Sorbent-based Oxygen Production for Energy Systems

Project DE-FE0024075

U. S. Department of Energy

National Energy Technology Laboratory

Dr. Arun Bose

Ms. Harolynne Blackwell

Prime Contractor:

Western Research Institute

Partners (Sub-contracts):

Arizona State University

New Mexico State University

Cosponsor:

LP Amina

2015 Gasification Systems and Coal & Coal-Biomass to Liquids Workshop
Lakeview Conference Center, Morgantown, WV
August 10-11, 2015

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Introductions:

Dr. Jerry (Y. S.) Lin-ASU, Regents' Professor

- internationally recognized pioneer in inorganic membranes
- known for his work with adsorbents that can selectively separate various gases and liquids
- serving as an adviser to 70 graduate and post-doctoral students

Dr. Shuguang Deng-NMSU, Bob Davis Professor

- Research Lead with BOC to work with adsorbents for separations of gases and liquids
- Inducted in the NMSU's chapter of the National Academy of Inventors
- Transitioning to ASU as a tenured faculty

Dr. Matt Targett-LP Amina, Vice President R&D

- Founding Member of US-China Clean Energy Center
- Head of Innovation, Asia Pacific for Bayer Technology Services
- LP Amina is pursuing power generation as a chemicals coproduction platform…

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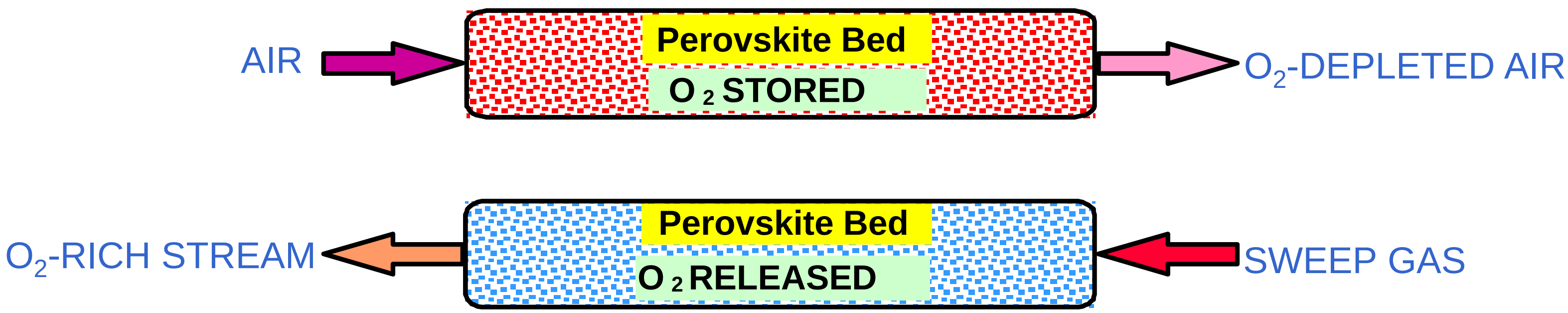
Background

Sorbent-based Oxygen Production Process (ABO_{3-x})



- Adsorb O_2 from air in a solid sorbent
- Use of vacuum, CO_2-rich flue gas and/or steam as sweep gas allows optimization of the O_2 concentration for various advanced energy systems.
- High-temperature process driven by partial pressure of oxygen

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Background

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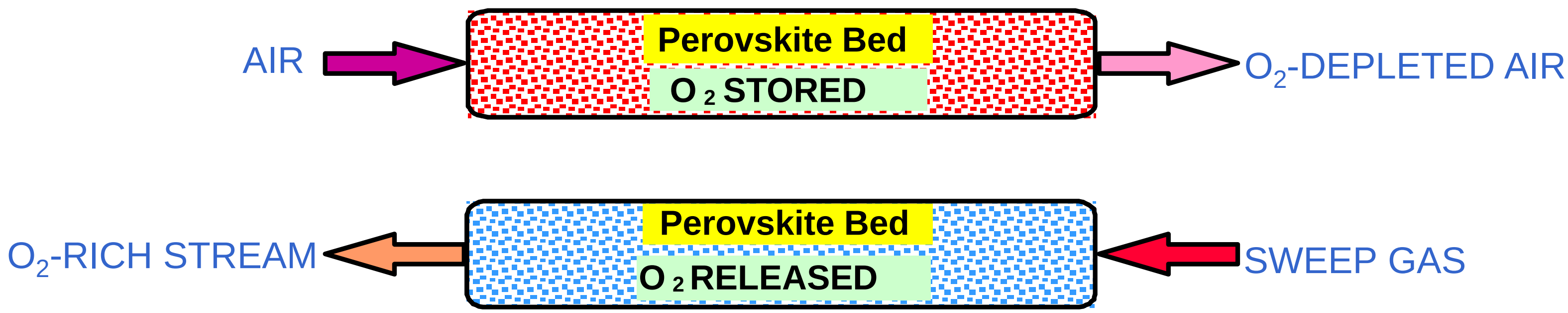

