GTL Technology and its Potential Impact on the Global Energy Markets

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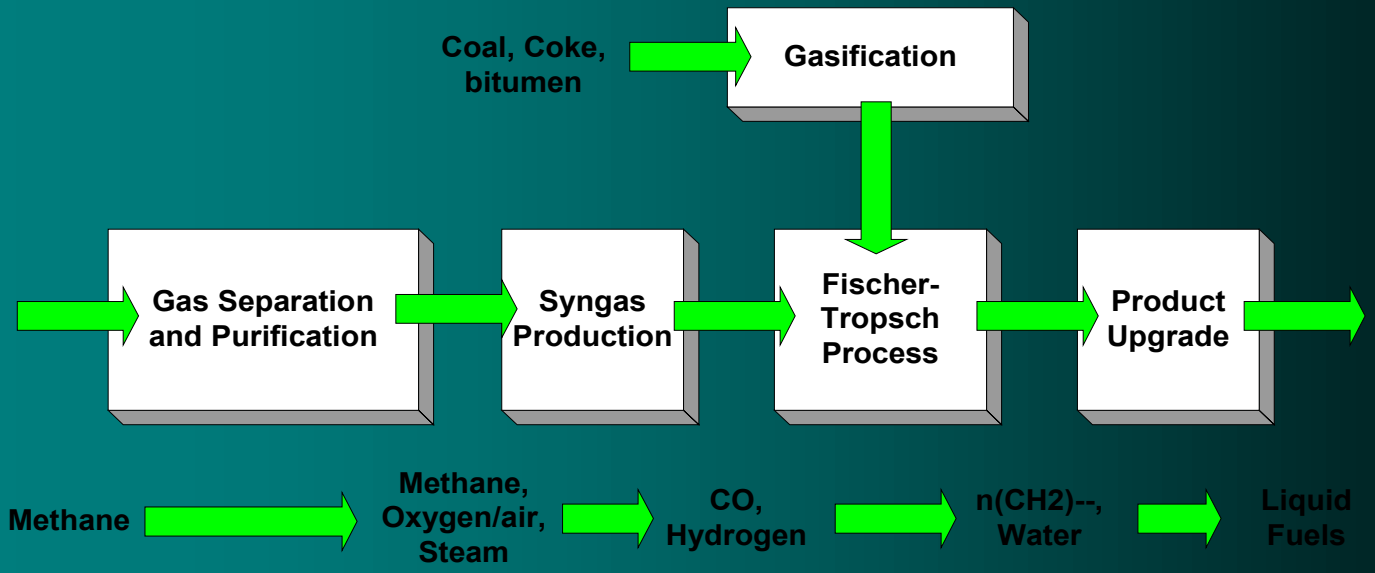
Introduction

- Recent interest in GTL technology and its products
- Units to come on line in the next 5 years
- What is GTL?
- How might it impact the global energy and petroleum products markets?

Key GTL Steps



- Production of synthesis gas ("syngas"):
  - Partial oxidation: $CH_4 + O_2 \rightarrow CO + 2\ H_2$ (exothermic)
  - Steam reforming: $CH_4 + H_2O \leftrightarrows CO + 3\ H_2$ (endothermic)
- Fischer-Tropsch synthesis
  - $CO + 2H_2 \rightarrow —CH_2— + H_2O$ (very exothermic)

