Structure

• Background and Terminology
• CTL - Characteristics and Status
• SNG - Characteristics and Status
• Economics
• Commercial Hurdles
• The Path Forward
Coal Conversion

• Combustion to produce steam/power
• Gasification to produce syngas (H\textsubscript{2} with CO)
  – Syngas to fuels (indirect liquefaction) - **CTL**
  – Syngas to chemicals, including methanol
  – Syngas to hydrogen
  – Syngas to synthetic natural gas - **SNG**
• Direct coal liquefaction (Not covered here: not commercial)
• Co-production (“polygeneration”)

*Note: Gas to Liquids (GTL) same as second part of Coal to Liquids (CTL)*
CTL and SNG

• CTL
  Coal to syngas (CO + H₂) and then syngas to liquids (fuels and/or chemicals)
  Second step called Fischer-Tropsch (FT) Synthesis

• SNG
  Substitute Natural Gas or Synthetic Natural Gas: Coal to syngas and then syngas to methane (natural gas)
Both require oxygen and steam to produce syngas

CTL produces a much wider range of products
- gases/liquids/waxes

SNG produces primarily methane (natural gas)
Status of CTL

Commercial
Only in South Africa by Sasol

Projects under consideration
Numerous studies at different stages of planning: many only early conceptual

More significant proposals
Sasol: China - Engineering in progress
WMPI (USA, PA) 5,000 bbl/d in pre-financing stage
Several Rentech proposals
FT (Liquids Synthesis)

Technologies differ:

- Catalysts and reactor types
- Product spectra
- Temperatures
- Stages of development
- Experience range from small pilot scale to large commercial scale

But: Proven technologies not readily accessible
Sasol CTL

- FT invented 1920’s
- South Africa saw opportunity in late 1920’s
- Developed pre WW II Germany
- Commercialized in South Africa 1955 and again late 70’s/early 80’s
- Other natural gas based ventures built and more in progress
Sasol

- Fuel products marketed at import parity $ prices; Chemicals marketed competitively internationally
- Government: loan guarantees and floor price
- All government support repaid in a short period – no net cost to taxpayer, no current special treatment
- Extensive expansions into chemicals and related products ongoing – highly profitable
- “Sasol Four” (Mafutha) in pre-feasibility phase
Sasol Secunda Plants ~ 1985

Initial capacity: 2 x 50,000 bbl/d, Then 40% of SA’s fuel needs, now 28%; Cost $6bn; Site 13 km² (~3,200 acres)
Two plants built sequentially with $500m saving
Construction work force 28,700 from 39 nationalities
250 million man-hours. Now 160,000 bbl/d
FT Diesel Fuels

- Primary product zero S, minimal aromatics
- Predominantly straight chain (high cetane number >70)
- Fuels fully compatible with existing fuels
- Suitable for aviation
- Emissions from diesel engines greatly superior to even CARB diesel performance
- Excellent blending stocks
FT Fuels

• Sasol experience of 50 years - >200 products; cumulatively >1.5 billion barrels of fuel

• Primary international need now diesel fuel
  (Note: USA 4.3% higher now than ’04)

• Large scale tests were/are done
  – Shell, Sasol and Syntroleum products - VW- Berlin, Bus London, California trucks, Daimler-Chrysler and others
  – Jet fuels
  – Superior emissions performance
Sasol Qatar Oryx Project (GTL)

- Commissioned 2007 at 34,000 bbl/d
- 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
SNG

• Technology well understood but commercially only applied in a few cases
• Economics “evasive”
• Reaction (methanation)
  $$\text{CO} + 3\text{H}_2 \rightarrow \text{CH}_4 + \text{H}_2\text{O}$$
• Gas very clean
• Potential co-products from gasification
Great Plains SNG Plant ND

6 m ton per year lignite and 160 million scf/d SNG per day. Reliability >98.7% since 1984; sell various chemicals and sequester up to ~5,000 t/d CO₂ in EOR in Canada
Great Plains SNG Plant
Economic Drivers