Between 2005 and 2008, under two separate Cooperative Agreements, a two-bed, 60-pph unit was developed by BOC/Linde and tested at WRI. The unit was integrated with an existing 250,000 Btu/h Combustion Test Facility to demonstrate oxy-fuel combustion concepts.

Conclusions:

- Improve oxygen uptake capacity
- Lower operating temperature from 850° C to about 600° C
- Improve desorption kinetics

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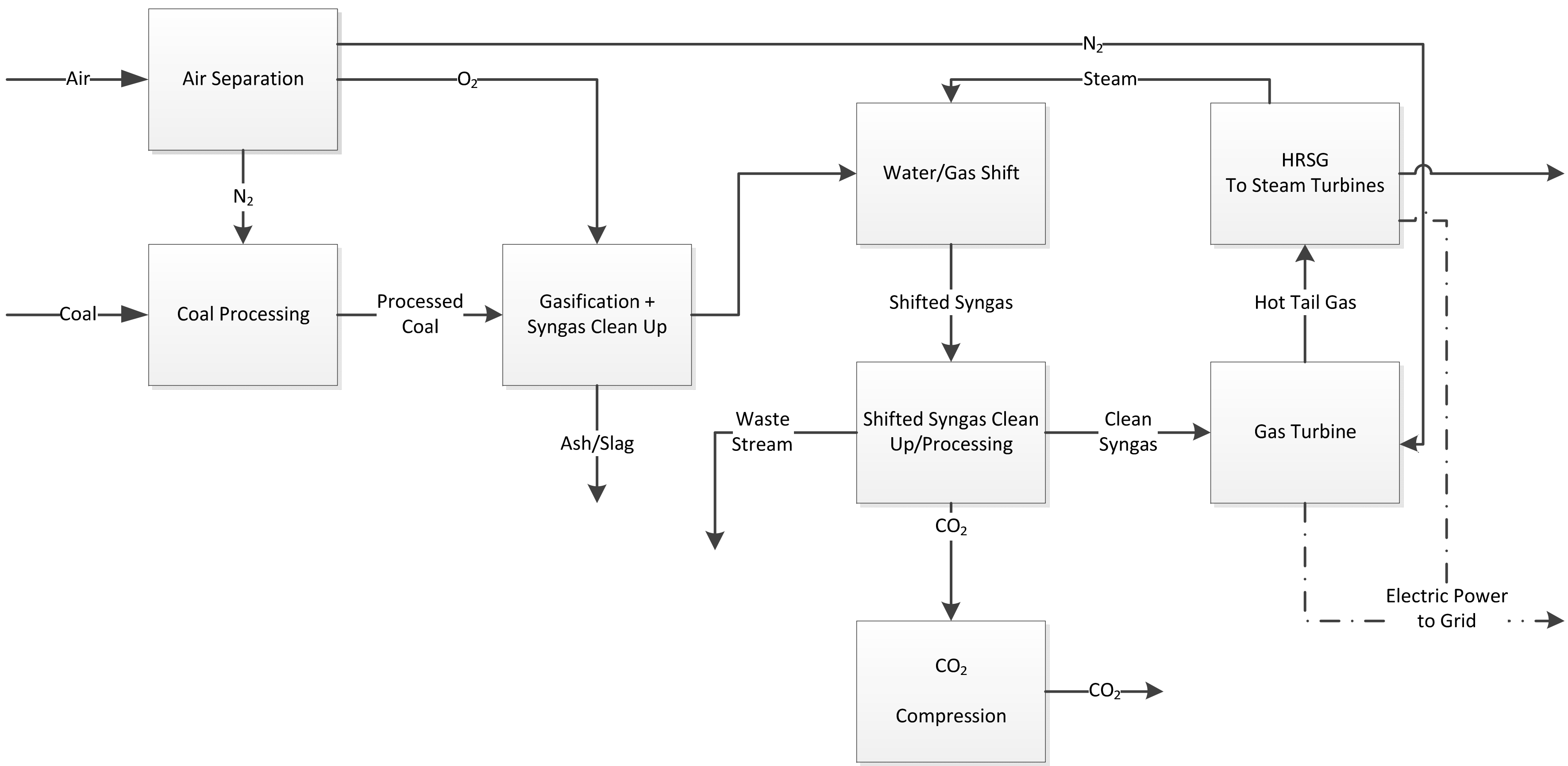
Integration with IGCC



