

Low-cost Oxygen (LCO) for Small-scale Modular Gasification Systems

Project DE-FE0028002

U. S. Department of Energy
National Energy Technology Laboratory
PO: Steven Markovich

Prime Contractor:

Thermosolv LLC

Partners:

WRI and LP Amina

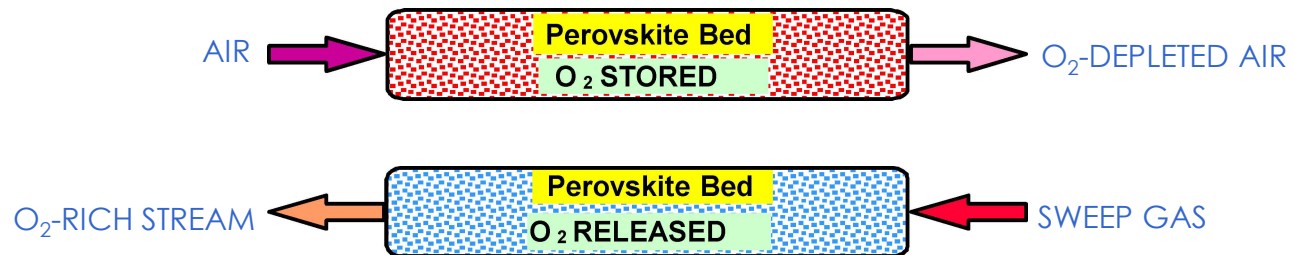
2018 Gasification Systems and Coal and Coal-Biomass to Liquids (C & CBTL)
Project Review Meeting
April 10, 2018

Beau D Braunberger

THERMOSOLV LLC

Background

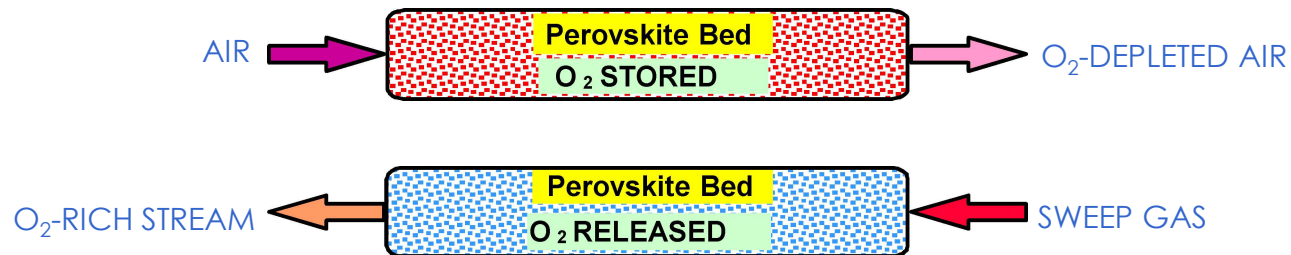
LCO Process (Perovskite Sorbent-based Oxygen)



- Adsorb O_2 from air in a solid sorbent
- Use of CO_2 -rich flue gas and/or steam as sweep gas allows optimization of the O_2 concentration
- Use of vacuum or condensing steam sweep to produce oxygen
- Elevated-temperature process driven by partial pressure of oxygen

Background

LCO Process (Perovskite Sorbent-based Oxygen)



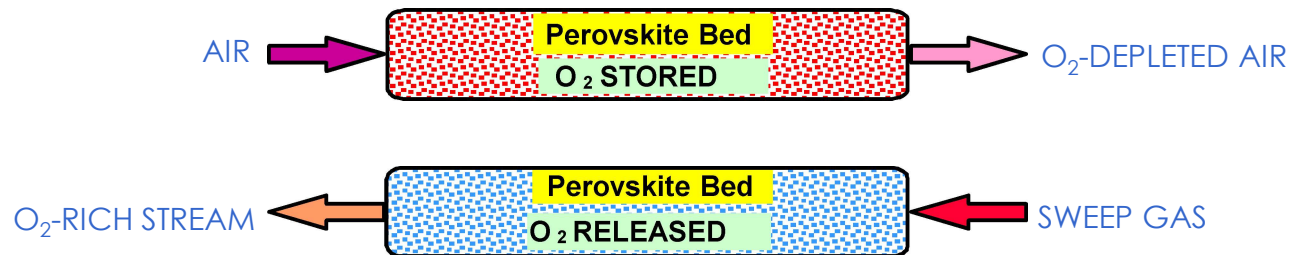
Between 2005 and 2008, under two separate Cooperative Agreements, a two-bed, 60-pph unit was developed by BOC/Linde and tested at EP&G/WRI (Thermosolv LLC). The unit was integrated with an existing 250,000 Btu/h Combustion Test Facility to demonstrate oxy-fuel combustion concepts.

