Advances in Coal Combustion

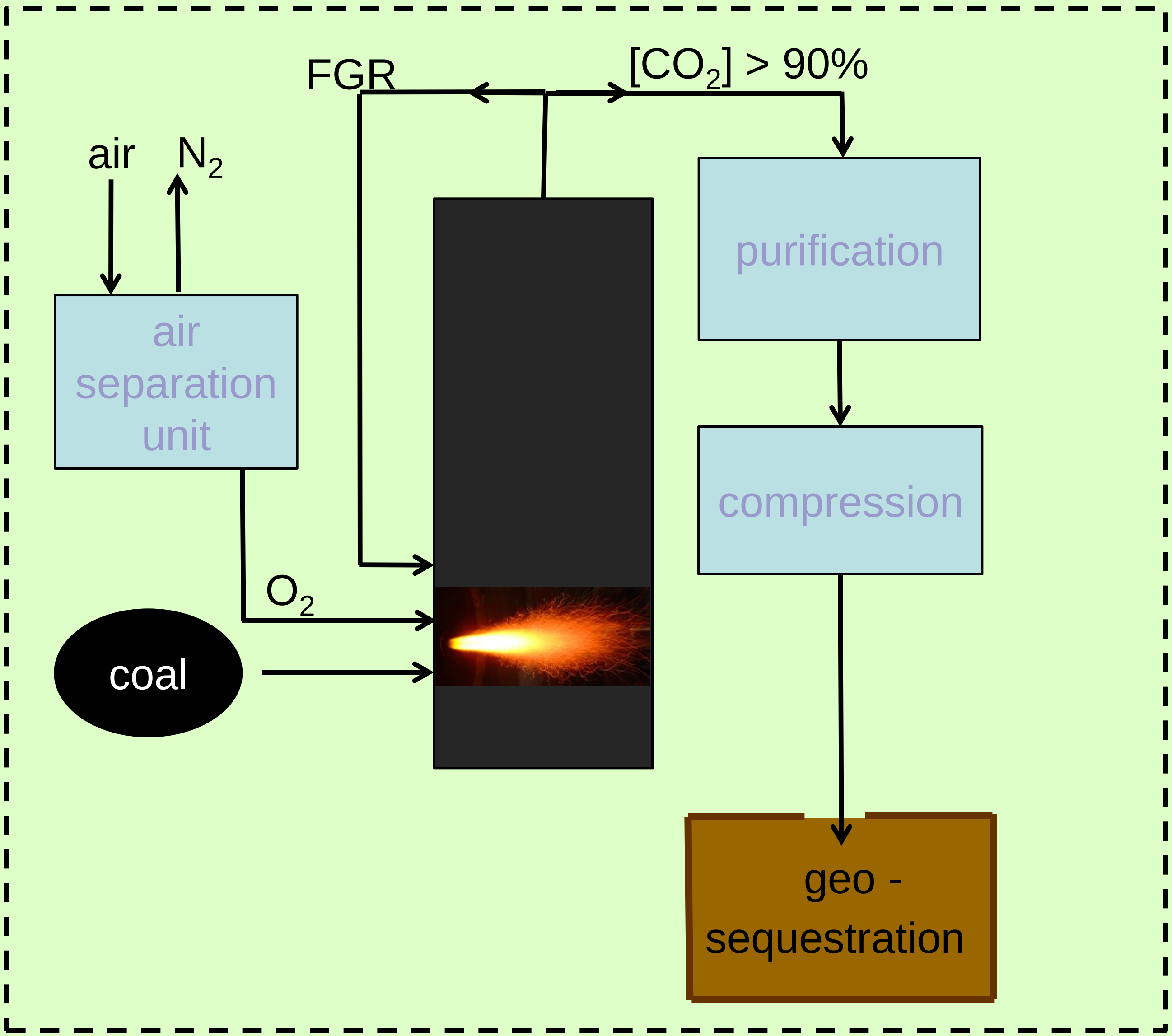
Richard L. Axelbaum, Ph.D.
Director, Consortium for Clean Coal Utilization
Professor, Energy, Environmental and Chemical Engineering
cccu@wustl.edu

