Developing Gasification Projects in a Difficult Environment

by

Conrad Anderson
Madison Power Corp

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Worldwide Gasification in 2007

Coal (55%)
Heavy Oil (33%)
Natural Gas (8%)
Petcoke (2%)
Biomass (2%)
- Energy crops
- Ag waste
- Wood waste

Gasification and Clean-Up

Steam CO₂ Slag Sulfur Mercury

“Syngas” (H & CO)

Chemicals, Fertilizer, Natural Gas (45%)
Fisher-Troppes Liquids (28%)
Electric Power (19%)
Gaseous Fuel (8%)

CC Plant

Source: Gasification World Database 2007; NETL, USDOE
Worldwide Syngas Capacity Operating in 2007

Worldwide Syngas Capacity:  $56,238\text{ MW}_{th}$
- 144 operating plants
- 427 gasifiers

- South Africa  27%  (97 gasifiers)
- China  24%  (44 operating plants)
- Europe  24%  (50 operating plants)
- North America  14%  (20 operating plants)

Source: Gasification World Database 2007; NETL, USDOE
Gasification Market Drivers

1. Escalating and fluctuating price of natural gas*
   - Periodic Price Spikes: to $9/10^6$ Btu in January, 2001
to $12/10^6$ Btu in Winter, 2006

3. Projected availability and low cost of refinery residuals (petcoke; heavy oil; asphalt) due to anticipated decreasing quality of crude oil

4. Opportunity to sell CO$_2$ for enhanced oil recovery (EOR) in west Texas, Gulf Coast, California, and elsewhere

5. Cancellation of several conventional coal projects
   (over 40 projects and more to come)

*Source: Gasification World Database 2007; NETL, USDOE
Gasification Market Hurdles

1. Inflated cost of fabrication, design, and constr of large projects
   - 2004 to 2007: 30% to 40%

2. Uncertainty of meeting expected future CO₂ emission regs
   - $5 to $40/ton of CO₂ (excluding comp & sequestration)

3. Unavailability of cost and performance guarantees from EPC contractors while they are so busy
   - Makes financing difficult

*Source: “Rising Utility Construction Costs: Sources and Impacts”; Brattle Group; September, 2007"
Four Gasification Projects
under Development by Steelhead Energy

Steelhead Energy: Owned by ArcLight Capital (Private Equity)
Managed by Madison Power Corp

1. **Phased IGCC Project** on the Illinois River (Petcoke/Illinois Coal)
2. **SNG Project** on the Illinois River (Petcoke/Illinois Coal)
3. **Heavy Oil Polygeneration Project** at a Refinery on Gulf Coast
4. **Heavy Oil Upgrading and Syngas Refueling Project** for a large oil company in California
Phased IGCC Project in Illinois

- Recycled Water
- HP Steam
- Water
- CO₂
- Clean Decarbonized Syngas
- Sulfur Recovery
- H₂S
- Steam
- N₂ to CTG or Vent
- Liquid By-Products for Sale
- O₂
- N₂
- Argon
- Barge or Rail Delivery
- Petcoke/Coal
- Air
- O₂
- Hg
- Slag
- CO → H₂ Shift
- Acid Gas and CO₂ Recovery
- STG
- Natural Gas Pipeline
- Evap Cooler
- CTG
- HRSG with SCR
- Switchyard
- Comm Ed 345 kV Line
- approx 4 miles
- approx 8 miles
- HP Steam
- N₂ to CTG or Vent
- Duct Firing
- Natural Gas (approx 8 miles)
- Condenser
- O₂
- Argon
- Air Separation Unit
- Petcoke/Coal Slurry
- Gasification Island
- Petcoke/Coal
- Natural Gas (approx 8 miles)
- Natural Gas Pipeline
- Madison Power
- -7-
Levels of Carbon Capture and Sequestration (CCS)

No CO₂ removed

Coal → Slurry Feed

Petcoke

Recycled Water

Gasification Island

Slurry

Particulate Free Syngas

O₂

Slag → Hg

Air → ASU

N₂ to CTG’s

Vent

Level #1

(No CCS)

Acid Gas Rec. (AGR)

Clean Syngas to CTG

Sulfur Recovery

CO₂ (25% removed)

(No Shift)

AGR

To CTG

Sulfur Recovery

CO₂ (50% removed)

Partial Shift

Steam

[CO + H₂O → CO₂ + H₂]

“Partial” Shift

AGR

To CTG

Sulfur Recovery

CO₂ (90% removed)

Max Shift

Steam

AGR

To CTG

Sulfur Recovery

Particulate Free Syngas

Recycled Water

Sulfur Recovery

Sulfur Recovery

Sulfur Recovery

Sulfur Recovery
IGCC Options

1. Repowering existing CC plant vs. greenfield development
2. Phased installation: simple cycle vs. combined cycle vs. IGCC
3. Energy Storage to maximize on-peak generation and sales
4. Extent of sulfur removal
5. Redundant gasifier capacity
6. Percent CO₂ capture and sequestration
7. Dry cooling to minimize water consumption
8. ASU by-product sales (LIN, LOX, LAR)
9. Sulfur product: elemental sulfur vs. sulfuric acid
10. Extent of compressed air integration
SNG Project in Illinois

**Notes:**
1. Based on a HHV of 14,000 Btu/lb for Pet Coke.
2. Cold gas efficiency (fuel to SNG) = 67%.
Heavy Oil Polygeneration Project at a Refinery in Louisiana

Heavy Oil from Refinery

Gasifier -> High Temperature Heat Recovery

Sulfur, CO₂

Acid Gas Recovery

Membrane Separator

H₂

Pressure Swing Absorber

Off-Gas

99.9% H₂ to Refinery

Combined Cycle Plant

To Refinery

Power

Auxiliary Power

Power Grid

By-product sales

O₂

Air

ASU

H₂, CO₂

HP Steam

N₂ (diluent)
Heavy Oil Upgrading and Syngas Refueling Project for an Oil Company in California

Heavy Oil Field → H.O. Upgrader → Light Oil to Refinery

Steam for EOR → Light Oil to Refinery

CO₂ for EOR → Gasifier and Clean-Up → Residual

Air → ASU → By-product sales

Light Oil Field → Light Oil to Refinery

Water → CO Shift

Sulfur → AGR

90% H₂ → Natural Gas Distribution Line

CH₄ → Boiler Fuel

Steam for EOR

Boiler Fuel → Light Oil to Refinery

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