Conclusions:

- Improve oxygen uptake capacity
- Lower operating temperature from 850° C to about 500° C
- Improve desorption kinetics

Background

LCO Process (Perovskite Sorbent-based Oxygen)



Project DE-FE0024075 (Complete)

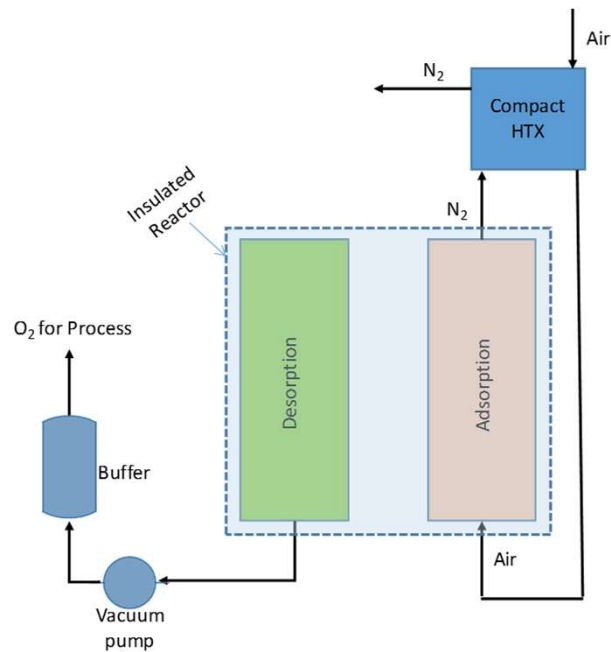
Perovskite(s) with order-disorder transition

- Lower heat of oxygen sorption
- Improved oxygen uptake capacity
- Lower operating temperature (about 500° C)
- Improved desorption kinetics
- CO₂ sweep can provide oxygen for oxy-fuel combustion
- Using air sweep enriched air can be provided for commercial applications
- VPSA cycle optimized to demonstrate 95% pure oxygen

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Low-cost Oxygen for Small-scale Modular Gasification

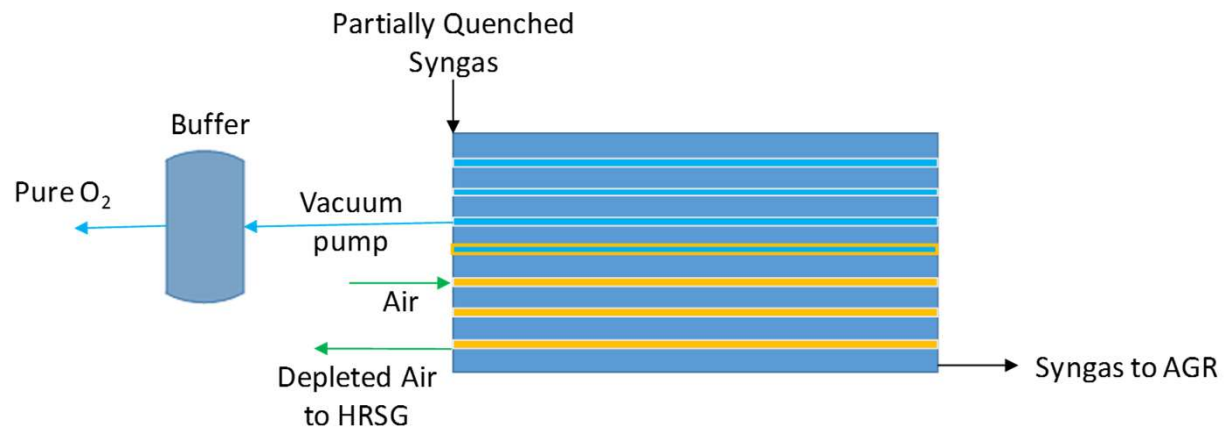
- Stand-alone >95% purity oxygen process for small-scale modular < 5MW coal gasification plants
- Design, build and operate a 1-tpd Oxygen Plant



