

Chemical Looping Gasification

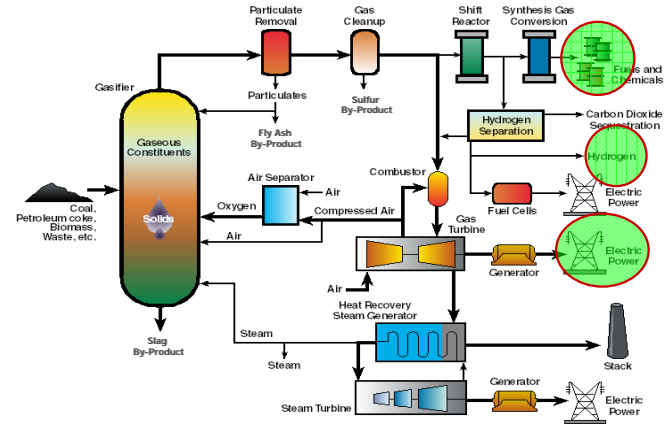
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Oct. 8th, 2008



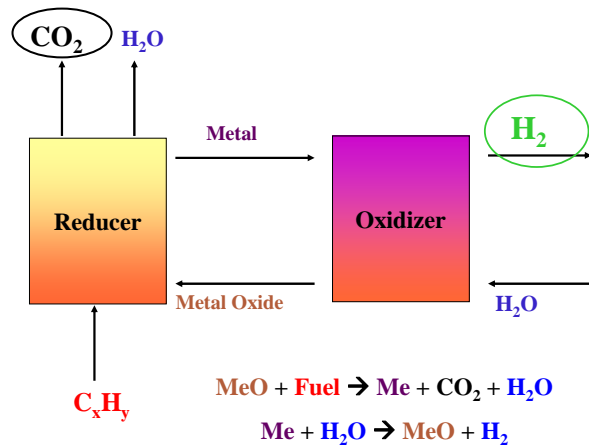
Background: Coal Gasification Technology