Consortium for Clean Coal Utilization

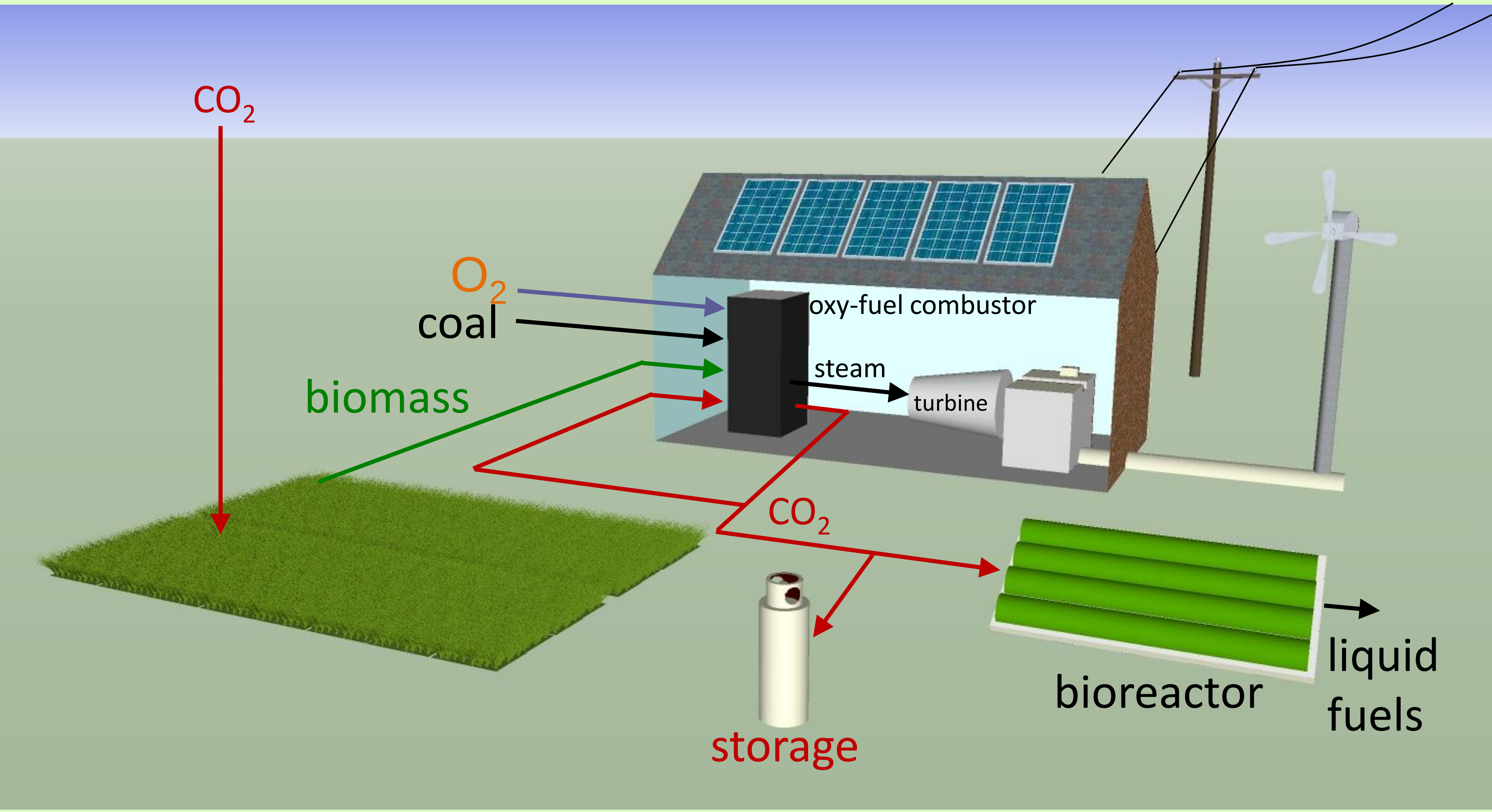
- Vision
  - Dedicated to addressing the scientific and technological challenges of ensuring that coal can be used in a clean and sustainable manner.
- Mission
  - A resource to industry for the advancement of technologies that foster clean utilization of coal by creating an international partnership between universities, industries, foundations, and government organizations.
- Goals
  - Develop state-of-the-art clean coal facilities that are unprecedented on a university campus
  - Support research projects at Washington University in collaboration with the McDonnell Partner Universities around the world.
  - Train a knowledgeable, motivated work force and increase public awareness
- Sponsors
  - Peabody, Arch Coal, Ameren
  - $12MM over 5 years