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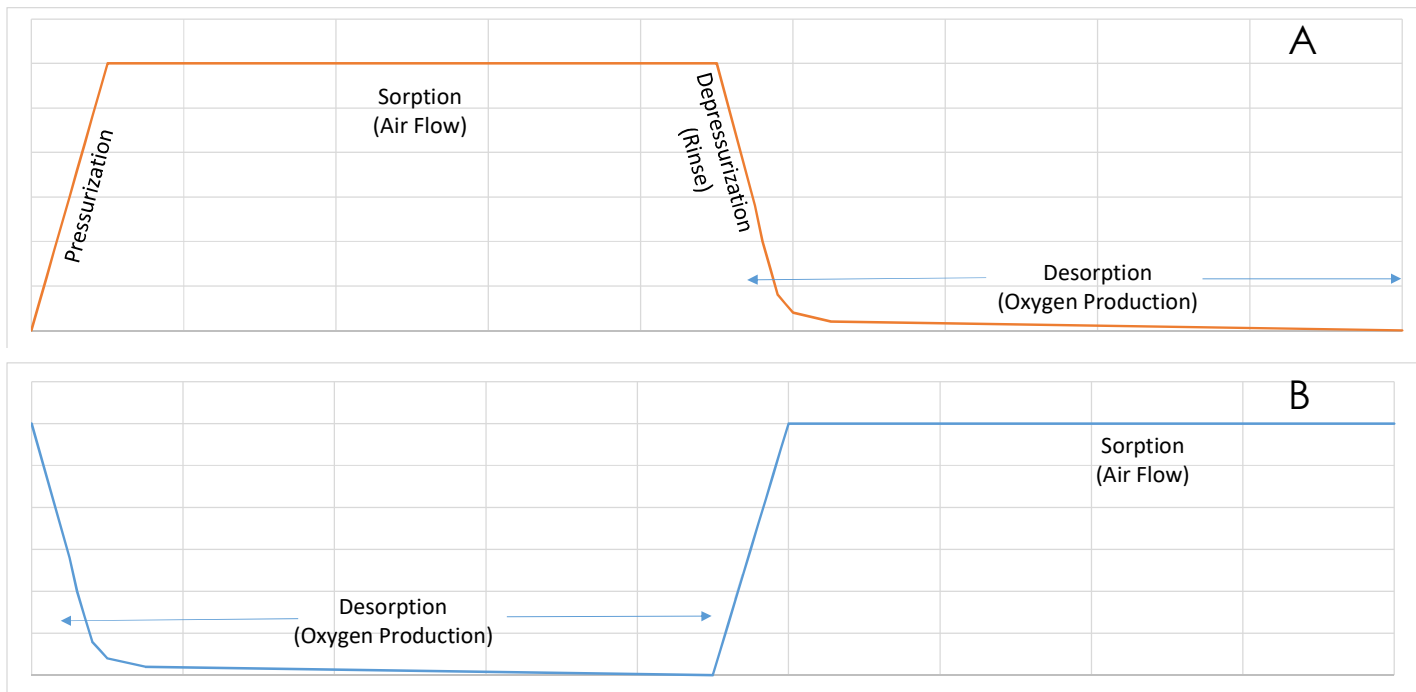
Low-cost Oxygen for Small-scale Modular Gasification

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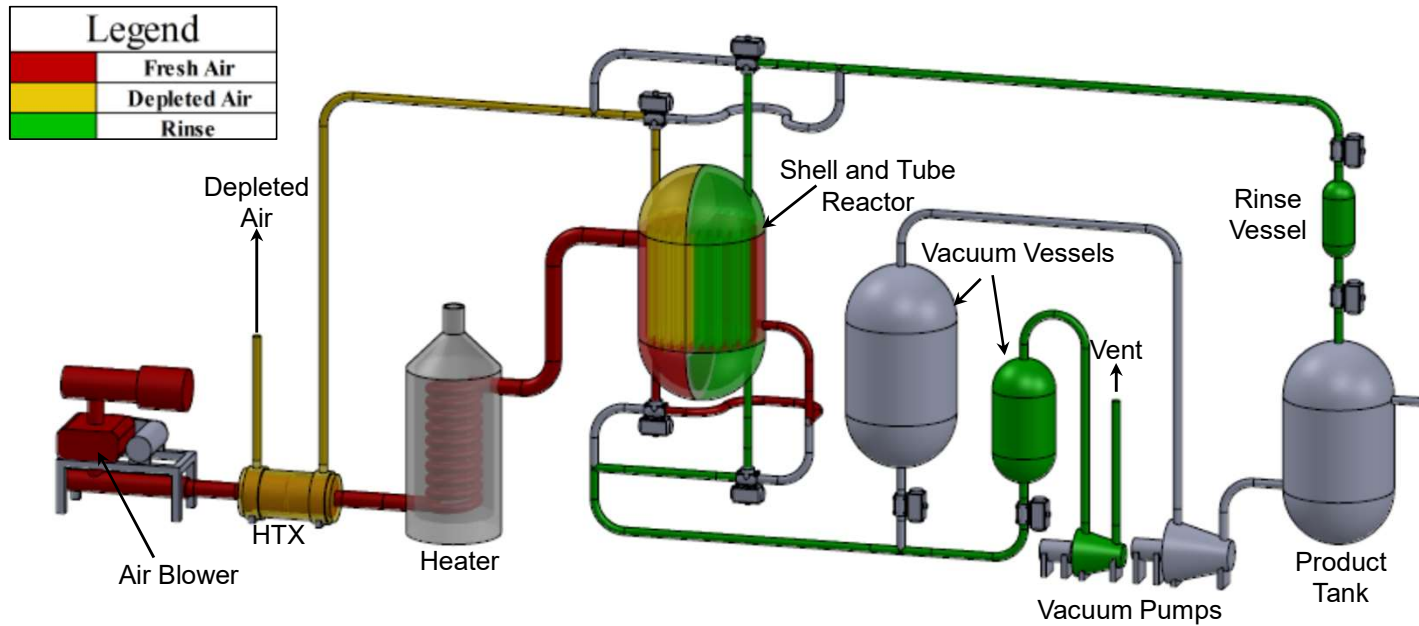
Two-Bed VPSA Cycle