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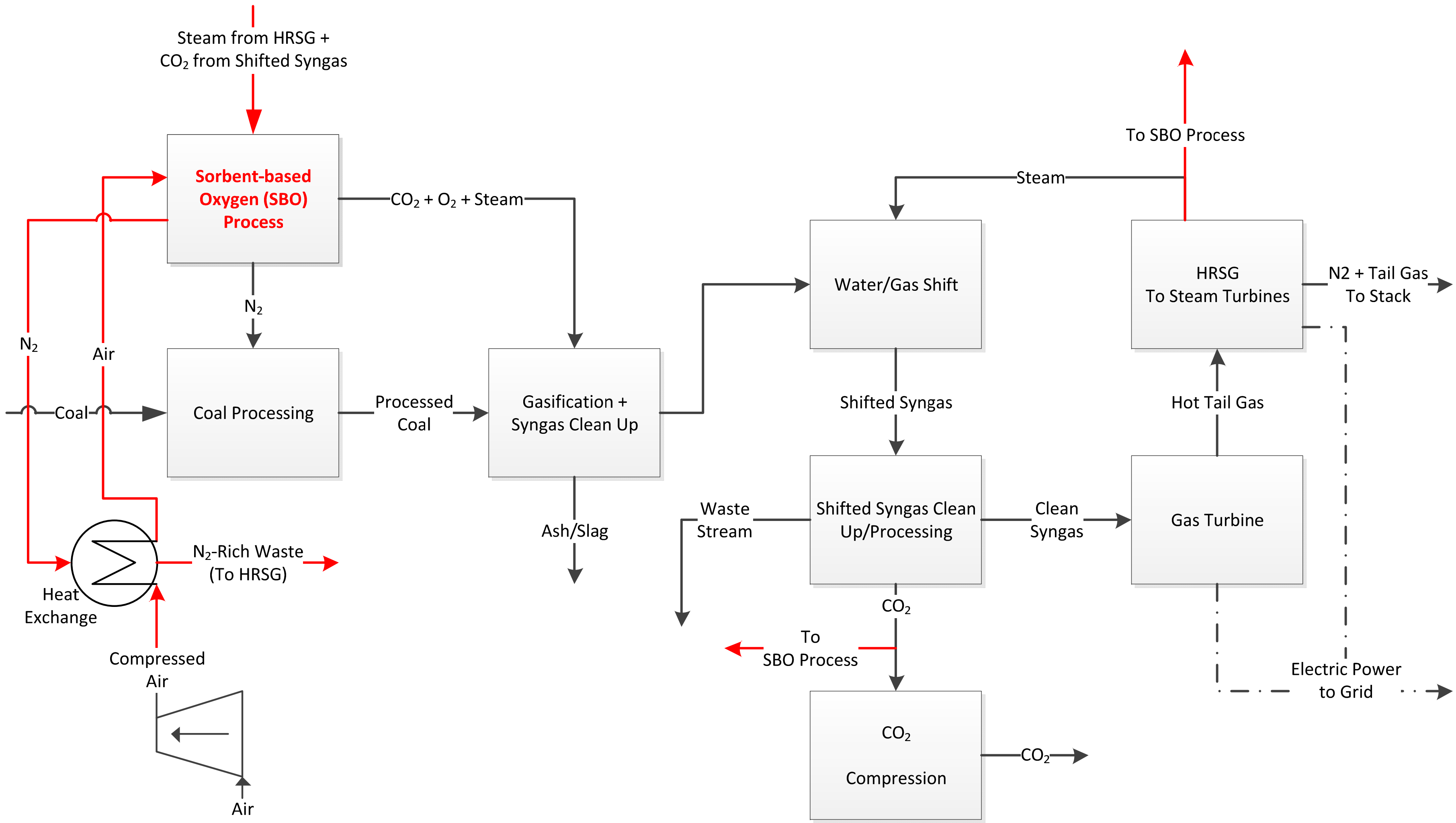