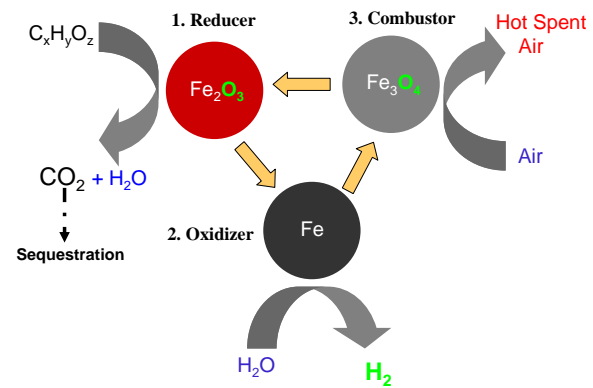
IGCC Efficiency: ~ 33% with CO₂ control

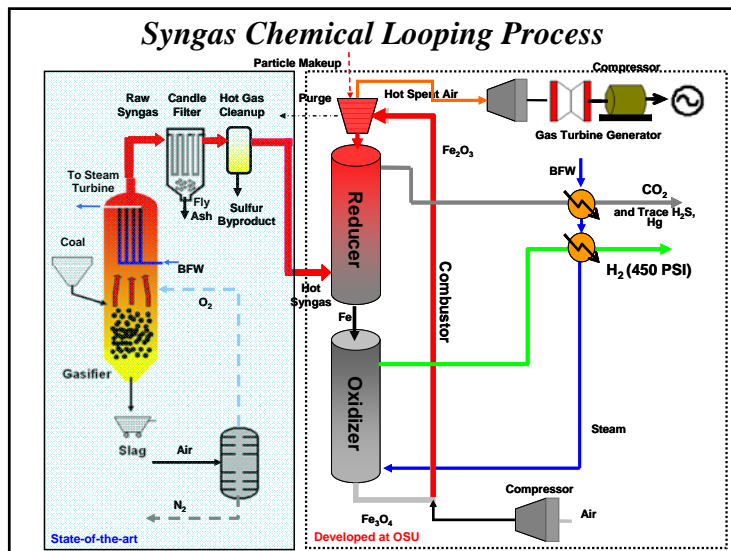
Steigel and Ramezan, 2006

Chemical Looping Gasification – Basic Concept

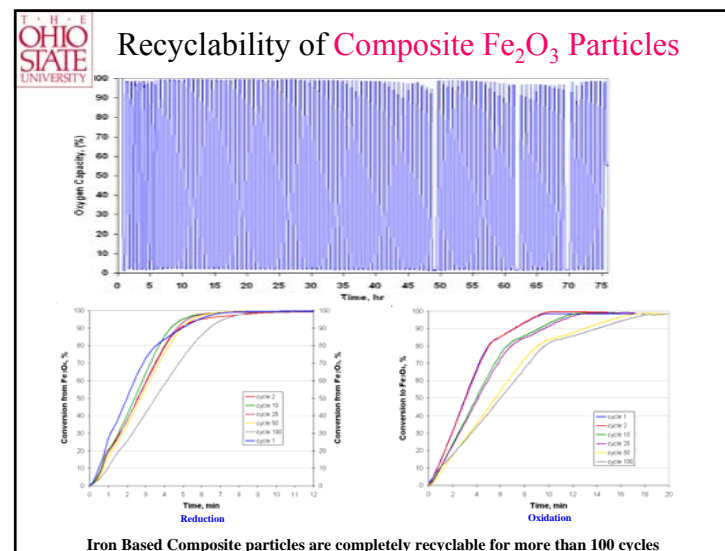
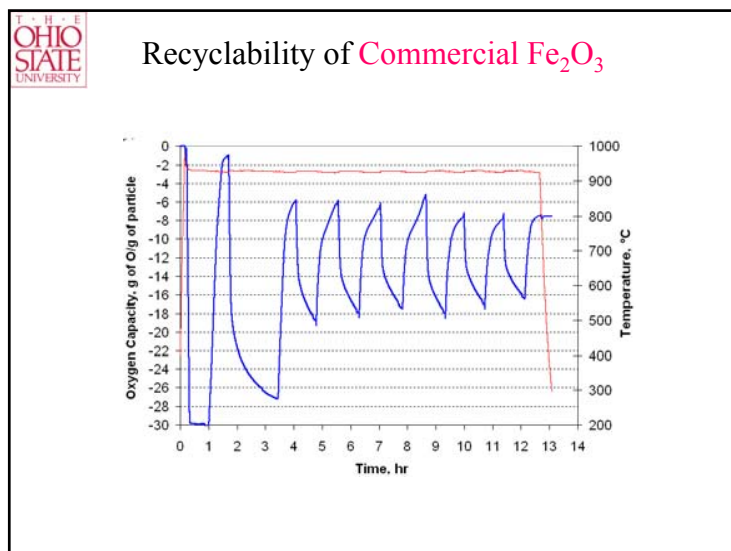


Syngas Chemical Looping (SCL) Concept





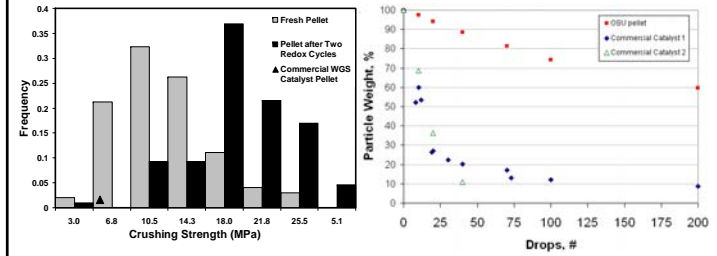
Oxygen Carrier Performance



Pelletization



Pellet Strength: Crushing Strength Test and Dropping Test (ASTM D4179)

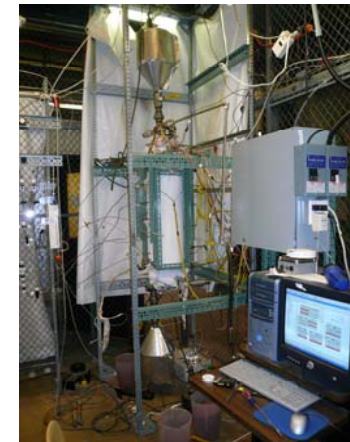
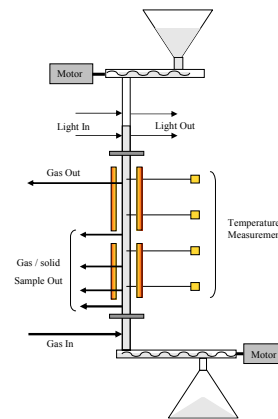


OSU Composite Pellets have significantly higher strength than commercial catalyst particles