Short Cycle - Faster Kinetics at Lower Temperatures

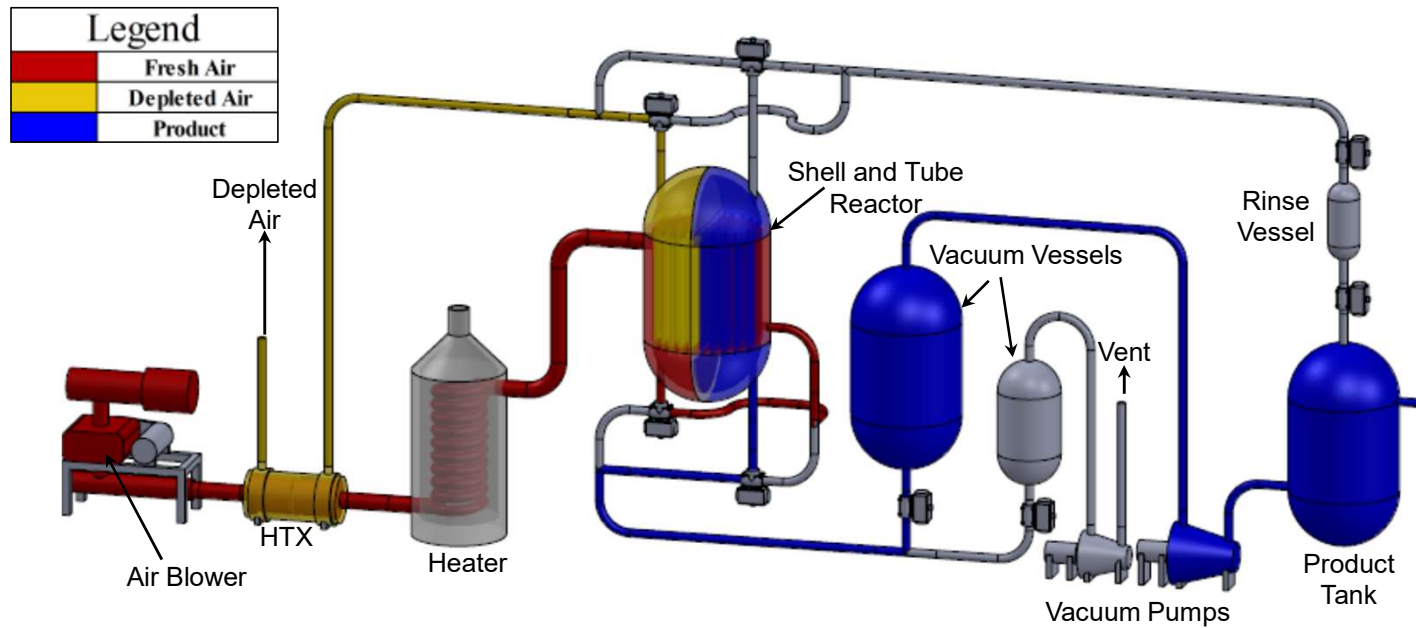
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Two-Bed VPSA Cycle