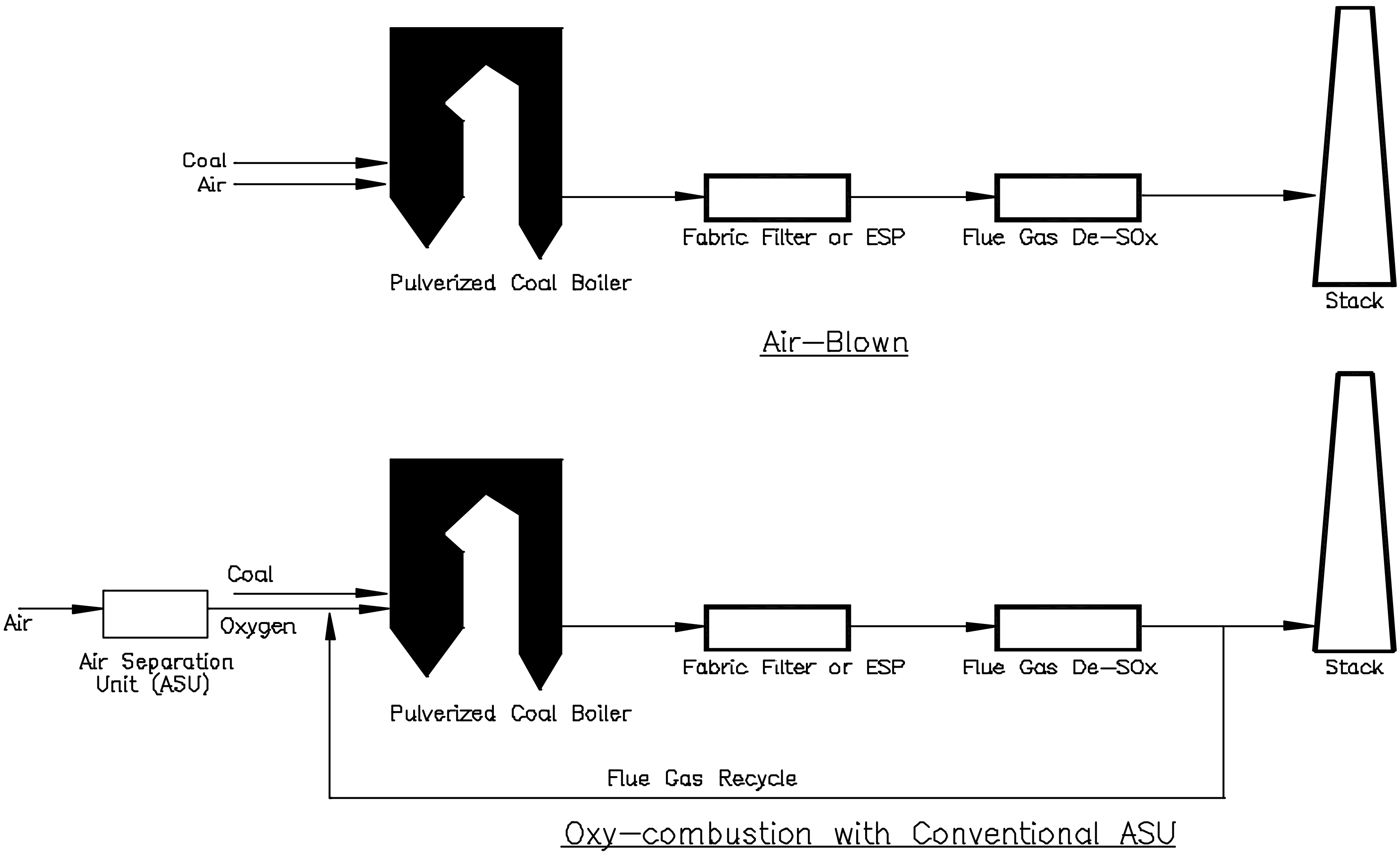
Integration with IGCC



