Oxygen Storage Incorporated into the Allam Oxy-Fuel Power Cycle

Prime Contractor: **Southwest Research Institute**

PI: Dr. Jeffrey Moore

Team Members: **American Air Liquide**

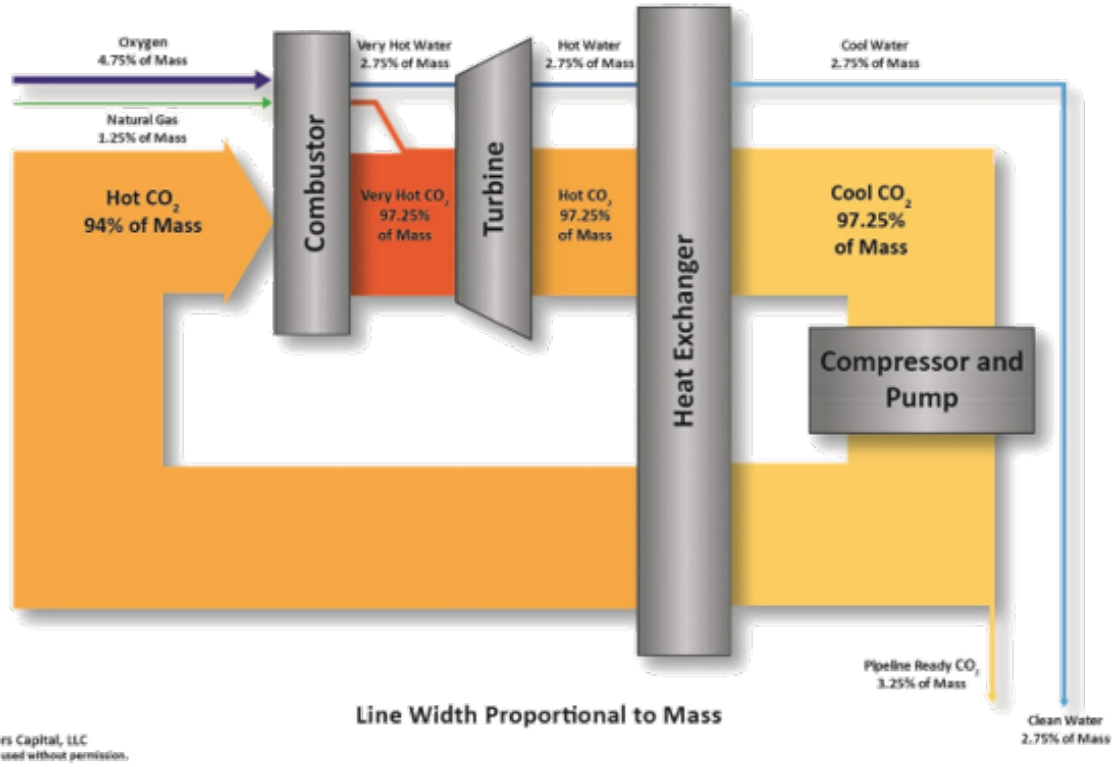
8 Rivers Capital

SoftInWay

Project Vision

Developing an Energy Storage Solution that makes Oxy-Fuel SCO2 Power Cycles even more attractive using Oxygen Storage.