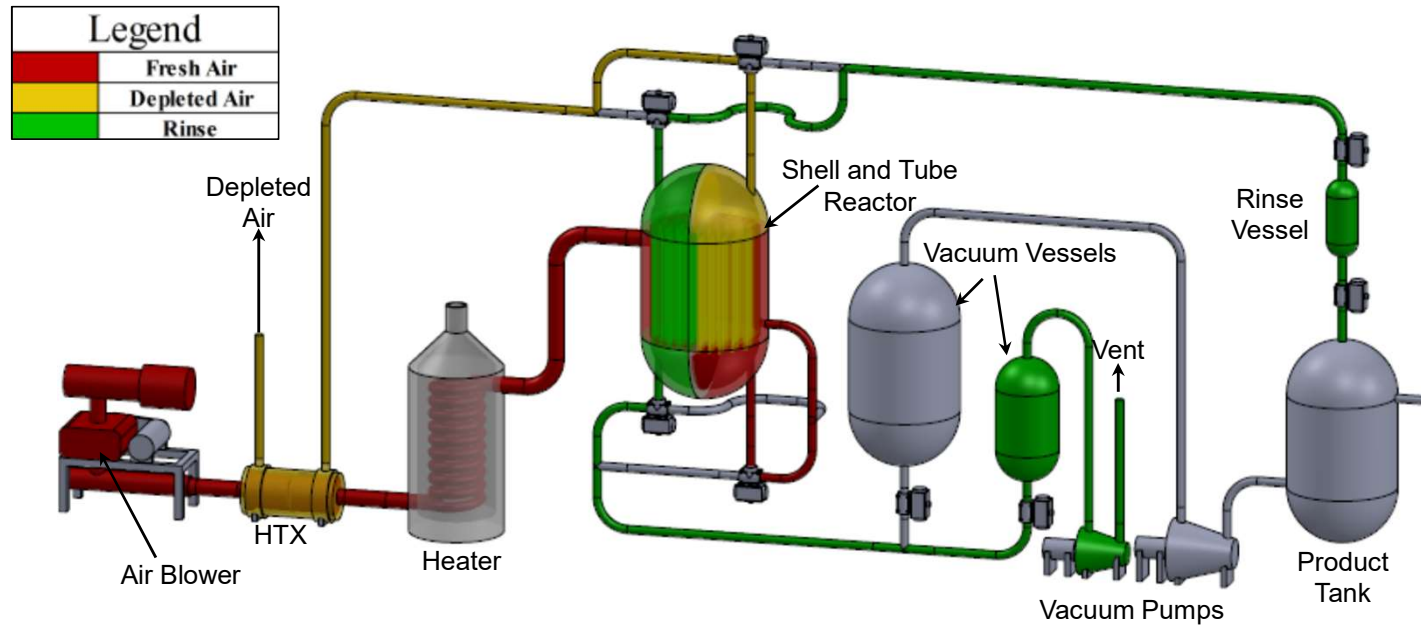
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Two-Bed VPSA Cycle



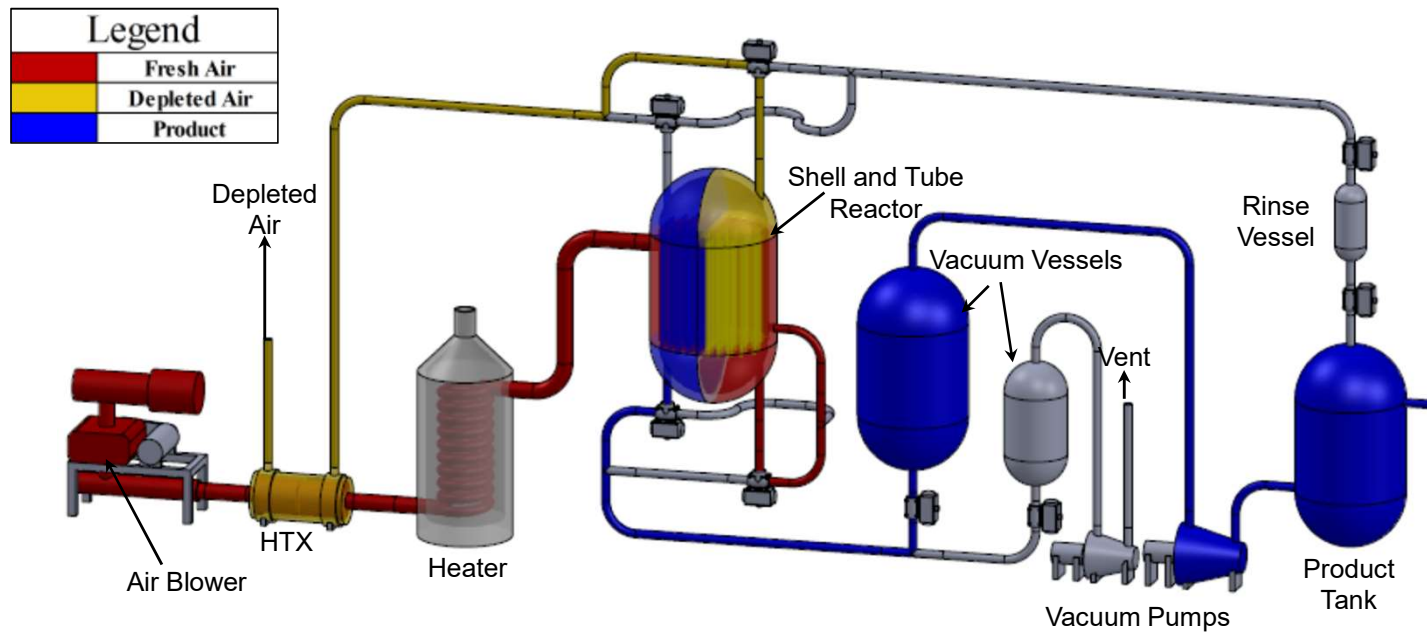
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Two-Bed VPSA Cycle



