Developing Premium Markets for GTL Products

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Major GTL Products

Sample product slate for 100 KBD facility

	No HC	With HC	Comments	
LPG	2	4	• Similar to other plant (LNG, refinery) LPG	• Can be co-processed and marketed with them
Naphtha	18	26	• Straight chain paraffinic • Near zero sulfur	• Preferred use: steam cracker feed
Jet-Kero /Diesel	50	70	• High cetane • Near zero sulfur	• Low density • Low aromatics
Lubes	30	<1	• High grade • Low volatility • Low pour point	• Low viscosity • Low sulfur
Wax	10	<1	• High quality	
Specialty	α-Olefins, Solvents, Detergents, Drilling Fluids,…			

IMPORTANT

- GTL, CTL, BTL ("XTL") substantially similar products
  - (Significant recent movement in BTL)
- impacts on the products market interact
  - Production volumes
  - Financing and commercialization status
  - Effects on product quality: feedstocks, catalysts, technologies
- Key consideration: the 2008-2009 global recession

FT Diesel Quality

- Two sources: straight run + hydrocracked wax/lubes
  - Linear, paraffinic
  - Poor cold start
- Typical cetane numbers in 70-80 (v. 40-50 for conventional)
- No sulfur (v. conventional)
  - Low lubricity
- No aromatics
- Lower density than refinery diesel
  - 0.77-0.80 Kg/L (v. 0.83-0.85 Kg/L for conventional)
- Colorless
- Tailpipe emissions

GTL Diesel Supply Projections

- Approx. 180 KBD 2009 total liquid production capacity
  - South Africa mix of GTL and CTL
  - Includes nameplate 33,000 BPD for QP/Sasol Oryx I

- Qatar Shell Pearl (140,000 BPD, start-up 2010-2012)
- Trinidad and Tobago World GTL (2,250 BPD, start-up 2010)
- Nigeria Escravos Sasol/Chevron (34,000 BPD, startup 2011-2013?)

- A large number of potential projects; a small fraction likely to be built

- California Energy Commission estimate:
  - 2015: 388 KBD global GTL diesel
  - 2020: 800 KBD

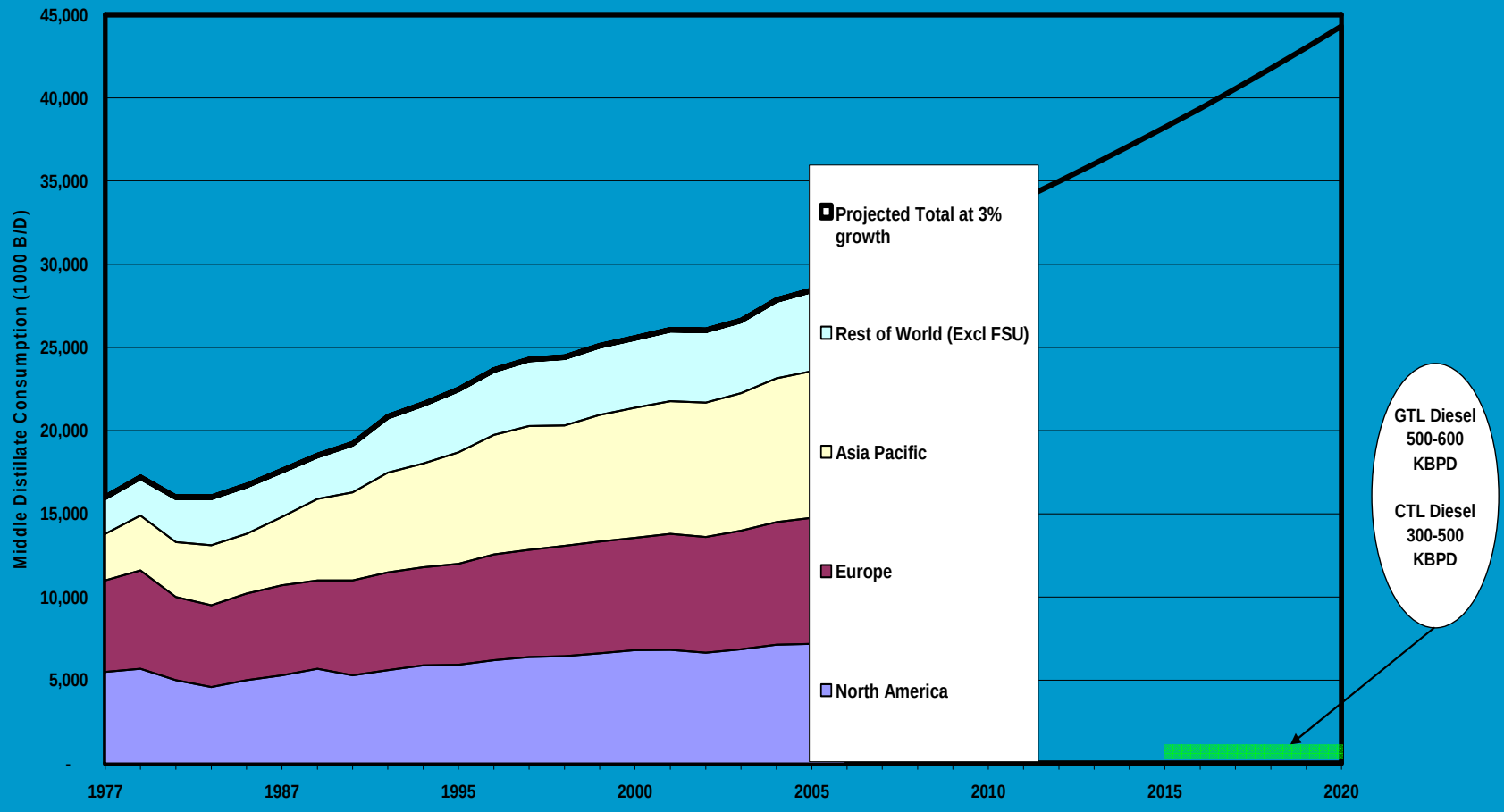
- Sasol Chevron estimate: 600 KBD by 2016-2019