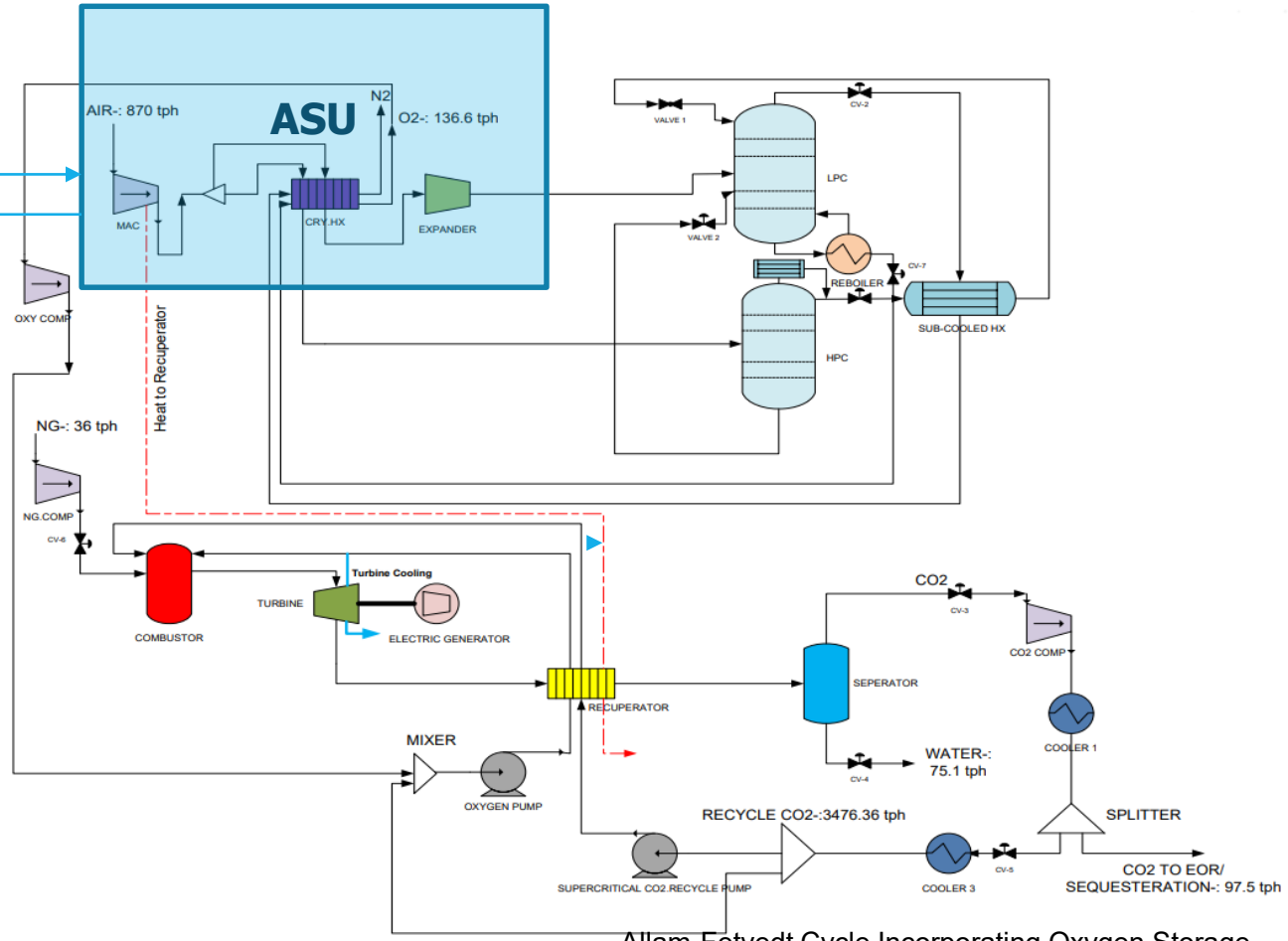
Allam-Fetvedt Cycle Description



- Highly-recuperated, oxy-fuel, semi-closed supercritical carbon dioxide power cycle.
- High-efficiency cycle operated at very high pressures (300 bar).
- >97% CO_2 captured.
- Economics may be improved by taking advantage of low-cost electricity to produce & store oxygen.

The Concept

Air Liquide Liquid O_2 Storage



Allam-Fetvedt Cycle Incorporating Oxygen Storage

Firing Temp = 1150C
Thermal eff = 59%
Natural gas or coal syngas fired
Pipeline ready high pressure
CO2 produced

