Air-blown Gasification for Ammonia Poly-generation Using Low-rank Coals

for Presentation at

October 12-13, 2009

Abstract and Goals of Presentation

- Historically, ammonia is produced from a methane reforming process with CO to H2 shift reaction, nitrogen addition and gas to ammonia synthesis
  - ✓ Gasification eliminates the methane reforming process
  - ✓ 2-stage air-blown gasification produces syngas with nitrogen to hydrogen ratio close to that required for ammonia synthesis (after a CO to H2 shift)
- 2-stage air-blown gasification allows for split gas streams
  - ✓ optimizes the gas to ammonia synthesis and provides a syngas stream for power generation
  - ✓ CO2 capture from conventional CO to CO2 shift provides CO2 for EOR or for urea production.
- Presentation reviews the process design and options for project implementation
  - ✓ Flow chart for an example system and approximate costs will be included.

EPIC Business Overview

- Privately held US corporation with 25% held by Peabody Venture Fund, subsidiary of Peabody Energy (NYSE - *BTU*)
- Headquarters – Houston, Texas
- Supply fuel gas as a replacement for higher-priced and restricted fuels for the clean & efficient production of various end-use products
- International and large, multi-facility corporate clients – license and/or special contractual relations (BOT, etc.)
- US Market - Build, own and operate fuel gas production facilities on customer site

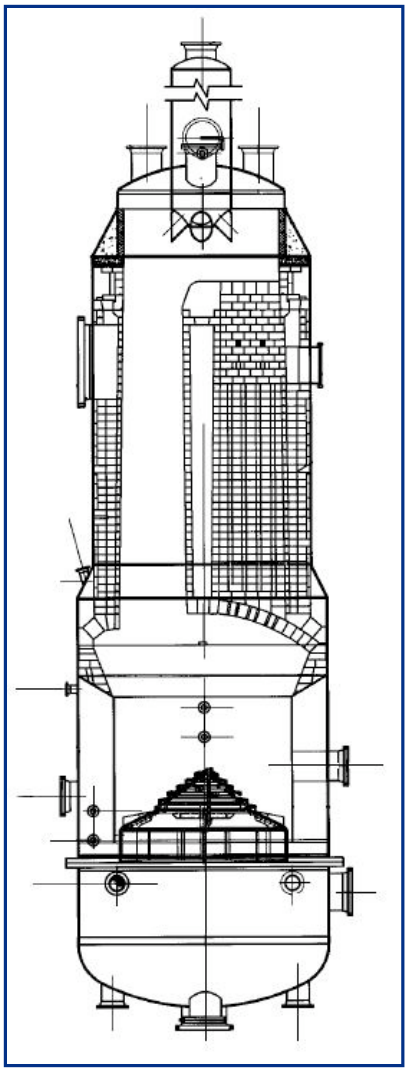
Burns & McDonnell Business Overview

- 111 years in Kansas City
- Safety Driven Organization
- 100% Employee-Owned
- 3000+ Employee-Owners
- 2008 Revenues $1.1 Billion
- 2009 Fortune Magazine

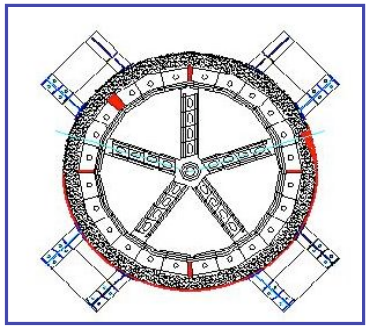
  "100 Best Places to Work" (50)
- Zero Debt

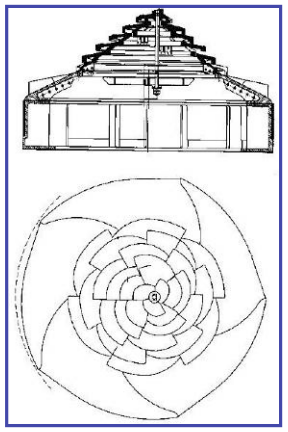
The Gasifier

Fixed Bed – EPIC EJ2ST-3.6HP



- Evolved from fixed-bed, dry-bottom gasifiers in operation for >50 years
- Designed to produce fuel gas and syngas for ammonia related processes
- Air as primary oxidant but O_2 enrichment is possible
- Overall vessel elevation at left and cross-section through refractory below