Title	PI	Co-I	Institution
Carbon Dioxide Capture and Conversion In Different Modalities	P. Biswas	 K. Iyer A.K. Suresh	WU IIT IIT
Air-Fired and Oxy-Combustion of Coal and Biomass	R. Axelbaum	 S. Li	WU Tsinghua
Life cycles of metals in coal combustion: Metal release and capture, speciation in flyash, and transformations during ash reuse and storage	D. Giammar	 P. Biswas J.G. Catalano A. Dikshit J. Hao	WU WU WU IIT Tsinghua
Development of a Microalgal System for Carbon Dioxide Sequestration	H. Pakrasi	 Y. Tang P. Wangikar	WU WU IIT
Integrated nanoscale catalysts for the conversion of CO_2 to chemicals and fuels	C. Lo	 J. Gleaves G. Yablonsky M. Dudukovic M. Sheintuch	WU WU WU WU Technion
Mechanisms and Kinetics of Multiphase Fluid-formation Mineral Reactions in Carbon Dioxide Geologic Sequestration	Y-S Jun	 D. Giammar A. Mehra S. Shimada	WU WU IIT U of Tokyo
Utilization of Fly Ash for Fire-proof Geopolymer Resins and Aluminum and Polymer Matrix Composites for Aerospace and Automotive Applications	S. Sastry	 R. Sureshkumar Y. Nugroho S. Astutiningsih R.C. Prasad P. Rohatgi	WU WU U. Indonesia U. Indonesia IIT U. Wisconsin
Numerical Modeling and Simulation of CO_2 Sequestration in Saline Aquifers	R. Agarwal	 S. Benson	WU Stanford

Oxy-coal combustion with CCS



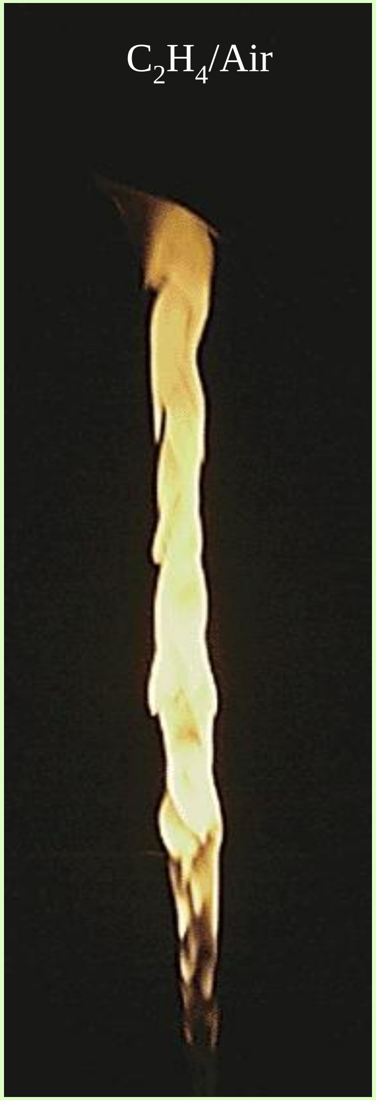
Conceptual Drawing of Potential Power Plant