- EIA 2009: 200-700 KBD by 2030 (range due to investment scenarios)

CTL Diesel Supply Projections

- Much less well-defined
- Key potential locations: US, Peoples Republic of China, Russia, Australia, …
- US (Baker and O'Brien study): potential 250 KBD of middle distillates by 2017-2022
- PRC :
  - Projected (Robinson and Tatterson, OGJ Feb 2007 study): as much as 160 KBD liquid fuels
  - Environmental concerns
  - 2008/2009: all but two projects cancelled
  - 20 KBD Inner Mongolia DCL: trial operation (Oct. 2009)
- EIA 2009: 300-2,000 KBD by 2030 (range due to investment scenarios)
- Hand-waving estimate: 300-500 KBD by 2020

FT Diesel v. Global Middle Distillates



- Small as fraction of total supply (less than 4% of diesel by 2020)
- Unlikely to impact global market greatly

Potential Diesel Volume Impact on Local/Regional Diesel Markets

- Local/Regional: GTL/CTL diesel supply could be significant
  - Example (Shell estimate): One large GTL plant would fully satisfy the city of London
  - Example (Baker and O'Brien): all US PADD 4 ("Rockies") and 20% PADD 2 ("Midwest") demand could be supplied by CTL
- Possible to develop a critical mass of GTL diesel as blendstock for a small market
  - Example: 30% Pura throughout Thailand from Shell Bintulu
  - Also sold as blendstock in Greece, Germany, and South Africa
- CTL diesel from PRC: could reduce price, availability, and supply security pressure in the Dubai/Singapore crude and products region

Likely FT Diesel Scenario

- Pure FT diesel would require separate infrastructure and auto modifications
  - Key FT benefit compared to alternatives: compatibility with current fuels and systems
  - Possible neat use in some fleets
- Most likely use: as a premium blendstock to bring slightly off-spec diesel into compliance
  - Sulfur, cetane, aromatics,…
- Competition:
  - Hydrotreaters in refineries, improvement in FCCs and other units
  - Biofuels (*e.g.*, ethanol, methyl esters) expected to grow
  - ➔ FT diesel sulfur premium might erode
  - ➔ Some observers: FT diesel premium primarily due to high cetane and low aromatics (benefit for Europe, less in US and Asia)

Recent FT Diesel Pricing Information

- Most analyses show premium relative to ULSD
  - (Note: ULSD ~ 20-30% premium over WTI)

- Early (90s) studies suggested 5-10 US cents/gal premium
- Raytheon study: FT diesel 57% over WTI (→ 20-30% over ULSD)
- Energy Research Center of the Netherlands (2005): 19% premium over conventional diesel