COST: ~ \$600/ton (2006 dollars)

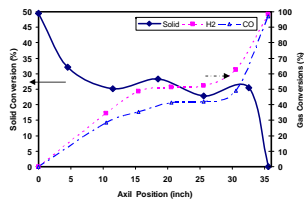
SCL Process Demonstrations

2.5 kW_{th} Bench Scale Moving Bed



Moving Bed Studies – Reducer Operation

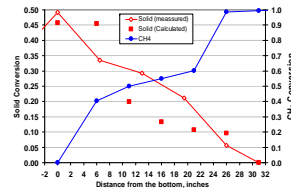
Syngas Experiment
(Reducer operation)



Nearly 100% conversion of syngas achieved

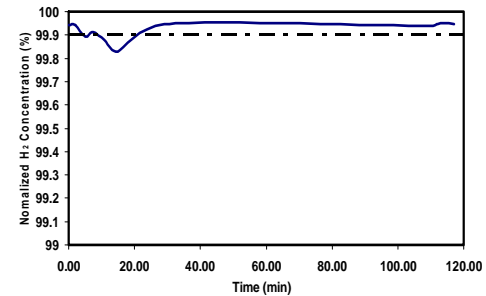
Syngas, Methane, and Other Hydrocarbons Can be Fully Converted to CO₂ and H₂O in SCL Reducer

CH₄ Moving Bed Experiment (Liquid Fuel Synthesis test)



Nearly 100% conversion of CH₄ achieved

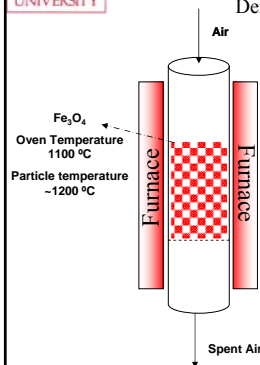
Moving Bed Studies – Oxidizer Operation



Solid is fully regenerated to Fe₃O₄, H₂ with an average purity of >99.95% is generated

Fixed Bed Studies

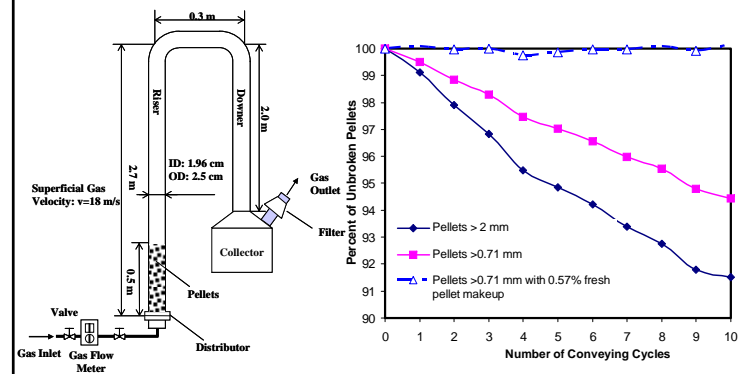
Demonstration of the Combustor



Significant temperature increase observed, particle found to be still reactive after being exposed under proposed combustor operating conditions (> 1200 °C)

Composite Particle Can Sustain 1200 °C

Pellet Strength: Attrition Test



0.57% fresh pellet makeup is sufficient

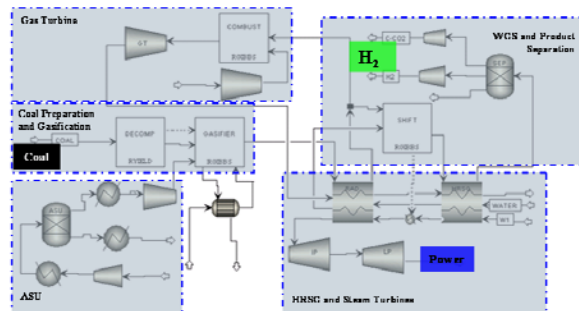
Simulation Studies



ASPEN® Simulation Common Assumptions

- A 1000 MWt (HHV) GE/Texaco is considered
- Carbon regulation mandates > 90% carbon captured
- The H₂ coming out of the system is compressed to 30 atm for transportation while the CO₂ is compressed to 2000 psi for geological sequestration
- No heat loss is assumed, heat can be integrated with a 100% efficiency
- The isentropic efficiencies is 0.83 for compressors, 0.86 for LP steam turbines, 0.88 for IP steam turbines, and 0.9 for gas turbines
- The energy consumption of PSA and sulfur removal units are provided by the low grade steam discharged from steam turbine
- **Performance data obtained from bench scale unit is used for looping simulations**