The Team

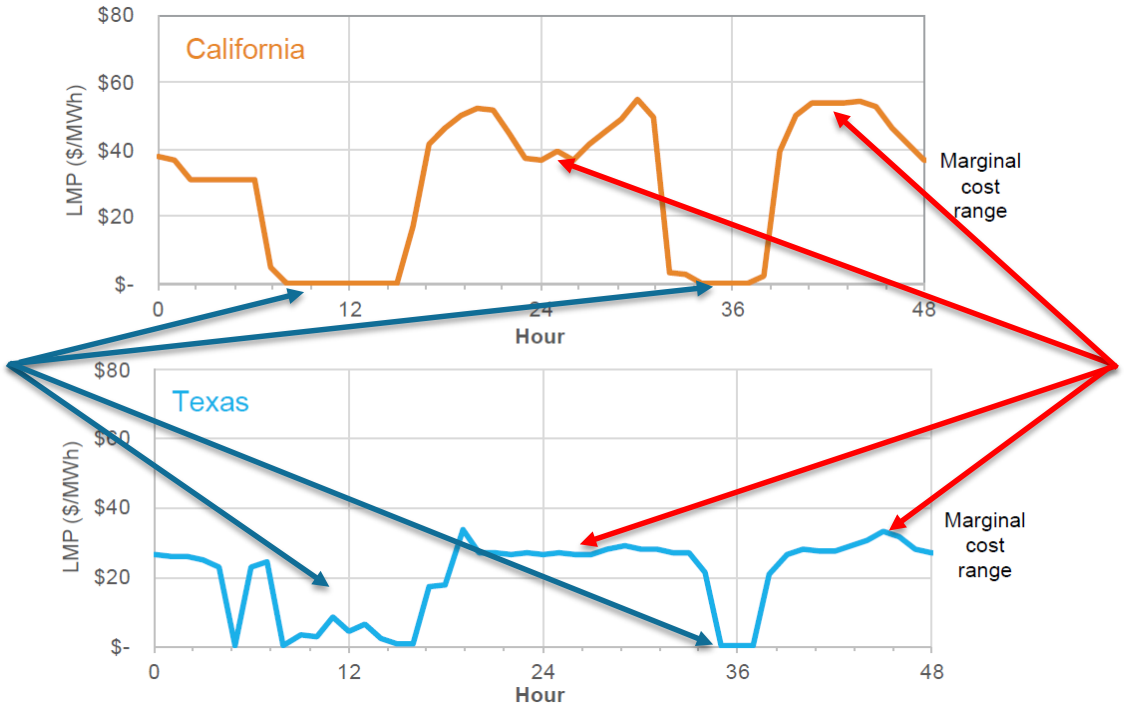
- Southwest Research Institute
  - Founded in 1947, 2500 employees, provides contract R&D for the power generation, alternative energy, and oil & gas industries.
- Partners:
  - American Air Liquide is the world's largest supplier of industrial gases by revenue and has operations in over 80 countries serving more than 3 million customers
  - 8 Rivers Capital, LLC is the inventor of the direct-fired, sCO2 Allam-Fetvedt cycle
  - SoftInWay has been offering engineering services to its clients in the design, analysis, and optimization of turbomachinery and has proven its expertise in executing such projects since 1999.

Subject matter expertise	Team member(s) responsible	Description/Justification
CCS technology	SwRI, 8 Rivers	CCS inherent in Allam cycle
Process modeling	8 Rivers, Air Liquide, SoftInWay	8 Rivers will generate the cycle model with input from other team members
Economic analysis	SwRI	LCOE calculation with input from team members
Optimization	All members	Optimization balancing part-load operation of ASU, power block, and storage to minimize weighted average LCOE and overall plant efficiency.
Power generation (if applicable)	8 Rivers	via Allam cycle

Projected Location Marginal Price (LMP) in California and Texas

- Due to high VRE penetration, daily price expected to go to zero or negative from 9am to 3pm in California