EPIC's Air-blown Gasifier and Gasification

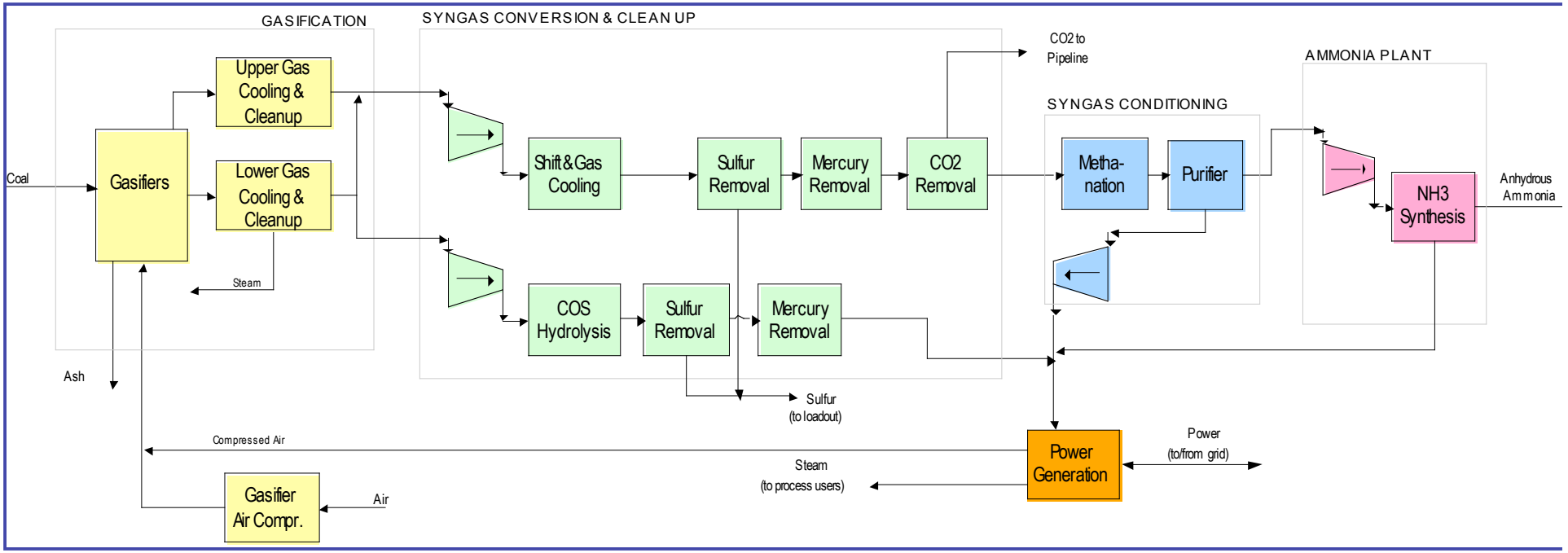
5 operating gasifiers installed in 1992

Refractory after 10+ years of operation

Rugged cast steel grates with individually replaceable leaves

- Individual gasifiers typically run 18+ months between shutdowns
- Multiple gasifiers lead to high availability and reliability
- Individual gasifiers - stable operation from 100% to 35%