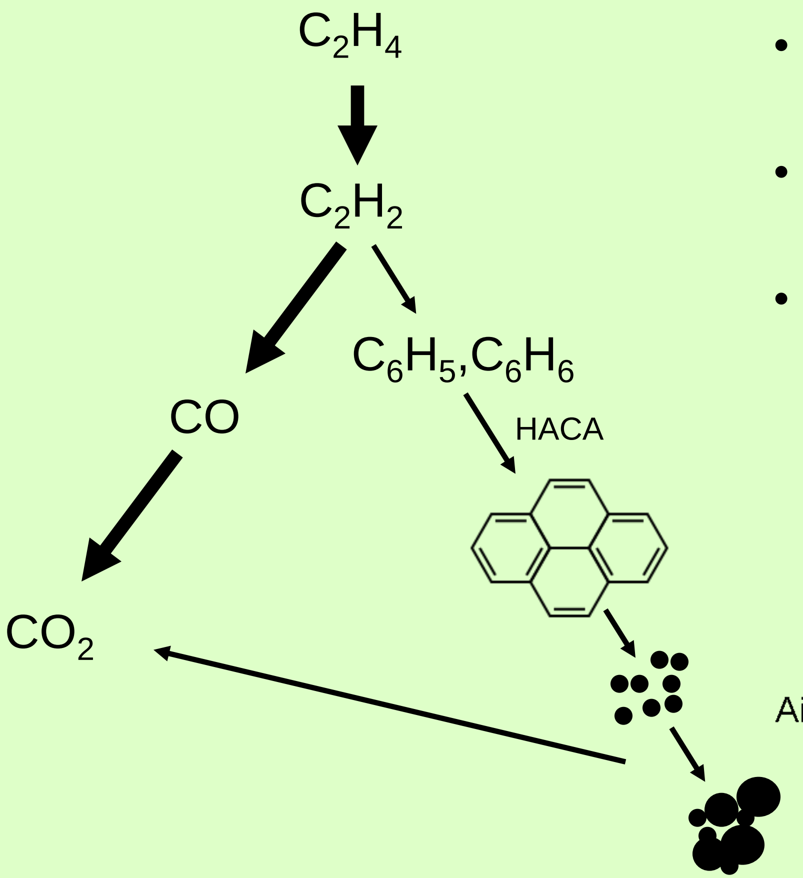
Benefits of Oxy-*fuel* Combustion

Previous results with gaseous fuels:

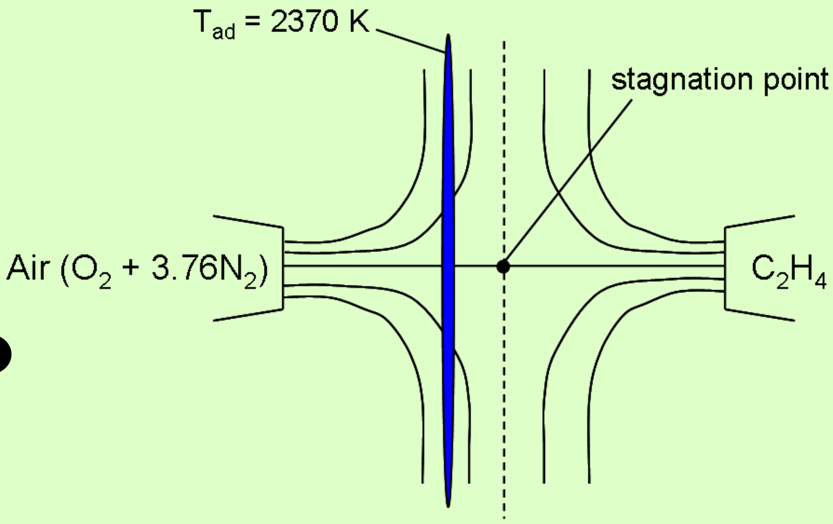
- Oxy-fuel combustion can be used to influence the flame structure (i.e. the relationship between temperature and species).
- Reduced soot formation and improved flame stability. Attributed to structural changes.