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Two-Bed VPSA Cycle



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Goal

Develop and demonstrate an advanced oxygen production technology for use in coal-fed gasification plants. The specific technical objectives are to scale-up the low-cost oxygen production based on vacuum pressure swing with high-temperature perovskite sorbent, evaluate performance as a function of operational parameters, and perform cyclic adsorption/rinse/desorption experiments to demonstrate oxygen production rate and purity.

Scope of Work

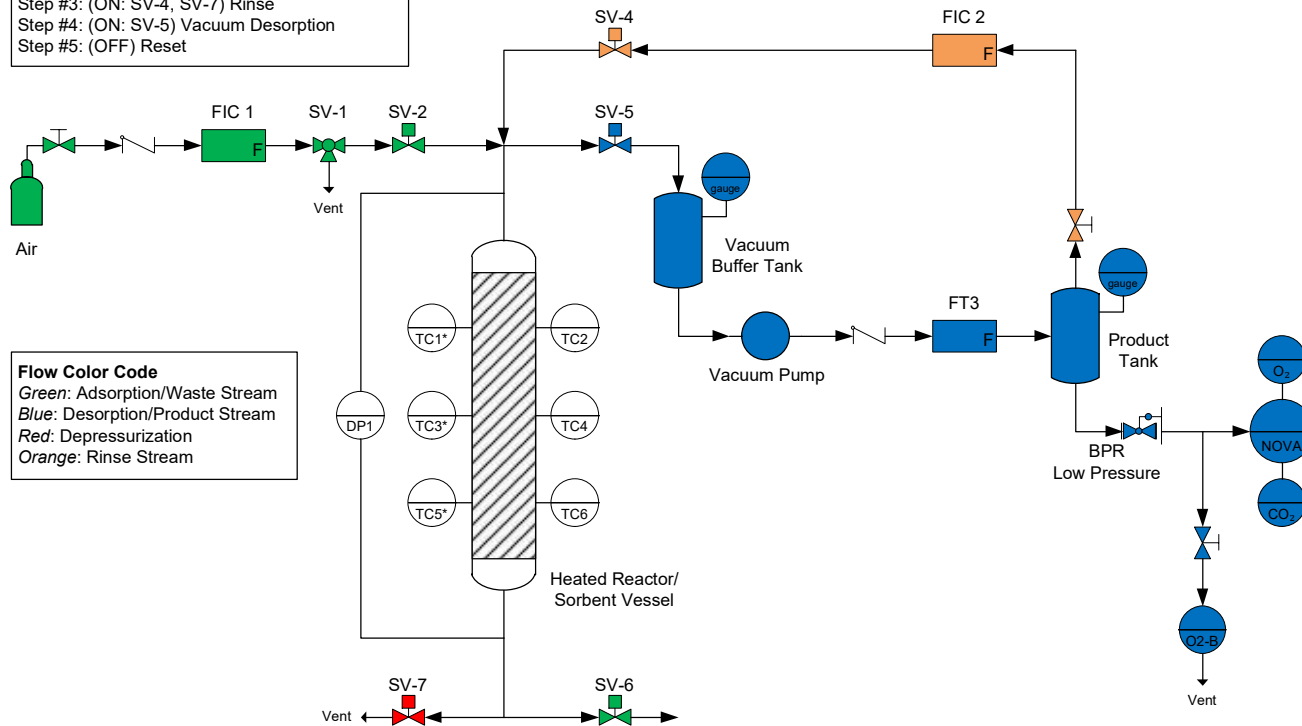
- Upgrade an existing bench-scale test setup to include provisions for modified rinse and desorption steps.
- Optimize the adsorption, rinse, desorption cycles as a function of operating temperature and pressure.
- Based on the results from bench-scale testing, develop a simulation model
- Using the model design a reactor and oxygen process of nominal 1-ton/day capacity
- Construct, debug and operate the 1-ton/day oxygen production facility to perform parametric tests
- Perform long-term performance tests to establish sorbent durability and service life
- Develop credible process economics for small-scale modular coal gasification power plants in the less than 5MW size range.