- Informal trader contacts: 5-15% over ULSD depending on market

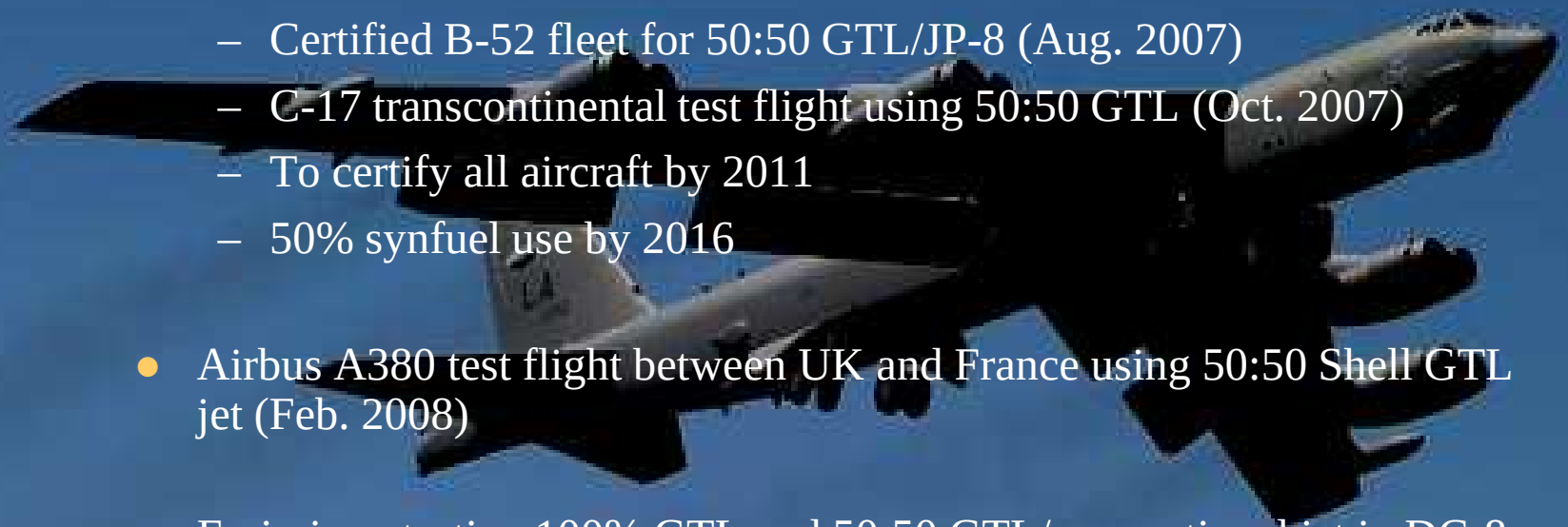
- Regulatory/Incentive activity impact. Example:
  - 2005 US Federal Transportation Bill—$0.50/gallon of FT naphtha and diesel.
  - Extended in 2007 Farm Bill to 2010 (incl. requirement for 50-75% CO_2 CCS).

Jet/Kero

- Good cetane (55-60)
- No sulfur, no aromatics
- Excellent smoke and flash points and other combustion properties
- Significant reduction in particulates emissions
- Acceptable freeze point
- Low density (issue for jet fuel) though high energy density

- Large market. Example: US 2008 Jet ~ 1.35 MMBPD
- Many interested parties
  - Issue: impact of biomass-to-liquid competition?