Integration with Oxy-Combustion



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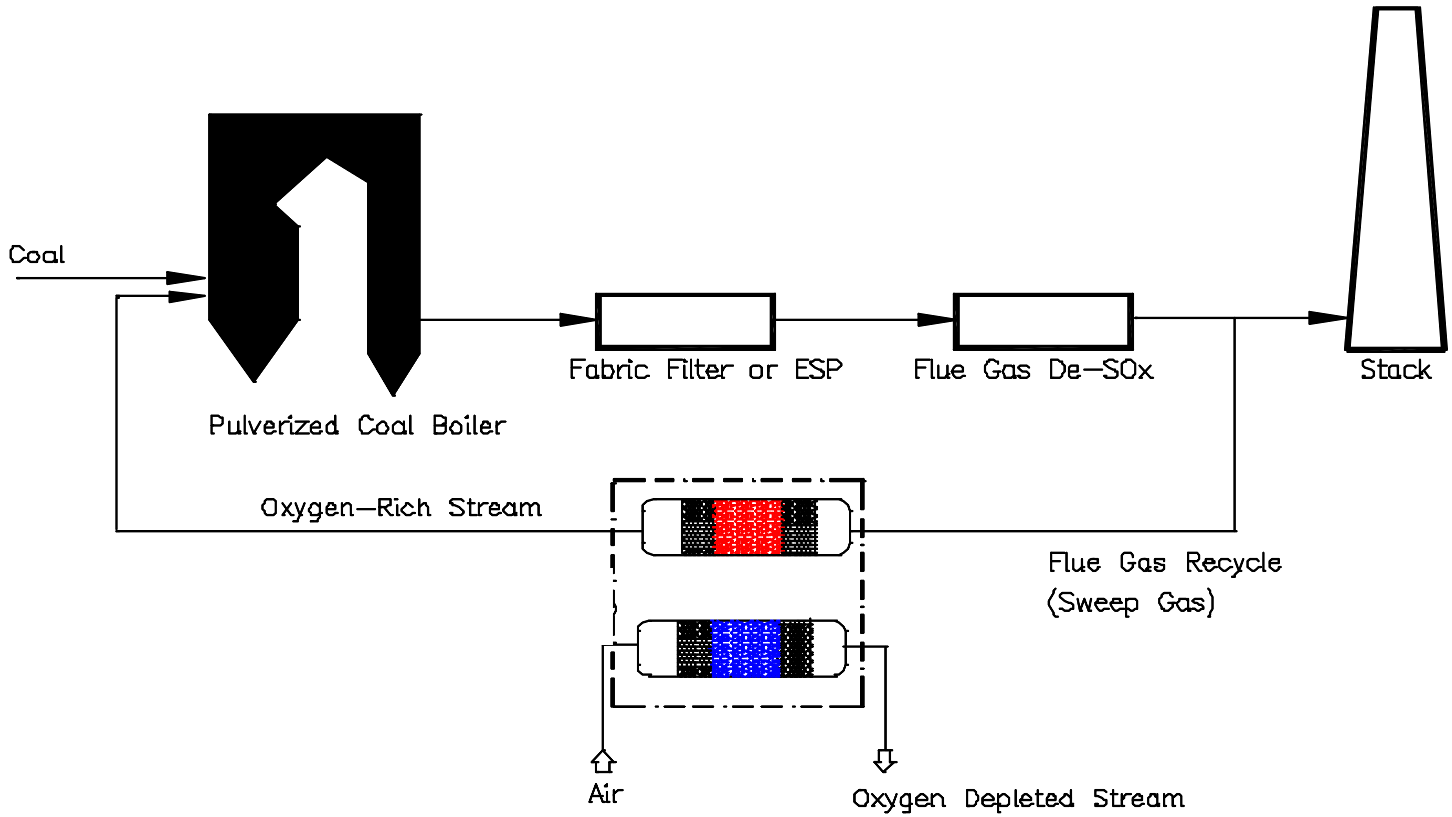
Integration with Oxy-Combustion