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Bench-scale test set-up for vacuum pressure swing testing

Step List (SV-1 to SV-7 are OFF unless noted)
 Step #1: (ON: SV-1, SV-2, SV-6) Adsorption
 Step #2: (ON: SV-7) Depressurization
 Step #3: (ON: SV-4, SV-7) Rinse
 Step #4: (ON: SV-5) Vacuum Desorption
 Step #5: (OFF) Reset

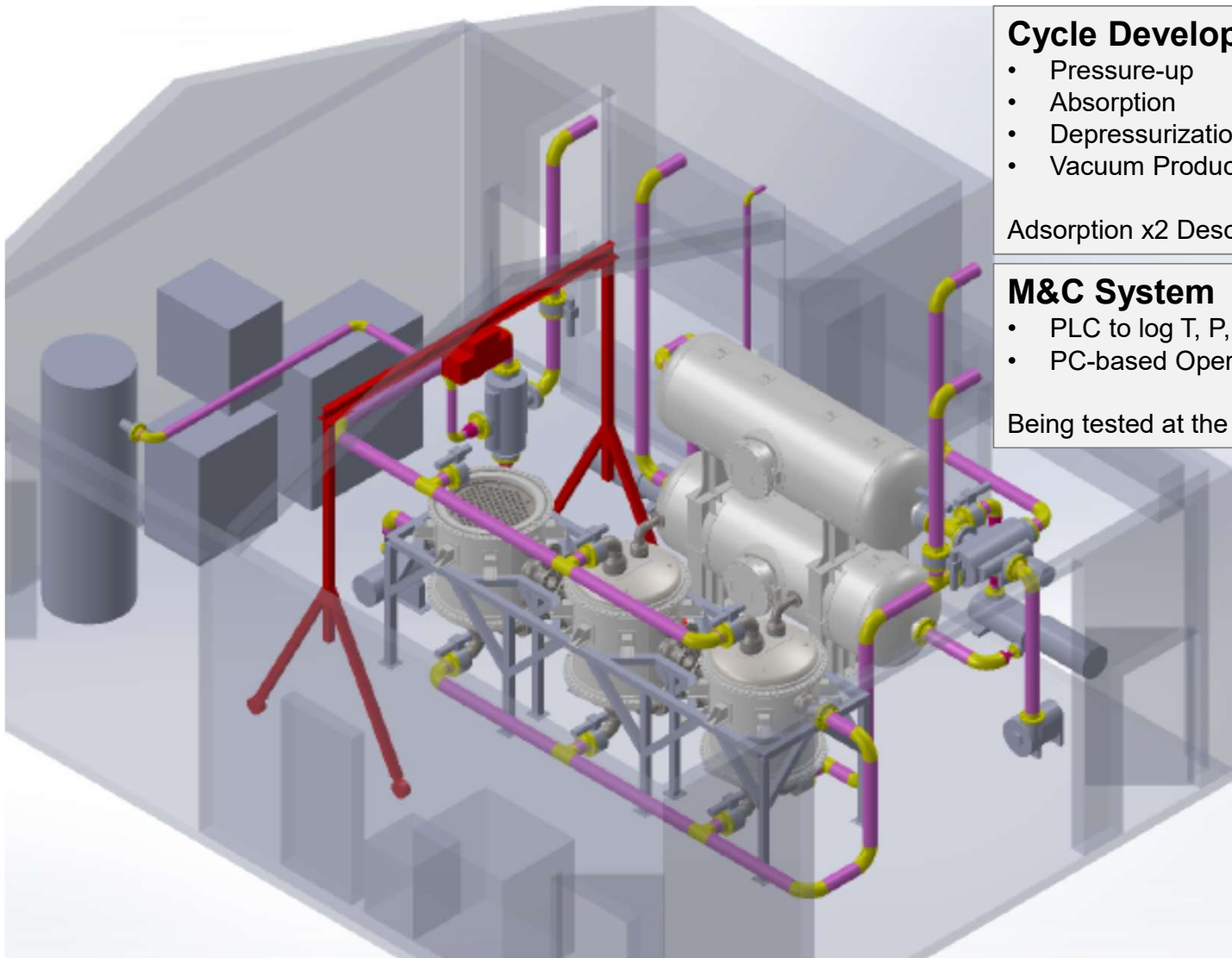
Flow Color Code
 Green: Adsorption/Waste Stream
 Blue: Desorption/Product Stream
 Red: Depressurization
 Orange: Rinse Stream