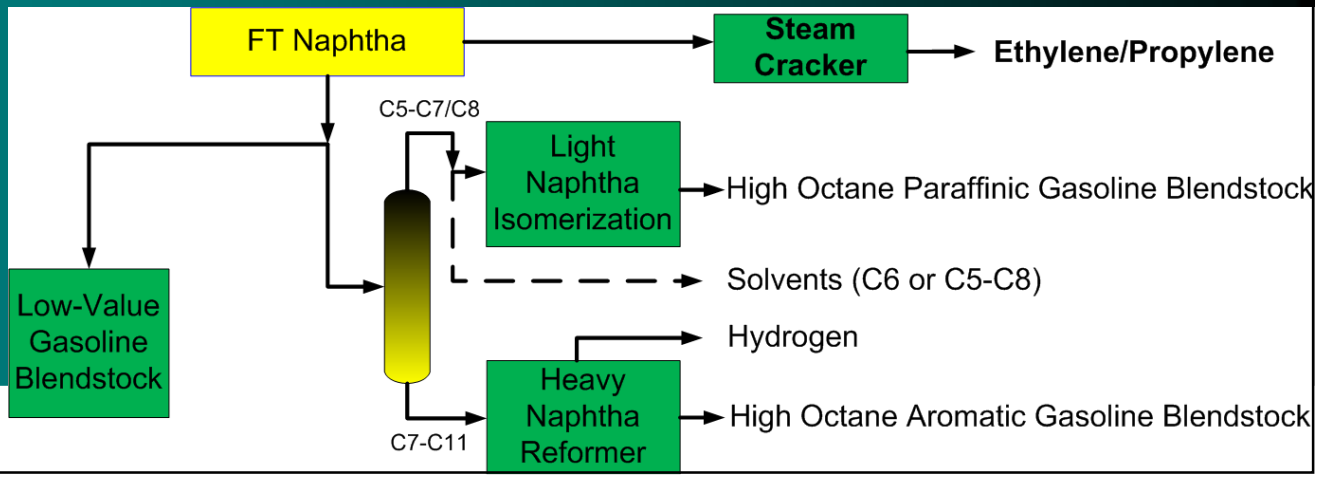
Recent Jet Market Developments



- USAF Synthetic Fuel Initiative:
  - Ground-tested several GE and P&W engines
  - Certified B-52 fleet for 50:50 GTL/JP-8 (Aug. 2007)
  - C-17 transcontinental test flight using 50:50 GTL (Oct. 2007)
  - To certify all aircraft by 2011
  - 50% synfuel use by 2016
- Airbus A380 test flight between UK and France using 50:50 Shell GTL jet (Feb. 2008)
- Emissions-testing 100% GTL and 50:50 GTL/conventional jet in DC-8 by NASA-led group (Feb. 2009)
- 50:50 GTL jet approved for use in civil aviation (ASTM D7566, Sept. 2009). First commercial flight (London-Doha, Qatar Airways).

Naphtha Market

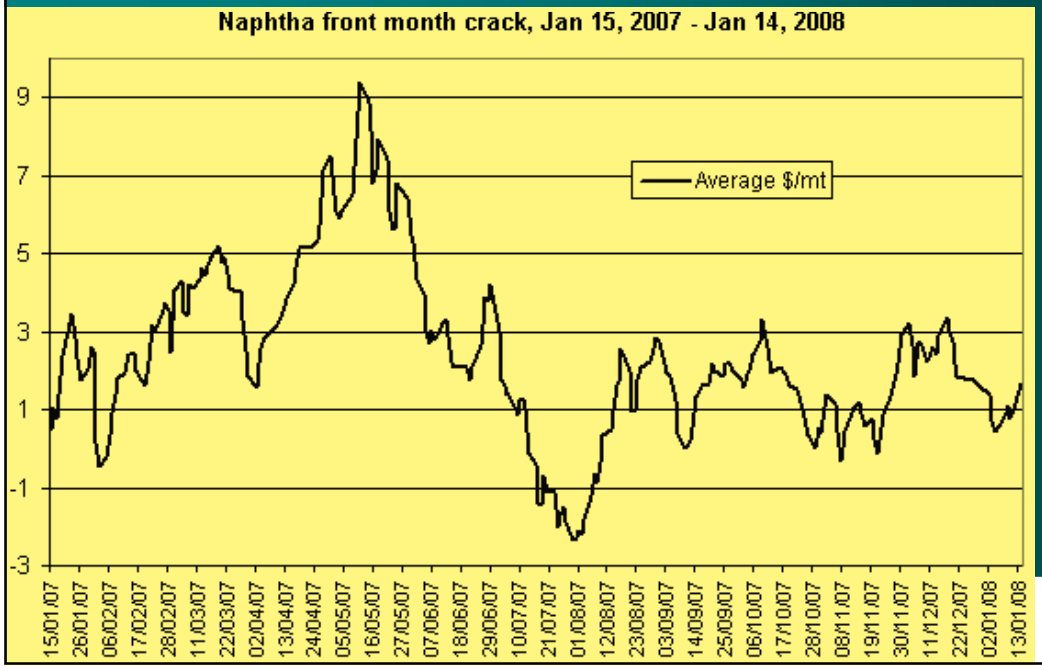
- In millions BPD
  - Example: Europe 1.5-2 MMBPD
  - Mostly “open spec” from the middle portion of paraffinic naphtha
- Main source: refineries (primarily simple/hydroskimming)
- Main uses: steam crackers to ethylene (and propylene)
  - 2009 global ethylene capacity: 127 MMTPY
  - Equivalent to naphtha demand of 3.7 MMBPD (if naphtha only feed)
  - FT naphtha: ideal—no aromatics, up to 10% higher ethylene
- Other use:



