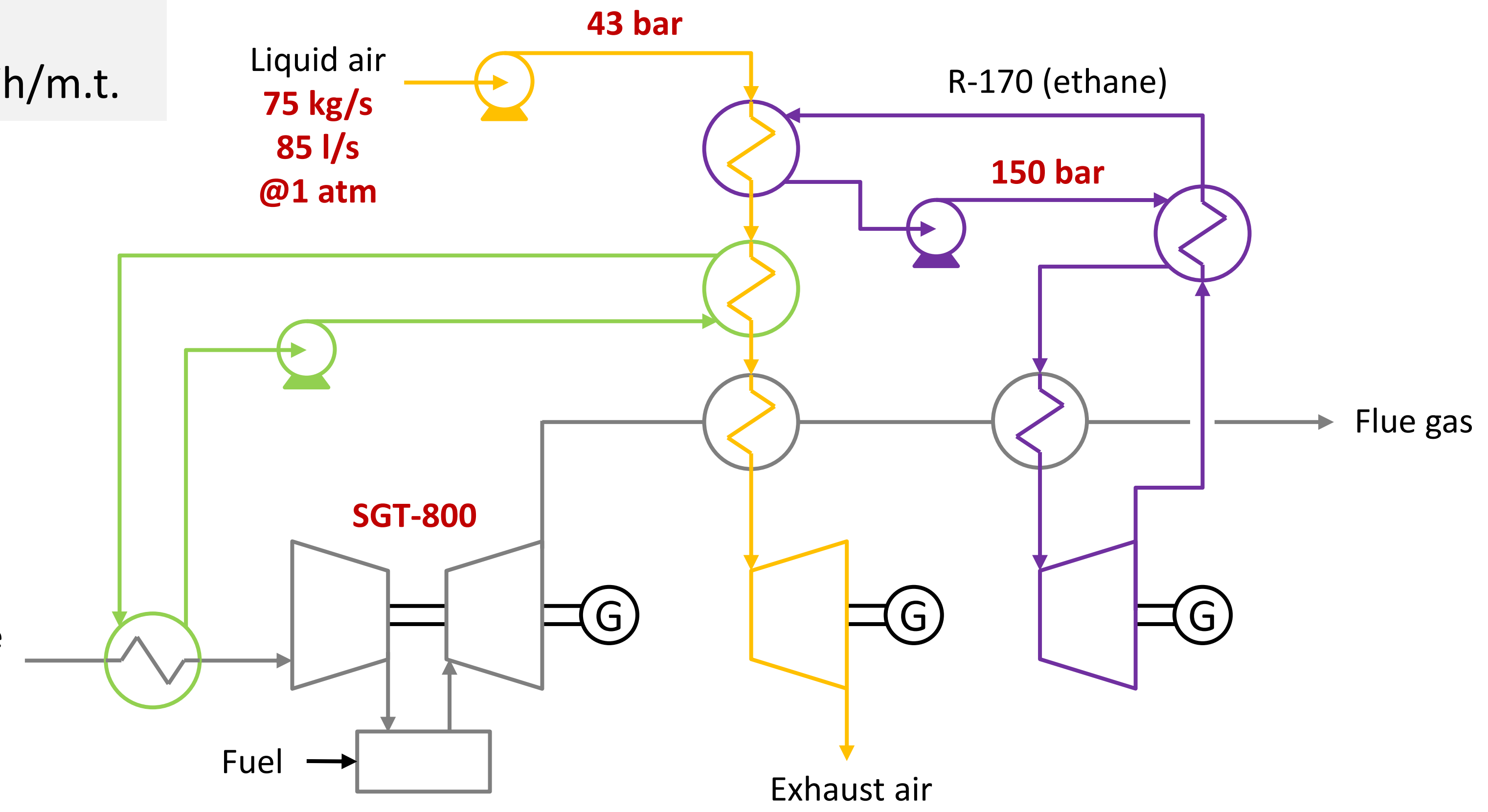
LACC can be applied to existing or new combustion turbine assets

- 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

$$\frac{\text{Charge energy}}{\text{Discharge energy}} = \mathbf{1.04}$$

- 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_2, Renewable fuel cost savings via low heat rate
  - Oxy combustion for carbon capture

Best suited for long duration

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 $kW_{discharge}$ to reduce $/ $kW_{discharge}$
  - Air is free, tanks have modest cost $/$kWh_{storage}$
  - Leverage LNG experience to reduce $/$kW_{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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