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New Materials

Sorbent	A	B	C	Linde/BOC
Operation temperature (°C)	400-700	500-700	700-800	850
Oxygen sorption capacity (g/g)	400--0.0154 500--0.0109 600--0.0102 700--0.0074	500--0.0176 600--0.0144 700--0.0118	600--0.0093 700--0.0086 800--0.0134 900--0.0131	0.008
Oxygen desorption rate (1/2)	$0.5\text{-}2x10^{-2}$	$0.2\text{-}1x10^{-2}$	$0.5\text{-}3x10^{-2}$	$1\text{-}4x10^{-4}$

- ✓ Improve oxygen uptake capacity
- ✓ Lower operating temperature
- ✓ Improve desorption kinetics

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Process Economics

Capital and Power Requirements for O_2 Delivery Rate of 400,000 Nm^3/hour*

	Cryogenic	Linde/BOC CAR Process	New Process
O_2 capacity (Nm^3/hour)	400,000	400,000	400,000
Total sorbent loading (ton)	N/A	637	255
Purge Gas	N/A	CO_2	CO_2
Adsorber temperature (°C)	N/A	800	600
Oxygen recovery (%)	N/A	90	90
Specific O_2 production system cost (\$/ton O_2/day)	25,000	14,000	9,800
Specific power requirement (kWh/ton O_2)	223	115	90