More on Naphtha

- Supply/Demand/Price can fluctuate significantly
- Tied to plastic plant (consumer) economics

- Example:
  - Turnarounds of several Asian crackers in 2008;
  - New naphtha capacity in India;
  - Modification of steam crackers to handle other feeds (*e.g.*, LPG)



- Also tied to crude prices and regional supply/demand:
  - Asian open-spec Aug. 2009: ~ USD 650/MT with USD 95/MT crack due to low supplies from Europe

GTL Lubes Quality and Cost

- GTL lubes produced from isomerization of FT waxes
  - Virtually no sulfur, nitrogen, or aromatics
  - Narrow HC distribution
  - Excellent oxidation stability
  - Excellent volatility and pour point
  - Very high VI (140+)

- Studies suggest attractive economics for production
  - Manufacturing costs similar to Group I/II
  - Quality similar to other basestocks of 140+ VI

Lubes Markets (1)

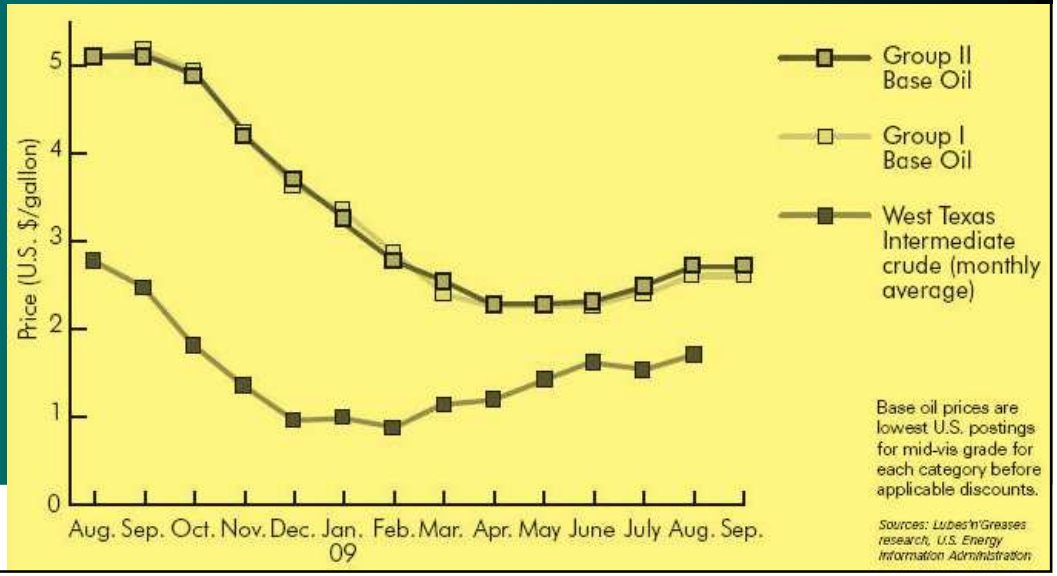
- Basestock global market size ~ 962 KBD in 2008 (800 KBD in 2005)
  - Group I: 62% (75% in 2005)
  - Group II: 23% (20% in 2005)
  - Groups II+/III/IV: 5% (2% in 2005)
- Groups II+/III/IV expected to grow to >10% by 2015 (perhaps as much as 20% depending on automaker demands)
- Basestock market is in great flux
- Group I capacity rationalizations in North America and Western Europe

Lubes Markets (2)

- Slow overall growth
  - Rapid demand growth in developing regions (*e.g.*, China, Brazil)
  - Decline in US, WE, Japan, Australia, New Zealand
  - Overall in 2008: 1.4% growth (1.8% in 2005)
- Increased demand for high quality (Group III/IV)
  - Evolving industry standards for passenger car motor oils (GF-4 in effect; moving towards GF-5)

Lubes Markets & Price Fluctuation

Base Oil Prices ($/MT)	Europe			USA
	April-08	April-09	October-09	October-09
Grp I	900-1220	365-805	790-835	710-1013
Grp II/II+			875-990	802-1016
Grp III			900-1120	1077
Grp III+				1339
Comments	Europe inc. exports and FSU		Europe/ME/Africa	
	For Reference: 1000 $/MT ~ 135 $/Barrel			