Kinetic Pathway for Soot

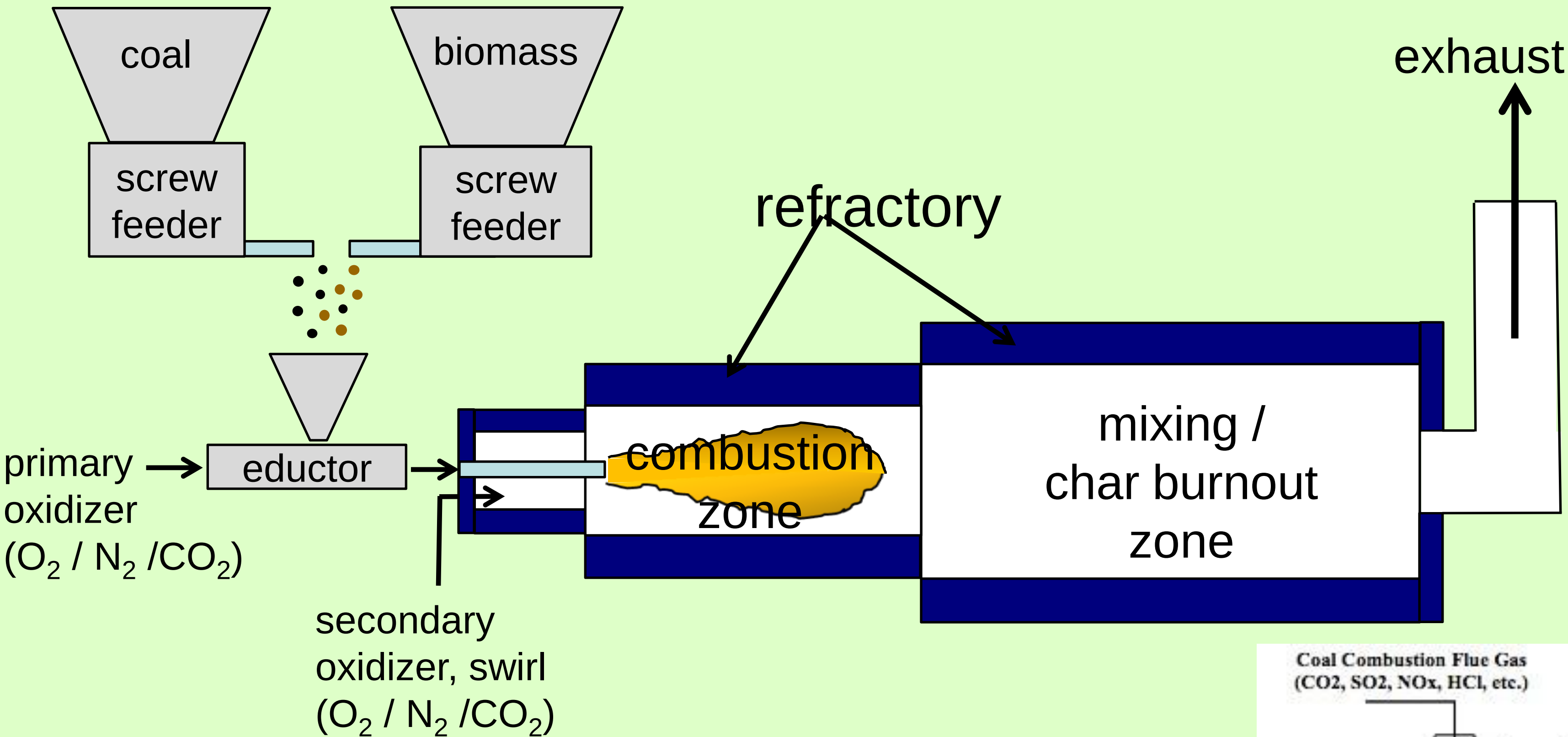


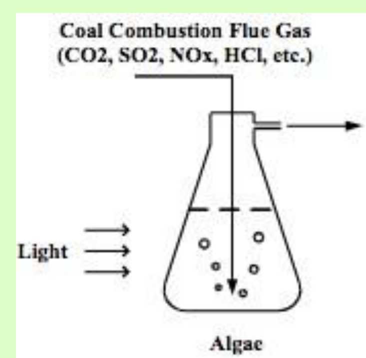
- Counterflow flame code (OPPDIF) with detailed chemistry
- Chemical mechanism: USC Mech II, Hai Wang et al.
- Constant T_{ad} = 2370 K, varying Z_{st}