** Based on early work performed by Alstom*

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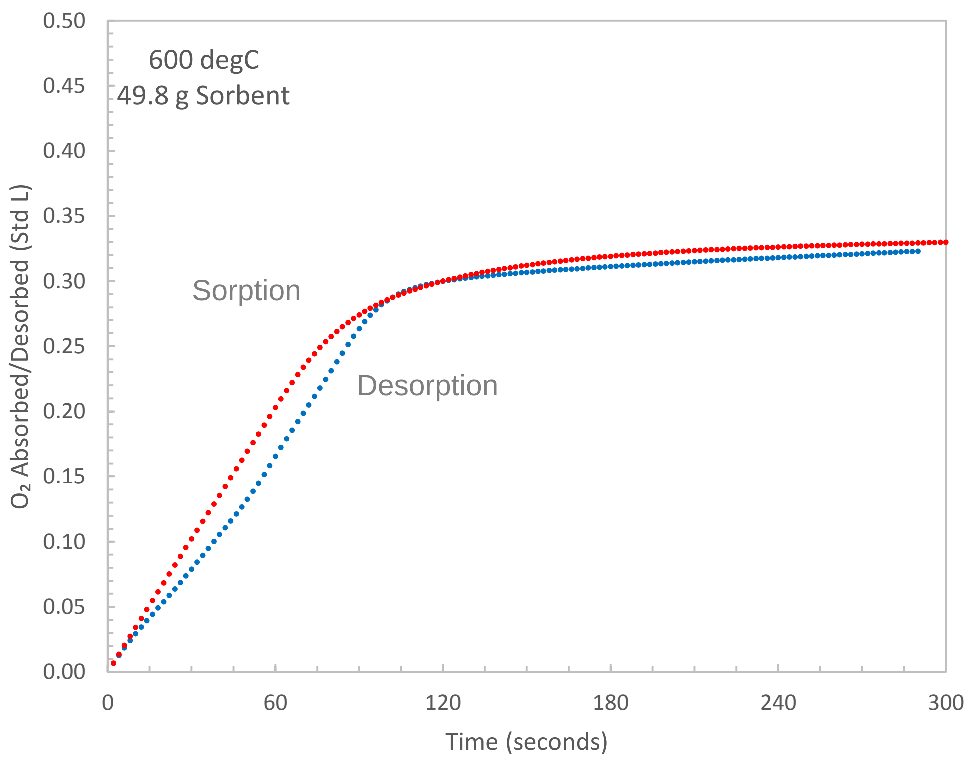
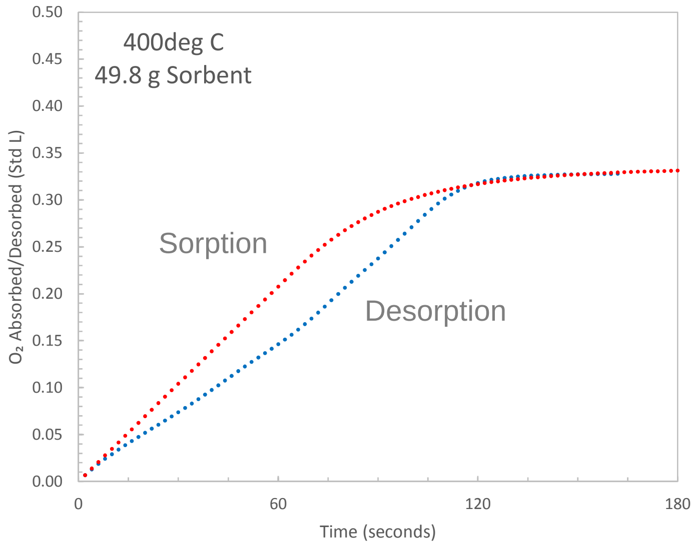
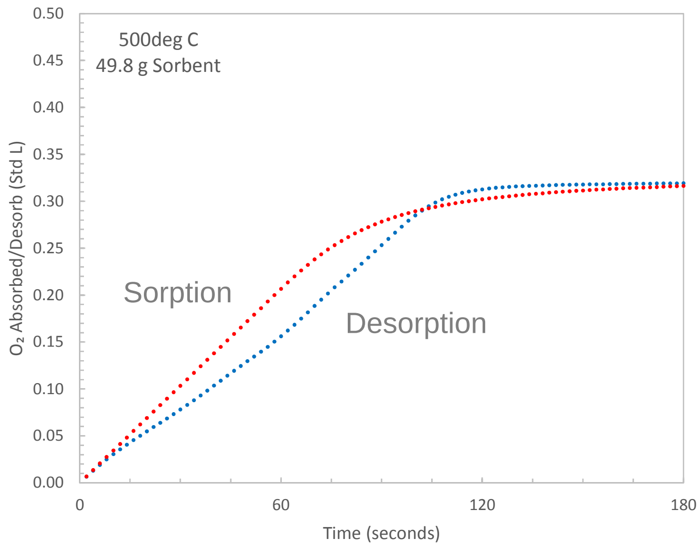
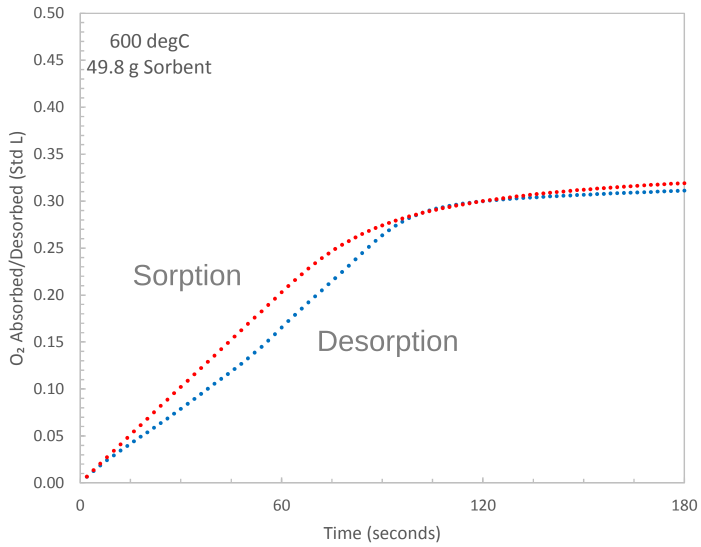
Preliminary Results



Preliminary Results







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Summary

DE-FE0024075:

- Deals with the development of a high-temperature sorbent-based oxygen production technology
- Is developing more efficient and stable, higher sorption capacity, newer class of materials operating at lower temperatures
- If successful sorbent-based oxygen production process represents a major advancement in air separation technology
- New ceramic sorbent materials have a higher O_2 adsorption capacity, >200 ºC lower operating temperatures, and up to two orders of magnitude faster desorption rates than those used in earlier development efforts
- The performance advancements afforded by the new materials can lead to substantial savings in capital investment and operational costs

Questions/Comments?

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