GTL Lubes Capacity Impact

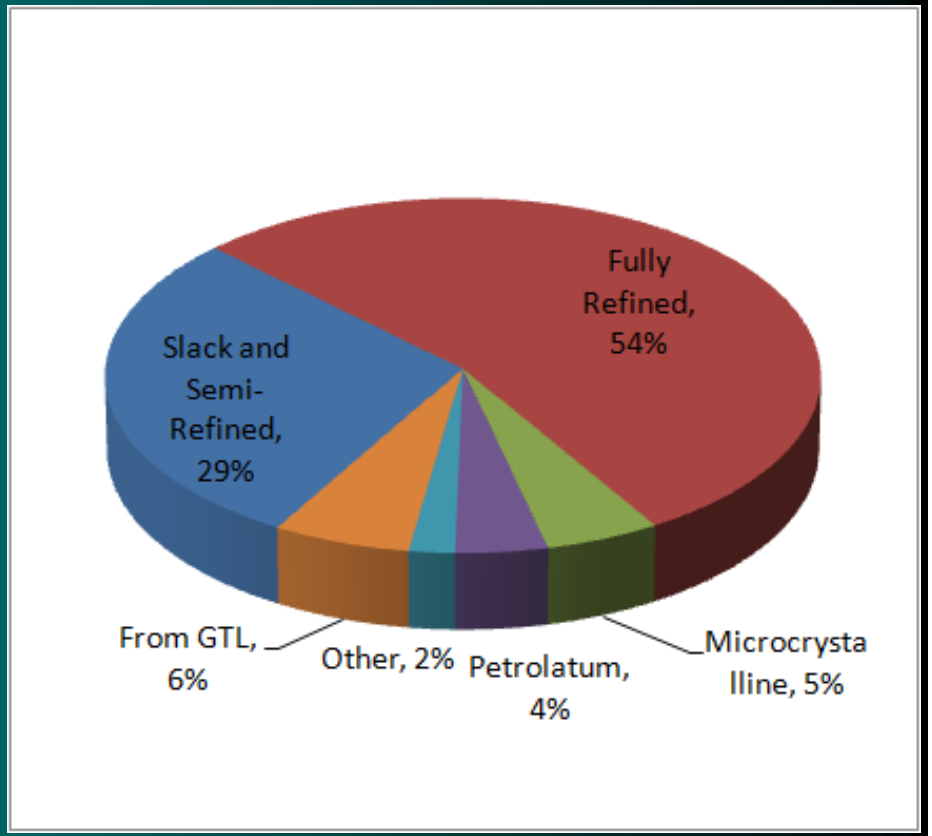
- One world-scale GTL could produce as much as 15-30 KBD lube basestocks (6-11% of current Group II/II+/III/IV supply)
- Example: ExxonMobil Qatar project (cancelled) would have produce 30 KBD lube basestocks
- Estimates and announcements: 20 KBD GTL lube basestock capacity by 2011
- Globally, possibility of 150-175 KBD of GTL lube basestocks by 2020

Likely GTL Lubes Scenario

- GTL economics primarily based on gas monetization to fuels
  - historical F-T plants (Sasolburg and Secunda) make no/little lubes
  - Max lubes yields of 20-30% from key GTL plants?
  - In reality: All major GTL plants will include some product cracking
- Likely scenario in terms of impact of GTL on lubes markets:
  - GTL lubes will trigger shutdown of less efficient lube capacity
  - Key: manufacturing cost
    - Group I plants highest—have been shutting down

Global Wax Overview

- 2005 capacity: 10,900 MMlb (~103 MBD)
  - 13% of the base oil market
  - Most mineral-based (lube refinery)
  - About 6% from Shell and Sasol GTL plants



Sources: *C. Garrigou. First ICIS-LOR Pan American Base Oils & Lubes Conference 2005. Wax Data.* In-house.

Wax Supply

- Lube refinery by-product
- Depends on rates of other key products especially Group I base oils
  - Rationalizations in NA, Europe, Asia
  - Wax isomerization to base oils
- Concentrated
  - 75% in 10 countries
  - 55% in 4 companies (CNPC, XOM, Shell, Sasol)

Total Wax Production incl. GTL (2005/2006)	%
North America	28
Latin America	5
Europe	18
Asia	35
FSU and Eastern Europe	11
ME/Africa	3
TOTAL (MMlb/yr)	~9,300 -9,900

Sources: *Wax Data 2005 and 2006. Kline & Co. 2007*. In-house.