Oxy-fuel combustor at WU

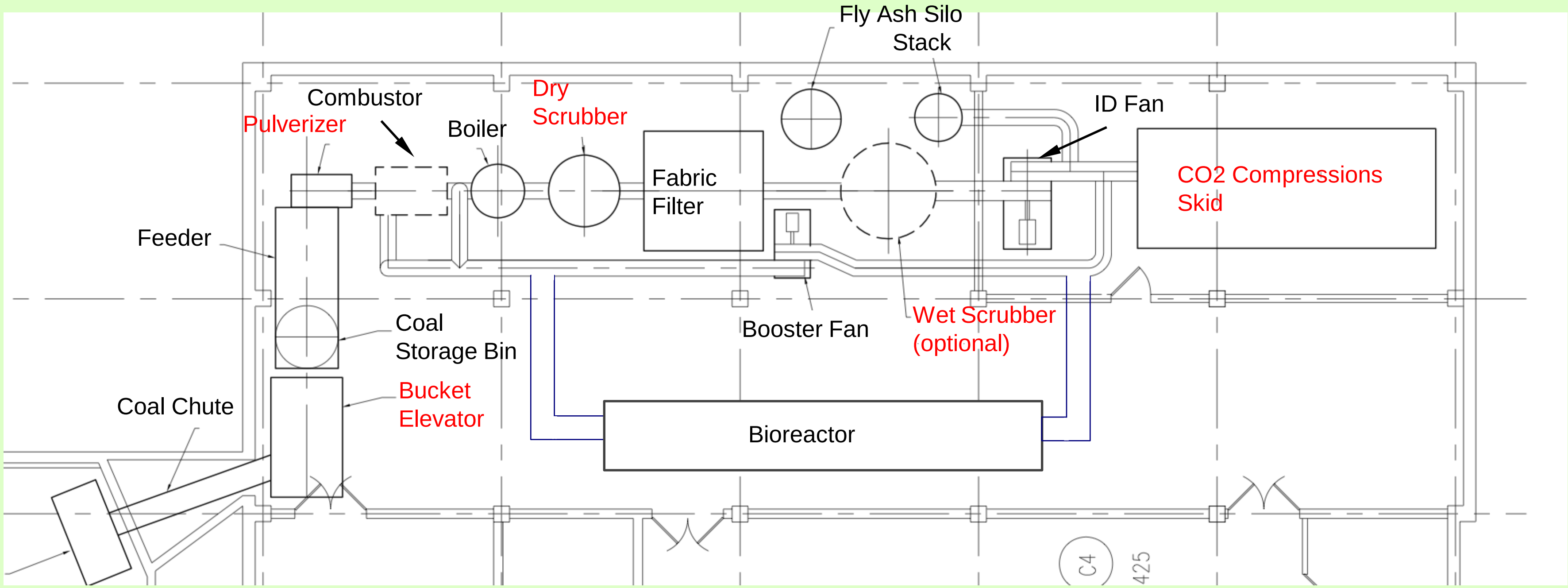
35 kW, self-sustaining
oxy/coal/biomass combustor





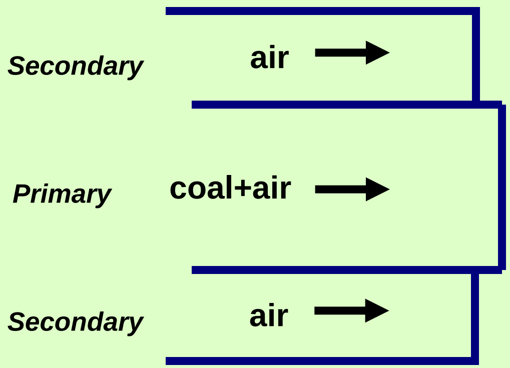
Research facility under development

- Designed to burn up to 2 tons of coal per day using up to 5 tons of oxygen ~ 0.5-1.0 MW_{th}
- Oxy-coal and air-coal
- Co-firing with biomass
- Steam generation for campus loop
- 4000 sq. ft (370 m^2) research facility
- Designed for flexibility