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Bench-scale test set-up for vacuum pressure swing facility





Cycle Development

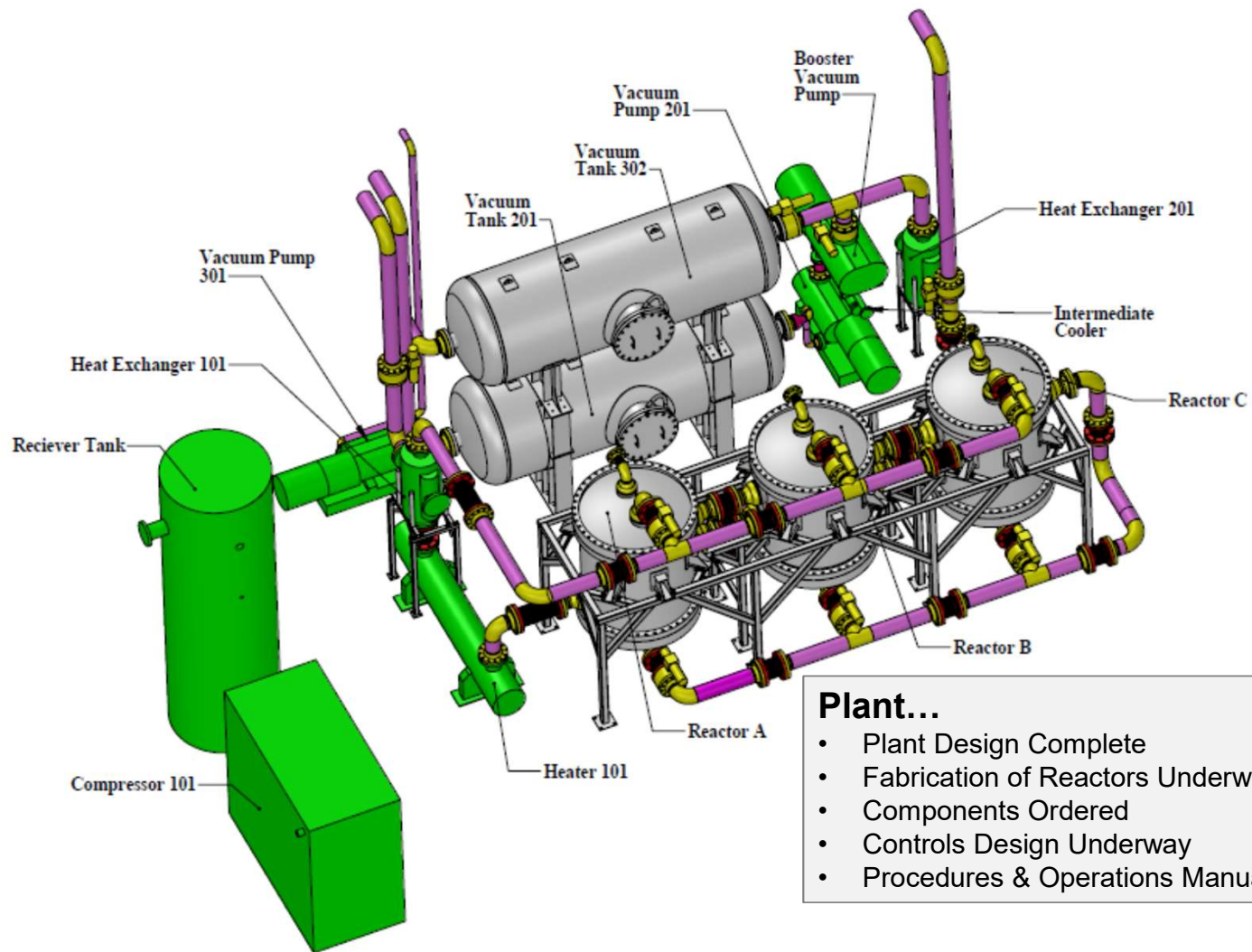
- Pressure-up
- Absorption
- Depressurization
- Vacuum Production

Adsorption x2 Desorption

M&C System

- PLC to log T, P, dP, flow and cycles
- PC-based Operator Interface

Being tested at the bench test set-up



- Plant...**
- Plant Design Complete
 - Fabrication of Reactors Underway
 - Components Ordered
 - Controls Design Underway
 - Procedures & Operations Manual in-Preparation

Questions