Charge: Generate LOX



Discharge: Operate Power Island using Storaged LOX

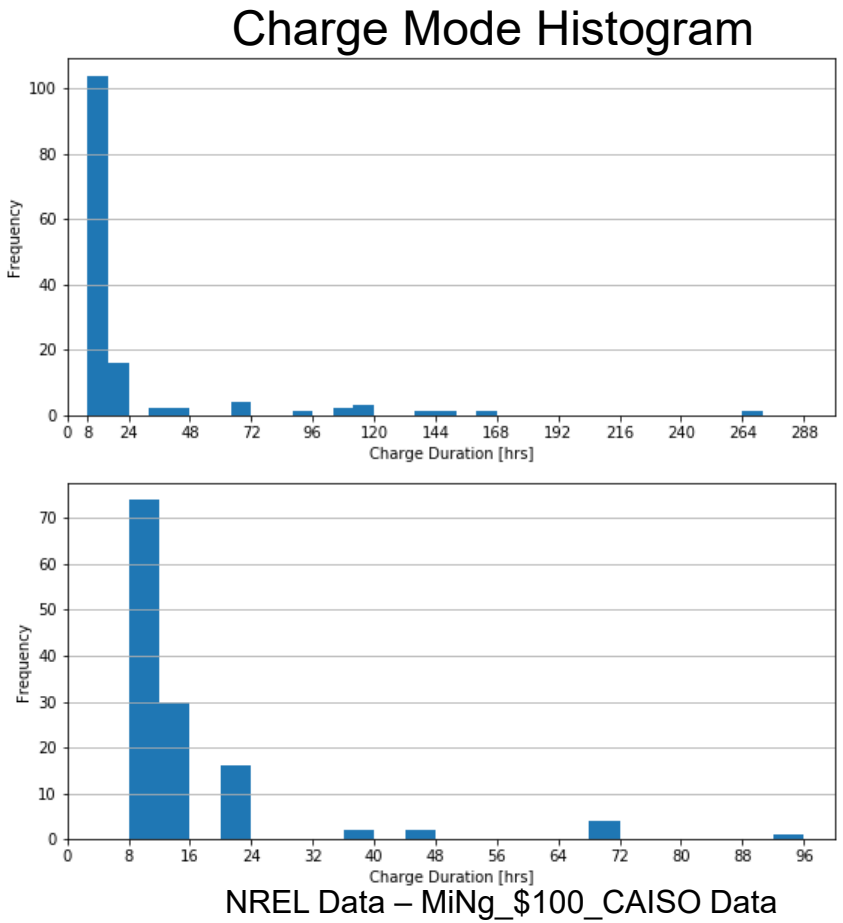
Projected LMPs in California and Texas in March 2030, with 50% VRE penetration [3]

Interpreting the Price Data

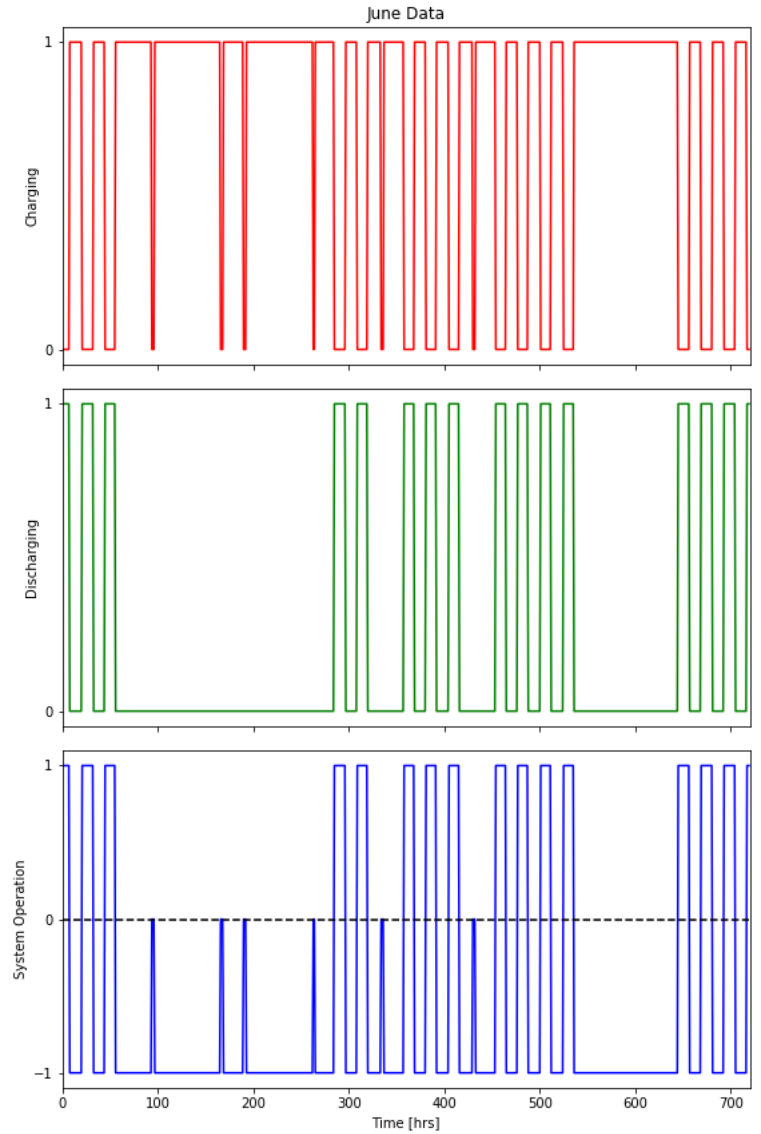
- What times can we store oxygen and when to run the power block?
  - Requires a certain amount of time for starting/shutting down
- Two systems that are running concurrently