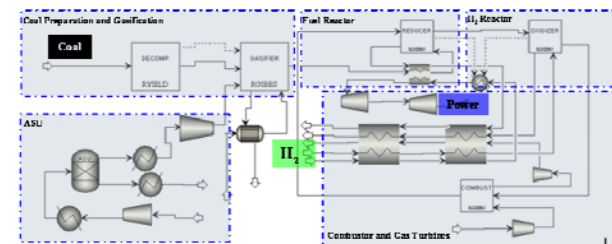
Traditional Coal to Hydrogen Process



Assumption used is similar to those adopted by Mitretek Systems in their report to USDOE/NETL*.

* Gray D. and Tomlinson G. Hydrogen from Coal. Mitretek Technical Paper. DOE contract No: DE-AM26-99FT40465. (2002)

Syngas Chemical Looping Process



Practical factors that are taken into account in the simulation:

- Pressure drop of the major chemical looping units,
- Energy consumption for particle transportation
- Energy loss due to the purging of the particles

The simulation results represent a very conservative estimation of SCL performance based on current demonstration outcome



ASPEN® Simulation

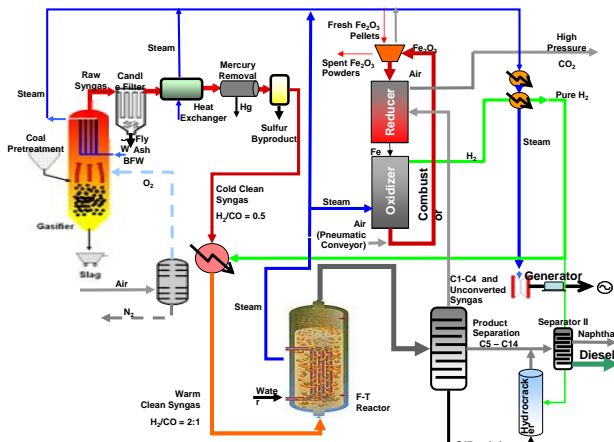
Comparison Between SCL and Traditional Coal to Hydrogen/Electricity Process

	Conventional Max H ₂	Conventional Co-Production	SCL
Coal feed (ton/hr)	132.9	132.9	132.9
Carbon Captured (%)	90	90	100
Hydrogen (ton/hr)	14.20	12.36	14.24
Net Power (MW)	0	38.9	66.2
Efficiency (%HHV)	56.5	52.69	63.12

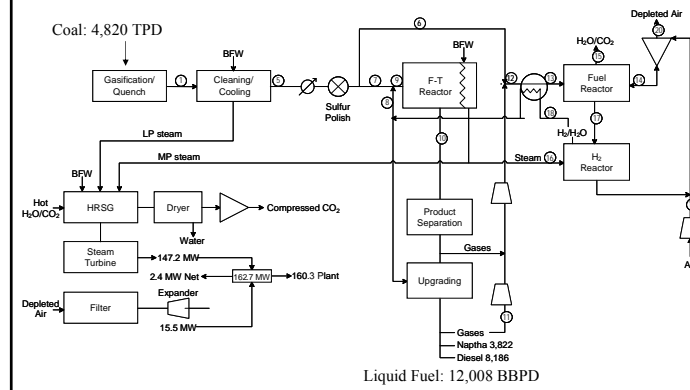
SCL process can increase the efficiency of State-of-the-art coal to hydrogen process by 7 – 10%