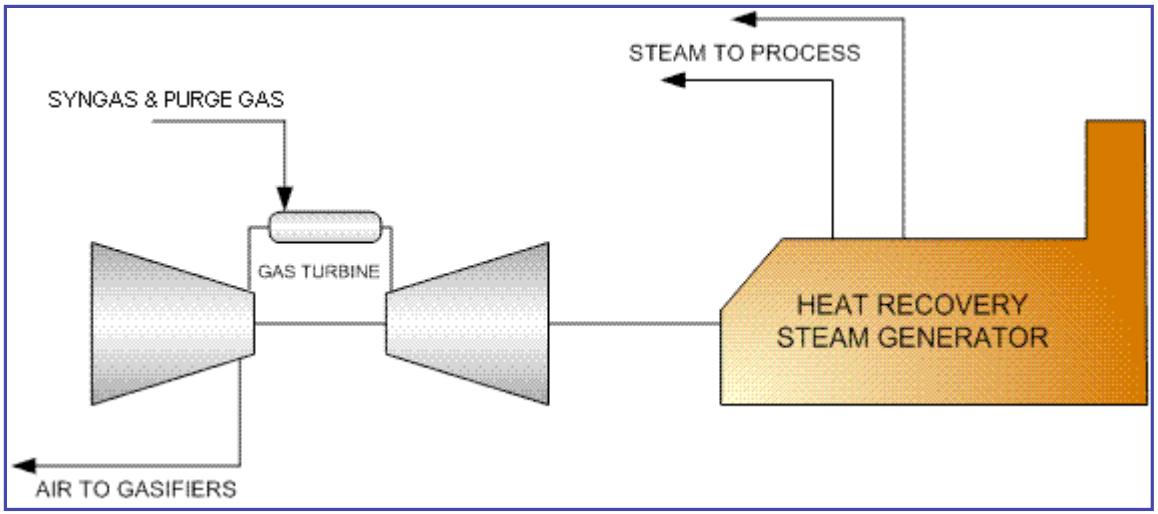
Overall Process Block Flow



Environmental Aspects of EPIC Gasification – Sulfur Removal

Simple, one-step H_2S removal up to >99%

Power Block



- Frame 6B GTG used – larger units are possible
- Firing combination of syngas and purge gas
- Compressed air to gasifiers
- Some additional power/steam possible with higher supplemental firing rates

Plant Performance Summary

ITEM	
INPUT	
Coal Feed (PRB), stpd	1,700
PRODUCTS	
Ammonia, stpd	720
Sulfur, stpd	10
CO_2, stpd	1,910
POWER	
Gross Power, kW (ISO)	42,000
Plant Aux. Load, kW	(41,100)
Total Net Power, kW	900

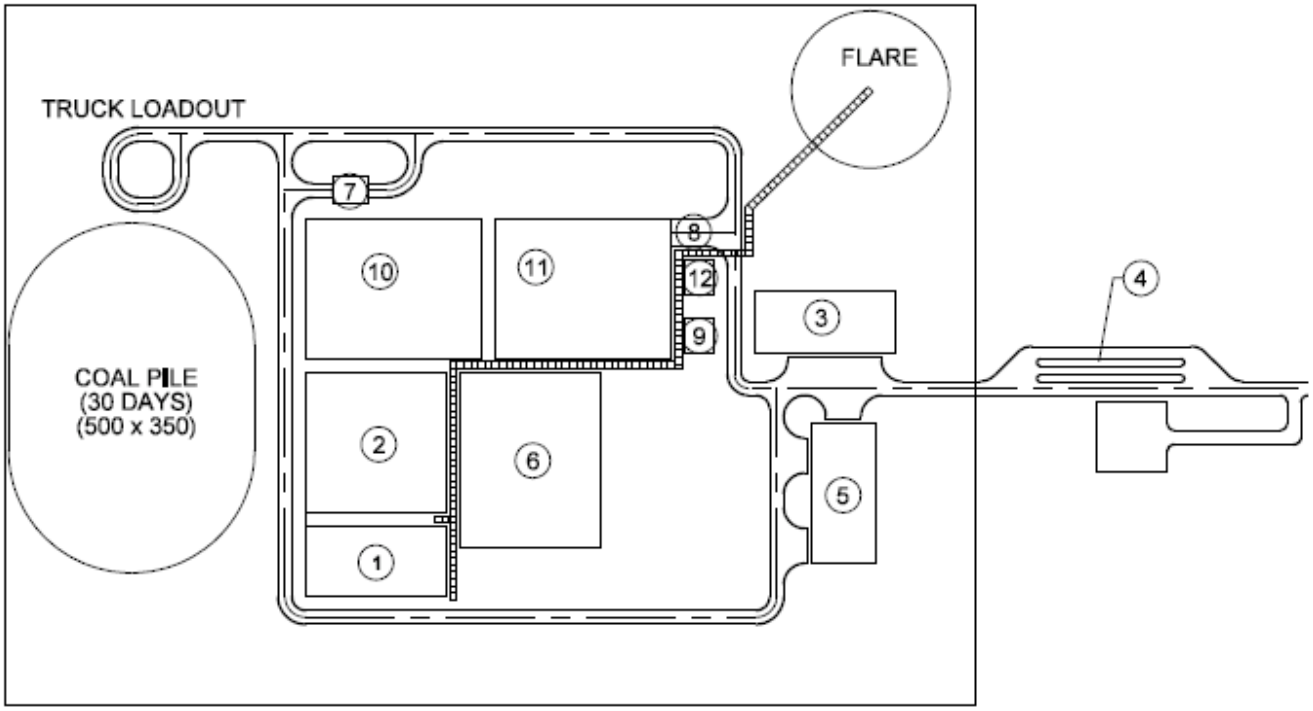
CO_2 compression not included in auxiliary load estimate.