Price Assumptions

Variable	Value
Price Threshold	$30 / MWe
Min. Charge Duration	8 hours
Min. Discharge Duration	8 hours



NREL Data – MiNg_$100_CAISO Data



Summary

- Due to high renewable energy penetration, the grid of the future will have significant daily price fluctuations
- The Allam-Fetvedt direct-fired SCO2 cycle can respond to rapid grid fluctuations and can start relatively quickly from a warm idle state
- Producing and storing LOX (charging) during periods of low price can store energy in the oxidizer and be used (discharging) in the power block when demand is high
- ASU multiplier and storage capacity being optimized depending on the projected grid data

Thank You

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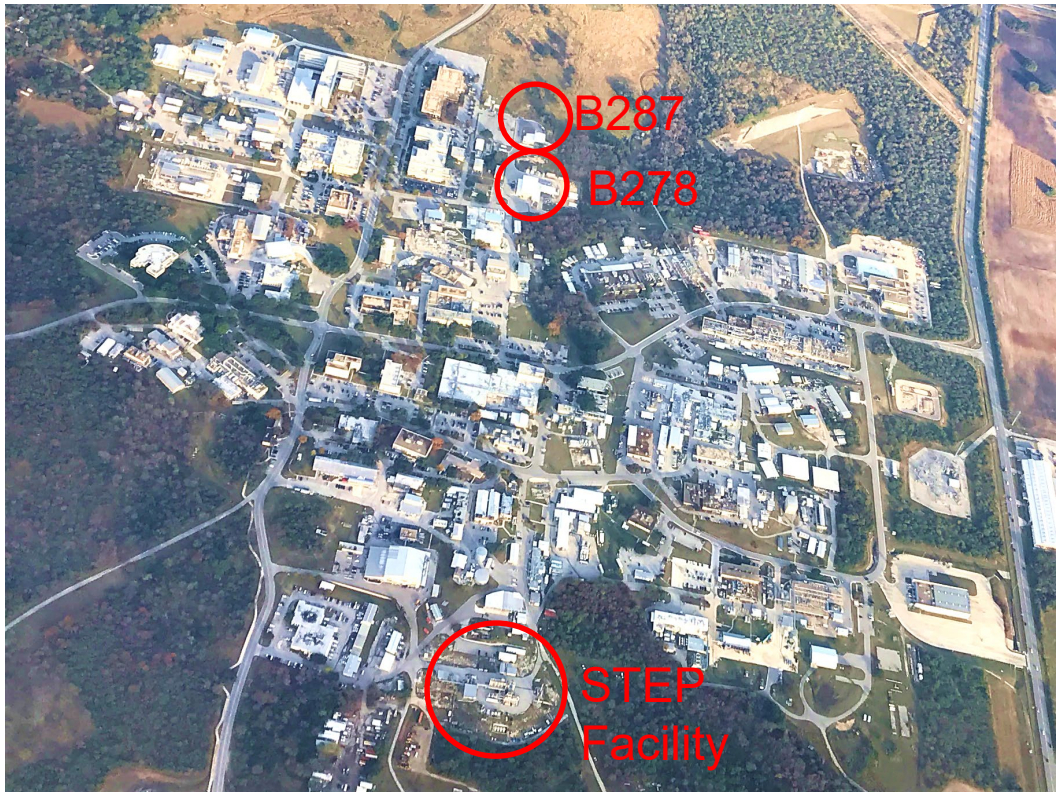

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