

Barriers and Opportunities Relating to the Production of Coal Liquids and its Environmental Issues

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Introduction

Often asked: If CTL is commercial, why should we put tax dollars into further research?

Some considerations:

- It is common practice to put federal money into areas with available commercial technology to improve and facilitate deployment
- This should be particularly true for areas of national strategic importance
- Commercial technologies are mostly well protected and open research can expedite deployment and develop skills
- Major FT players continue to invest in R&D. This is indicative of a continuing need for R&D – especially “open” R&D

Context/Considerations

Accept as background:

- Need for liquid fuels to meet projected growth
- Growing crude imports and strategic concerns
- High crude prices
- Favorable coal reserves
- Uncertain time line for H₂ economy
- EPAct 2005 provided initial incentives
- CTL fuels have superior performance and environmental characteristics

Coal Conversion

Focus here on Indirect Liquefaction of coal (CTL)

- Gasification to produce syngas (H_2 with CO)
 - Syngas to fuels (Indirect Liquefaction)
 - Syngas to chemicals, including methanol, DME
 - Syngas to hydrogen
 - Syngas to synthetic natural gas (SNG)
- Direct coal liquefaction
- Co-production (“poly-generation”)

Note: Fischer-Tropsch (FT) is common for CTL and natural gas to liquids (GTL) – even biomass: “XTL”

Here: CTL = Gasification + FT

(i.e. FT does not include gasification)

Sasol CTL Plants At Secunda ~ 1985



Initial capacity: 2 x 50,000 bbl/d; Now 160,000 bbl/d total

Then 40% of SA's fuel needs; now 28%; Site ~ 3,200 acres

Construction work force 28,700; 250 million man-hours.

GTL

- **Mossgas (now PetroSA) (1992)**
 - Natural gas based; State owned
 - Original capacity ~16,000 bbl/d ;Sasol FT technology
 - Cost ~ \$90,000 per daily barrel
 - Commissioning a 1,000 bbl/d Slurry Bed Reactor with Statoil
- **Shell Bintulu (1992)**
 - Natural gas based
 - Original capacity ~ 14,700 bbl/d
 - Cost ~ \$50,000 per daily barrel
- **Sasol/Qatar (2006) 34,000 bbl/d**
 - Cost ~\$30,000 per daily barrel: Inaugurated 6/06
- **Development projects**
 - Syntroleum, Rentech, BP and others

Sasol GTL Oryx Project in Qatar



- Two reactors 60 m high, 10 m diameter; @ 2,200 tons
- Project expansion to add 66,000 bbl/d fuels and 8,500 bbl/d lubricants

Summary of CTL Status

Commercial CTL

Only in South Africa: until 2005 plants at Sasolburg and Secunda,
In 2005 Sasolburg changed to natural gas

More significant CTL proposals

Sasol: Projects for two 80,000 bbl/d plants in China approved and continuing

WMPI (USA, PA) 5,000 bbl/d in pre-financing stage

Several Rentech proposals

Gasification

Well known internationally and being developed further for IGCC

FT developments (including GTL pilot plants)

Many companies, few commercial; others have pilot units up to 300 bbl/d e.g. BP, ConocoPhillips, ExxonMobil, Statoil, ENI and Partners, Syntroleum, Rentech etc

CTL Economic Considerations

CTL capital investment (Sasol 2006)

- For 50,000 to 80,000 bbl/d green field cost \$60,000 to \$80,000 per daily barrel
(Note: GTL ~\$30,000/dbbl)

Operating costs

- Total ~\$35-40/bbl crude equivalent price or \$45 – 50 finished products
- Very dependent on location and structure of the project

Yields

Two bbl (finished product) per ton a rule of thumb.
i.e. for 80,000 bbl/d about 15 million t/year coal

Southern States Energy Board Study

- Completed July 2006
- Comprehensive analysis of US energy security at <http://www.sseb.org/AES/AES.htm>
- Data for CTL: Capital required
 - 10,000 bbl/d: \$87 - \$128k/dbl (\$0.87-\$1.3Bn)
 - 30,000 bbl/d: \$72 - \$98k/dbl (\$2.16 - \$2.9Bn)
 - 60,000 bbl/d: \$62 - \$72k/dbl (\$3.7 - \$4.7Bn)
- Oil equivalent diesel prices : \$34 to \$61/bbl (larger cheaper)
- Cost breakdowns given for 16 cases

Some Hurdles to CTL Commercialization

- Not insurmountable: can be done again; can make money
- Economic uncertainty and perceived high risk for high capital layout – even though less economical smaller plants might be the first ones in the US
- More plants required to obtain comfort for financiers
- Large companies reluctant to lead commercialization
 - Not yet a “Synfuels Industry” in the US
- Many studies done but inadequate data of actual plants available to validate economics
- Some lessons are only learnt at large scale
- Current shortage of skilled workers: engineers, scientists; workshop and construction capacities

CTL R&D Topics and Needs

Note: Gasification R&D not covered here

- Commercial concerns dominate at this time but multifaceted R&D can and will improve viability
- Open (non IP protected) R&D can be very significant
 - Establish a greater understanding of technological issues
 - Do credible and verifiable enabling research which companies often cannot do (many publications are deceptive)
 - Encourage pre-competitive and later competitive technologies
- CTL currently not a line item in DOE FE budget (but WMPI, Syntroleum and Headwaters recently selected/funded)
- Section 417 of EPLA of 2005 authorized \$85m for Illinois basin CTL – not funded yet. Next proposed step: 1/2 bbl/d test plant at CAER for fuels production and small scale testing by Coal Fuel Alliance members

R&D Needs - 2

- Existing FT catalysis R&D already extensive – a CTL plant involves much more than FT catalysis (10 -12% of plant capital) but still scope
- Catalyst/wax separation unresolved in the public domain for slurry bed reactors
- Integration issues an opportunity to bring capital costs down (can be 30-40% of plant capital)
- Improving syngas cleaning: combine separations into fewer steps with better efficiencies (“process intensification”)
- Modeling aspects: the FT system and the overall highly integrated production process with extensive utility and power generation options
- Complex physical properties of multiphase reaction systems at operating conditions

R&D Needs - 3

- Research on products for niche and bulk applications: DOD, aviation, automotive, chemical co-products
- Performance testing of fuels combined with FT optimization
- Integration of process and environmental research (CO₂)
- Water needs and effluent treatment; solids disposal
- Pursue innovative and unconventional options in parallel with the necessary incremental efficiency and economic improvements
- Learn by doing as well as by theoretical studies
- Invest in risky science and technology so that there will be new concepts to demonstrate in 5 to 10 years
- Doing R&D is a powerful way of developing human resources

Conclusions

- CTL has become increasingly viable and viability can be improved by more research
- Expected crude oil prices and trends support CTL
- Large facilities will get full economy of scale benefits and fuels are to provide base capacity - US will probably start smaller
- Initial unit costs will come down as technology develops and ripens
- The environmental superiority of products and CTL sequestration potential fit current thinking

Action

Step out and take on the challenges which the current circumstances offer us to use coal cleanly and efficiently:

Research and

Development and

Demonstration and

Deployment/Commercialization

➔ Accelerate the pace and act in concert