- **Designed to be power "neutral"**
- **Can be optimized with condensing/extraction steam cycle**

Overall Plant Layout

KEY NOTES:

1. POWER BLOCK & SWITCHYARD
2. WATER TREATMENT PLANT
3. CONTROL CENTER/ADMINISTRATION
4. GATEHOUSE AND WEIGHBRIDGE
5. WAREHOUSE
6. AMMONIA PLANT
7. ASH LOADOUT
8. SULFUR LOADOUT
9. METHANATION AND PURIFIER
10. COAL GASIFICATION
11. SYNGAS CLEANUP
12. CO2 COMPRESSION



Capital and Operations Costs

Capital Cost Estimate

(2009$)

ITEM	($MM)
DIRECT COSTS	
Procurement / Construction	320
INDIRECT COSTS	
Engineering, CM, COP	180
TOTAL EPC	**500**
OWNERS INDIRECTS *	
Owners cost (inc. contingency)	100
TOTAL PROJECT COST	**600**

- *Owners costs do not including financing, IDC, taxes.*
- *Initial estimate range +15% -35%*

Operations Cost Estimate

(2009$)

ITEM	
ASSUMPTIONS	
Capacity Factor (%)	90
Gasifiers	3+1
FIXED COSTS ($MM) Annual	
Personnel, Admin, Other	11
VARIABLE COSTS ($MM) Annual	
Equipment Maint., Catalysts, Chemicals, Water	7
TOTAL OPEX ($/annual ton product)	**76.00**

- *Opex costs do not include water supply costs, fuel, standby electrical power, taxes, insurance.*

Carbon Issues in Ammonia Production

Energy source	Process	CO2 emissions (st/st ammonia)
Natural Gas	Steam reforming	1.76
Naphtha	Steam reforming	2.75
Heavy fuel oil	Partial oxidation	3.3
Coal	Partial oxidation	4.18

Source – International Fertilizer Industry – Fertilizers, Climate Change and Enhancing Agricultural Productivity Sustainability – July 2009

Low rank coal	Partial oxidation	1.3*

* Includes carbon capture and CO2 use in EOR

Conclusions

- Superior ammonia synthesis performance and efficiency
- Low emissions approach to making ammonia from coal
- Air-blown gasification is proven to be environmentally and economically and viable for ammonia and fuel gas applications
- EPIC gasification:
  - ✓ Proven technology for ammonia production
  - ✓ Offers significant cost stability over natural gas based systems
  - ✓ Simple operation
- The use of air-blown gasification could provide a new standard for ammonia production in the US and other parts of the world.

Author Contacts

Econo-Power International Corp.
1502 Augusta, Suite 425
Houston, TX 77057
Telephone 713-979-5191
Fax 713-979-5322
Website – www.epic-power.com
David W. Wakefield – President
(email dwakefield@epic-power.com)

Burns & McDonnell Engineers
9400 Ward Parkway
Kansas City, MO 64114
Telephone (816) 822-3899
Fax (816) 333-3690
Website – http://www.burnsmcd.com
James A. Jurczak – Director- Gasification Projects
(email jjurcza@burnsmcd.com)