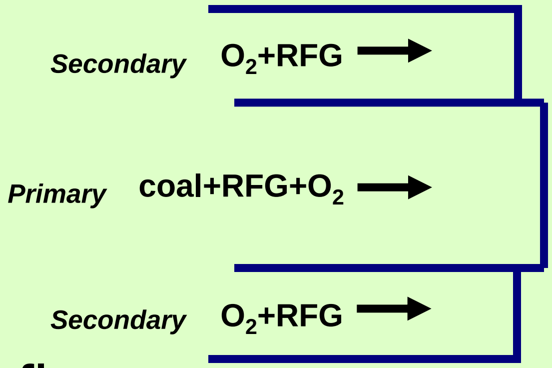


Conventional vs. Oxy-coal Combustion

Conventional Coal/Air Combustion



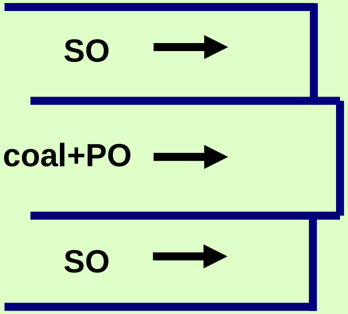
Oxy-Coal Combustion

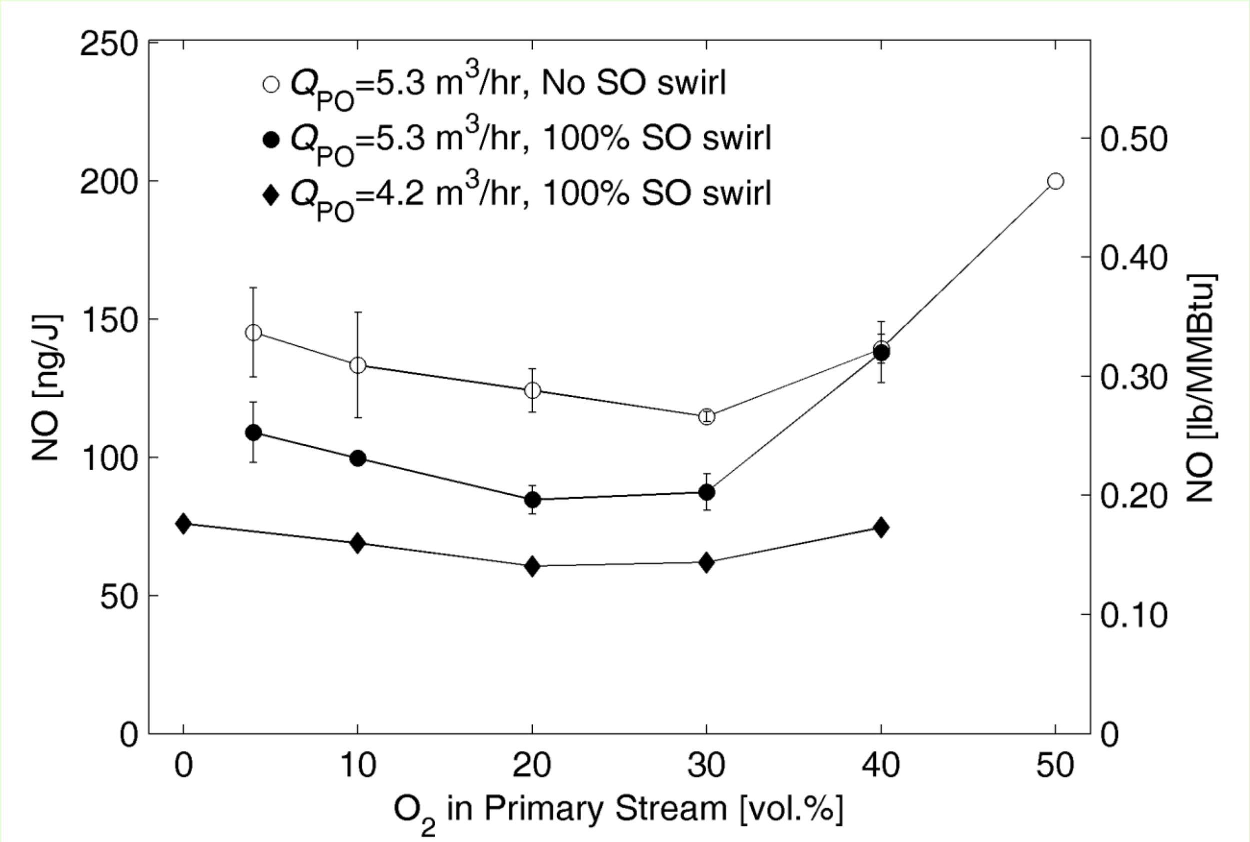


Mass flow fuel → fixed
Primary flow rate → fixed
Mass flow O_2 → fixed
O_2 concentration func. of RFG
High O_2 conc. → less Secondary flow