Coal to Liquids Applications

Syngas Chemical Looping in CTL Applications



Process (ASPEN) Simulations



Source: Noblis Systems

2.5 Bbl Fuel/Ton of Coal

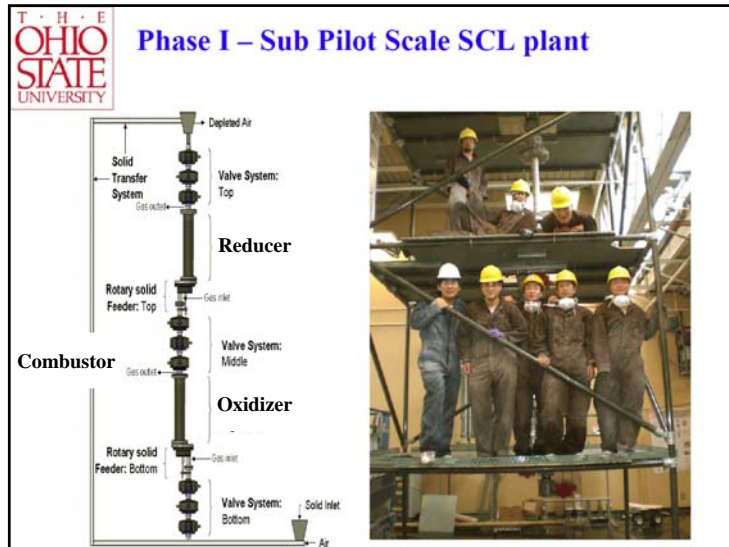
**Chemical Looping Process
in a Coal-to-Liquids Configuration**
DOE/NETL-2008/1307



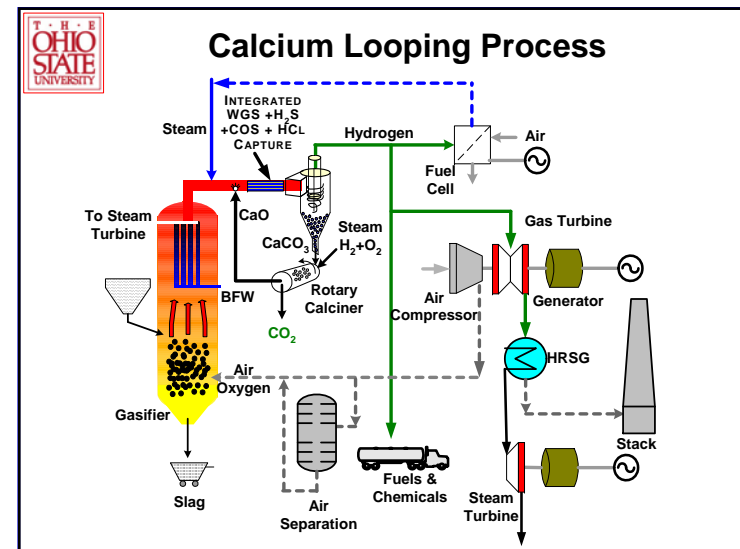
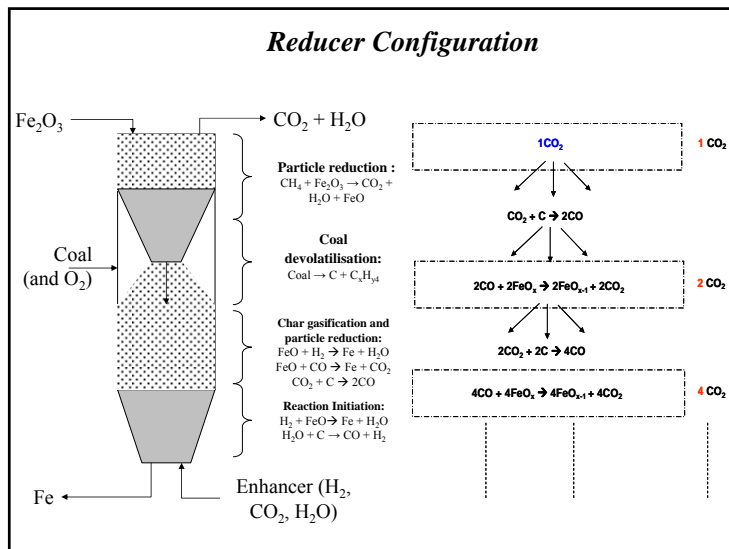
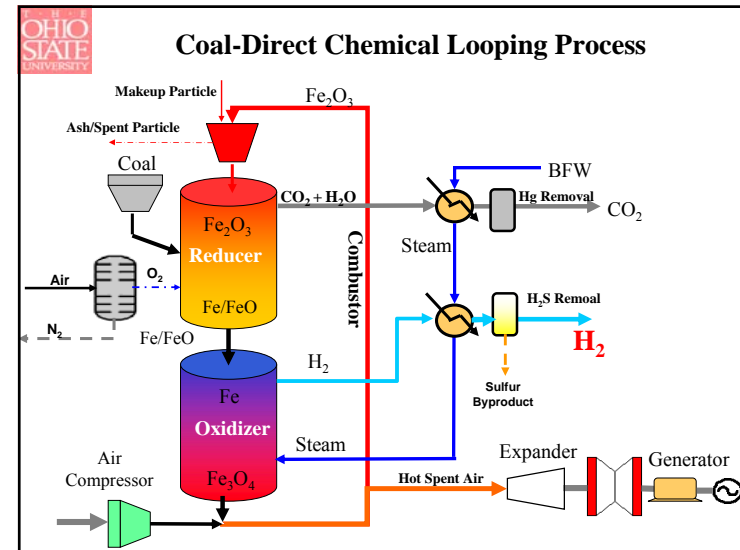
Independent Assessment
of the Potential of the Chemical Looping in the Context of a
Fischer-Tropsch Plant