• Strategic considerations - more self-sufficiency and greater flexibility in supply/demand
• High crude prices
• Increasing cost of alternative ways to meet environmental performance specs of fuels
• Environmental opportunities – CO$_2$ sequestration capable and environmentally superior fuels
• Progress with gasification for IGCC
Economics

• Distinguish between actual (real) costs and paper studies
• Real costs hard to get by and very site and configuration specific - what is in/what is out?
• Usually no incentives for operating companies to provide data
• Escalation and scale factors can mislead
• Pre-investment for additional options - caution
• Lego-block estimates can be deceptive
• Plant integration, utilities and infrastructure integration critical
Economics

Operating costs: Location specific

- Infrastructure available in and outside of plant
- Site/town development, accessibility, roads, water
- Local labor and skills – construction and continuous operation
- Coal availability and cost
- Marketing (CTL and SNG)
- Manufacturing/workshop capabilities and capacities
- Financing structure and potential liabilities
- Insurance regime and options
- Fiscal regime
Economics

Operating costs: Products

– Product spectrum - market driven: defines choice of reactors/processes
– Extent of product work-up/refining
– Specialized products: marketing lag and risks for market penetration
– Take-off contracts
– Realizing expected fuel quality premiums
– Impact on capital costs
Economics: Process Factors

Some inter-dependent elements:
- Syngas production (H₂/CO), P, purity
- Syngas conversion system
- Product work-up: aqueous and hydrocarbons
- Process integration: steam, fuel gas etc
- Start-up
- Catalyst replacement and/or make-up
- Turn-down ratio
- Instrumentation and control
- Scale critical for work-up economics
Economics: CTL Costs

CTL capital investment (Sasol 2006)
• For 50,000 to 80,000 bbl/d (2 to 3 million tons/yr) green field cost $60,000 to $80,000 per daily barrel
  (Note 1: GTL ~$30,000/dbbl
  Note 2: 2007 above roughly 50% higher)

Operating costs (~2004)
• About $5/bbl for coal at $10/ton
• Cash plant costs (catalysts labor etc) ~ $10/bbl

Owner’s costs depend on financing packet and commercial conditions

CTL yields: About 2 barrel/ton of coal, depending on coal, i.e. for 80,000 bbl/d about 15 million t/year coal
Some Hurdles to Commercialization

Hurdles are not insurmountable: has been done, can be done and can make money

- Little generic design data available – site and project specifics determine economics
- High capital investment for economy of scale
- General economic uncertainty and perceived high risk for high capital layout
- More plants required to give comfort to investors and financiers (“I’ll build the next plant”)
More Hurdles

- Large companies reluctant to lead initiatives for commercial deployment - Potential owner-operators scarce
- Uncertainties and scepticism about products
- Perceived risks
- Environmental claims doubted – CO₂ issues
- CTL and SNG: Coal perceptions, but coal can be clean
Looking Forward

- CTL and SNG made big strides in technology and cost reductions, e.g. new large FT reactors
- Chemicals may be attractive - needs large scale for economy of scale - fuels (CTL and SNG) to provide base capacity
- Co-production ("polygeneration") can improve viability but beware of added complexity
- Technologies available, but further development will improve the economic viability
- Energy Policy Act of 2005 and subsequent bills provide valuable incentives
Looking Forward - 2

• Focus on costs to come down – new/novel gasification to beat limitations of conventional gasification

• Bring down capital and operating costs with smart engineering and operations: Learn by doing

• CTL now becoming increasingly feasible – with high oil prices even more so

• Potential carbon constraints are to be factored in

• Convince financial skeptics by excellent performance
Conclusions

• CTL and SNG proven with superior product properties and environmental performance
• Expected crude oil prices and trends support coal conversion technologies
• Some replacement of imported crude strategically essential - including for chemical industries
• For meaningful strategic oil replacement, the target should be at least 1 million bbl/d
• Requires a national will and strategy
• The bold could get the rewards
• Do it again and start now