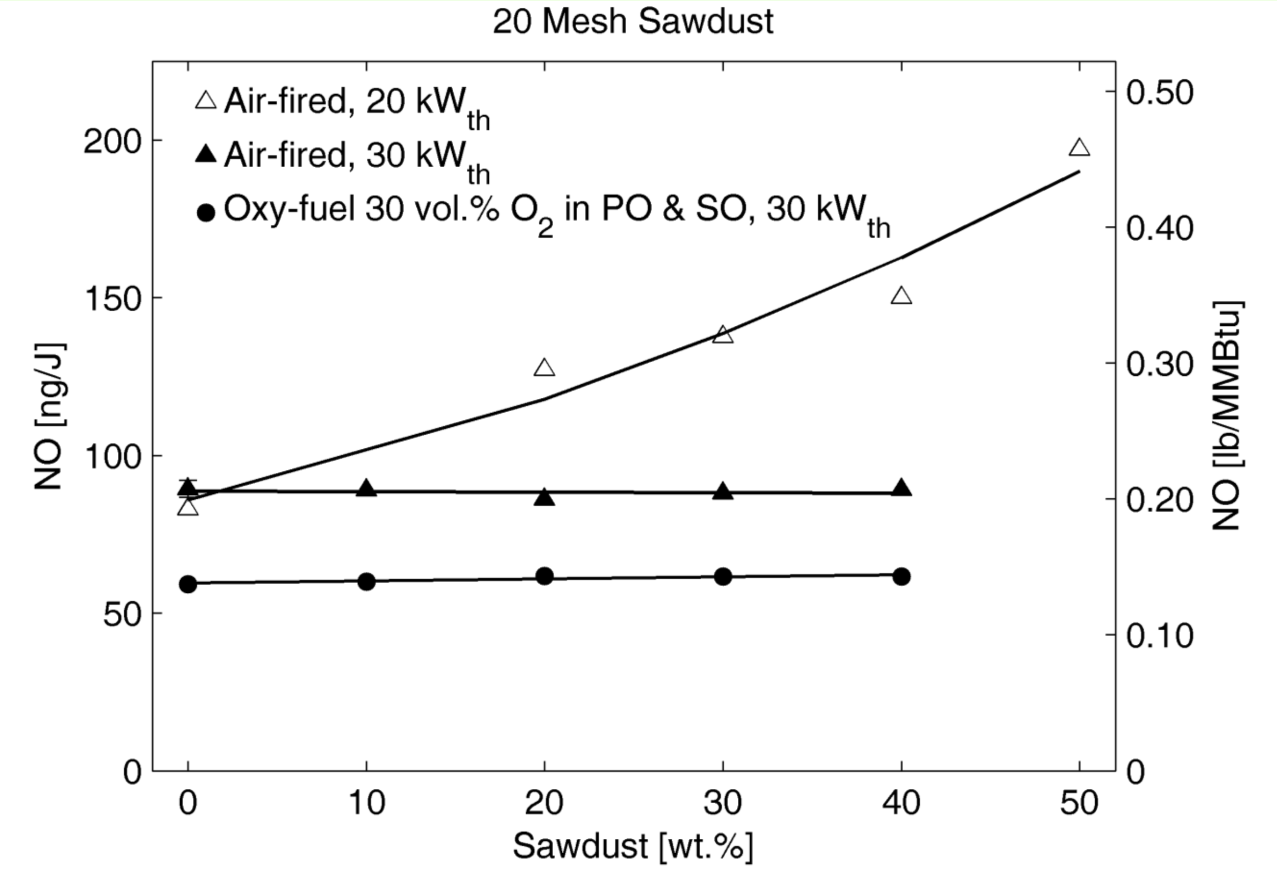
Vary PO and SO O_2

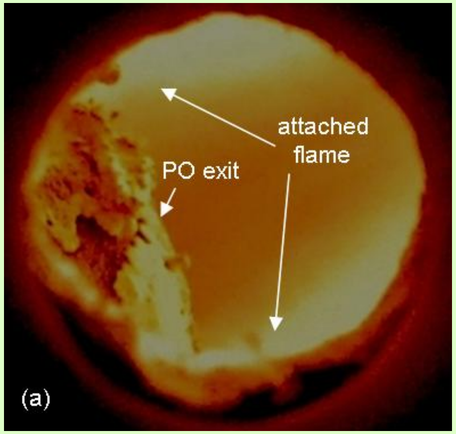
- 30 kWth
- Constant *T*ad
- Vary O_2 in PO and SO at constant flow rate
  - Variable λ_{PO}

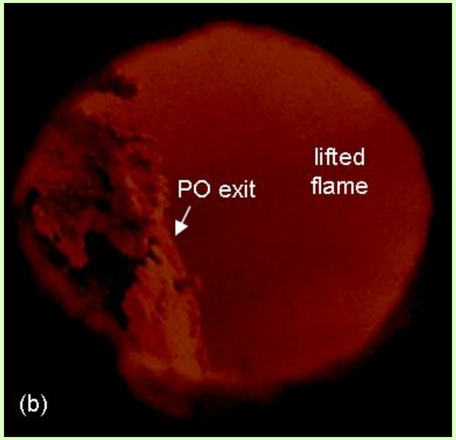




Sawdust Cofiring, 20 Mesh







Sawdust Cofiring, 50 Mesh