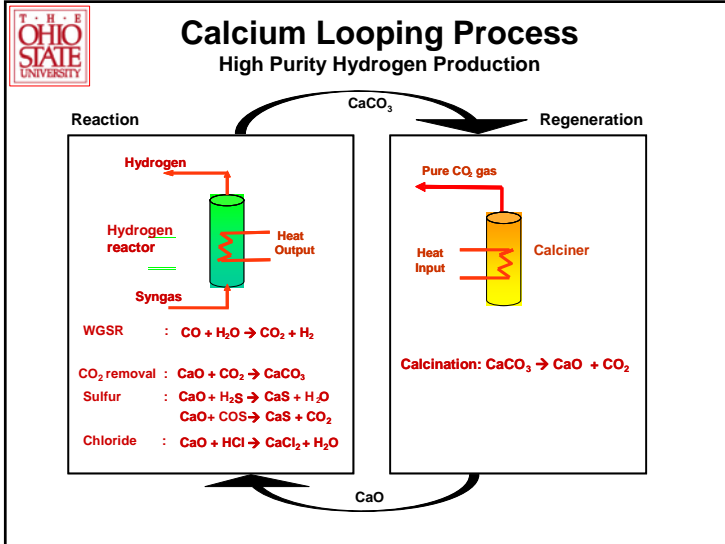
Conclusions: Overall, the Chemical Looping system proposed by OSU has the potential to significantly (~10%) increase the yield of the state-of-the-art Cobalt based F-T process and allow more efficient heat recovery and much lower (~19%) carbon emissions.

Sub-pilot Scale Demonstrations



Other Chemical Looping Gasification Processes





CCR Process

Use of metal oxide (CaO) in a reaction based capture/regeneration system

Carbonation: $\text{CaO} + \text{CO}_2 \rightarrow \text{CaCO}_3$

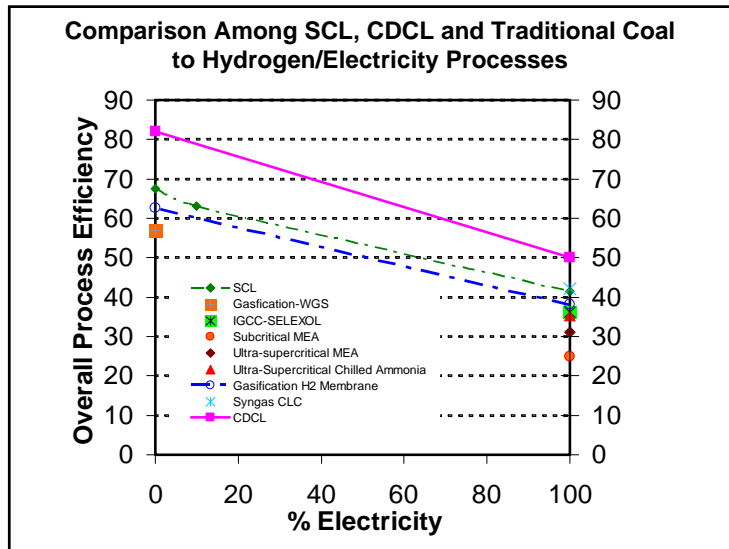
Calcination: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$

Advantages of Carbonation/Calcination Reaction (CCR) Technology

- Operation under flue gas conditions
- High equilibrium capacities of sorbent
- Use of sorbent can achieve low equilibrium CO_2 concentrations
- Regenerative cycle produces pure CO_2 stream



Concluding Remarks



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Acknowledgements

- **Ohio Coal Development Office (OCDO) of the Ohio Air Quality Development Authority (OAQDA)**
- **USDOE**

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Questions ?