Wax Demand

- Relatively steady growth in global demand in the past 25 years
  - Expected to continue at 3% annually
- Regional and end-product shifts likely
  - 2/3 refined waxes (significant capacity in PRC with export to North America)
  - ½ food grade

Approximate Wax Demand by Region (2005)	%
North America	30
Latin America	14
Western Europe	17
Asia	23
FSU and Eastern Europe	12
Middle East/Africa	4

Sources: *Wax Data 2005 and 2006* and in-house

Wax Trends—China

- Chinese refinery crude becoming less paraffinic (more imports) + Reduction in wax production
- Increase in domestic wax consumption
- Loosely correlated to economic growth of 8-10% annual and end-use shift
- Trend expected to continue
- Net Result: less Chinese wax available for export

Chinese crude production (3.4-3.6 MMBD)

- Waxy/paraffinic projected to hold for ~15 years per upstream reserves estimate

Economic growth: 3-fold crude demand increase over last 15 years

- Import 40% of crude (primarily ME, Russia)—less waxy
- New refineries focus on transportation fuels
- Some historical wax-producing refineries changing output and reducing/eliminating wax manufacture
- Operational issues with imported crudes (?)

Overall Global Wax Trends

- Continued growth in demand
- Reduction in supply of petroleum-derived waxes
  - Potential increased supply of natural waxes (*e.g.*, soy, palm)
- Opportunity for GTL to impact these trends

Wax Prices

Wax Prices ($/MT)	Northwest Europe		USA Gulf
	April-08	April-09	April-09
Low Melt (52-54C)	1438-1484	1037-1104	1098-1268
Mid Melt (56-58C)	1516-1609	1104-1157	
High Melt (60-62C)	1547-1719	1224-1277	
Comments			MP~52-60C

GTL Wax Quality

- FT wax is primarily linear in the C_{20-100} range
  - (mineral-based wax: mix of iso and n-paraffins)
  - Benefit in high melt applications
- Typically: produce two wax grades (MPs) and blend to other MPs
- Shell Bintulu and Sasol Secunda provide about 6% of worldwide waxes (low oil content, high MP)
- Oryx and planned GTL projects
  - Tight wax markets may create opportunity
  - Possibility: softer wax than from current GTL units with oil content close to slack waxes

GTL Wax Supply and Demand

- The wax market is easily overwhelmed
  - Example: typical GTL plant can produce 500-1,000 MMlb/yr of high grade wax (if not hydrocracked)
    - 6-12% of total projected market
- One analysis (Shell): potentially as much as 4,400 MMlb/yr new wax by 2015 from GTL
- Another analysis (Kline & Co.): 1,000-1,500 MMlb/yr of FT wax might be needed by 2014 to keep balance

Likely GTL Wax Scenario

- ➔ Most GTL plants will hydrocrack their wax-range products into diesel and other light products
- ~1/3 left for use/sale as slack wax or to isomerize into base oils
- Can fine-tune wax produced in light of market
  - Analysts expect GTL wax to fill high-end niche applications and possibly move into petroleum wax market space

Specialty Products Examples (1)

- Linear α-Olefins from raw FT diesel
  - Petrochemical building blocks for detergents, polymers, lubricants, plastics, …
  - Processing required (including, in some cases, odd-even separation)

- Solvents from FT naphtha fraction
  - C5-C8, no aromatics or sulfur, low odor
  - Hexane, Special Boiling Point Solvents
  - Used in oil seed extraction, polymerization, dry cleaning, rubber manufacture

Specialty Products Examples (2)

- Hydrocracked wax fractions: high linear paraffin content, biodegradable, no sulfur
  - C10-C13 for laundry detergent applications
  - C14-C17 used in making chloro-paraffins
- Drilling fluids from diesel fraction
  - Linear chains, biodegradable
  - C17-C22 fraction
  - Replacement for traditional “mud” in some applications

Summary

- Many products of quality exceeding specifications
- High-volume, fuel products key: diesel, jet/kero, naphtha
  - Proven as blendstocks with very large markets
- Lubes and waxes limited by product market sizes
  - Small amounts of high-quality products highly profitable
- Variety of other non-fuel, specialty products including feedstocks to detergents, polymers, solvents

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