Sample GTL Product Slate

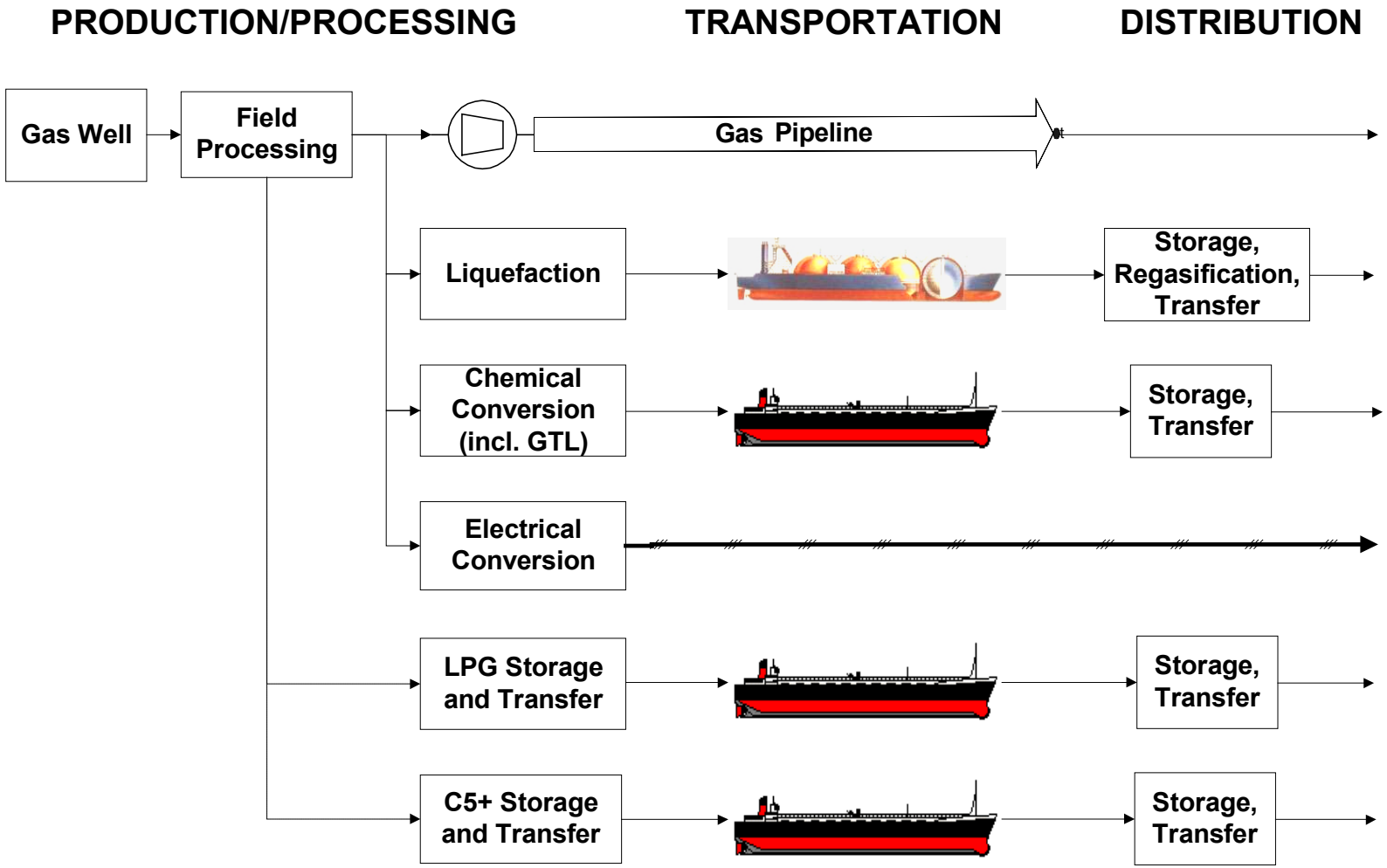
50 MBD Plant

	No HC (MBD)	With HC (MBD)	Comments	
LPG	1	2	• Similar to other plant (LNG, refinery) LPG	• Can be co-processed and marketed with them
Naphtha	4	13	• Straight chain paraffinic • Near zero sulfur	• Preferred use: steam cracker feed
Diesel	25	35	• High cetane • Near zero sulfur	• Low density • Low aromatics
Lubes	15	<1	• High grade • Low volatility • Low pour point	• Low viscosity • Low sulfur
Wax	5	<1	• n-paraffins • High quality	

GTL Drivers

- Reduction in cost of transport of NG
  - Monetization of stranded natural gas
  - Economic utilization of associated gas
- High current and projected demand for liquid transportation fuels
  - Higher costs tied in with crude markets and refining capacity issues
  - Clean fuels
- Flaring reduction and environmental concerns

Natural Gas Transport Mechanisms



After "Natural Gas Production, Processing, Transport" by Rojey et al.

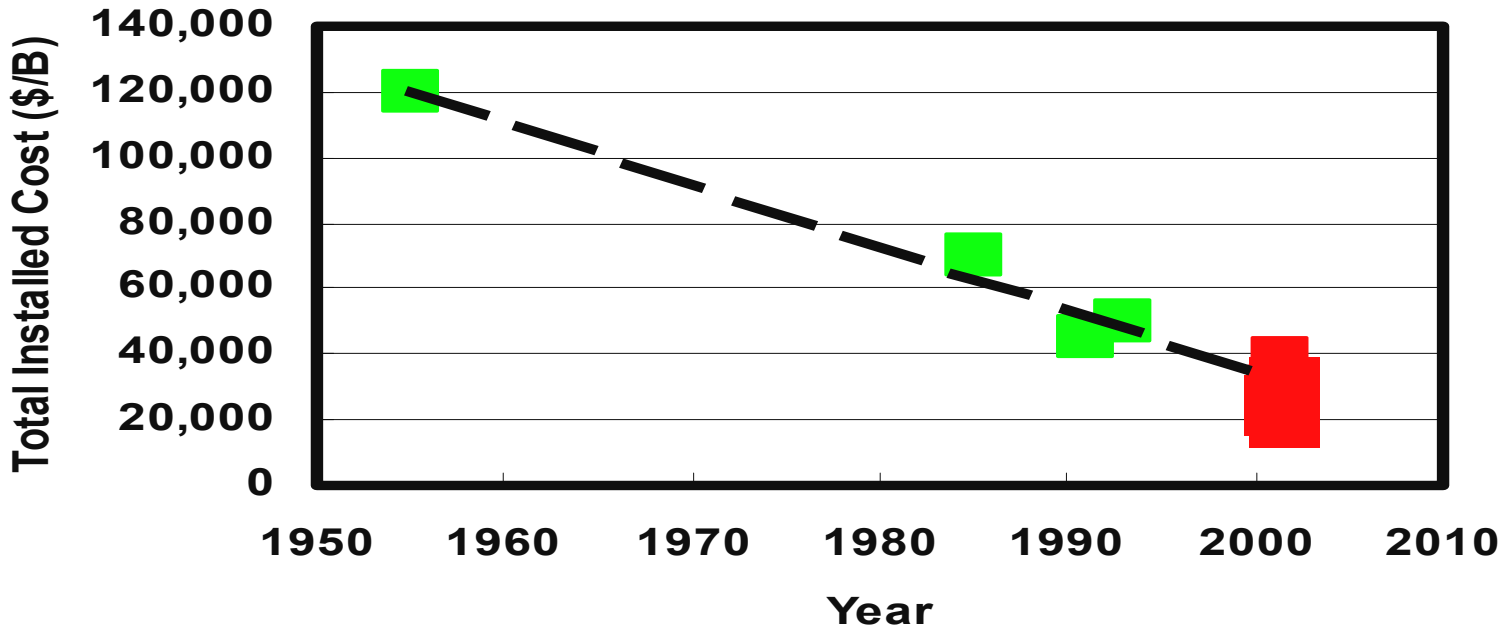
4.1 TCF Natural Gas Flared in 2000

Excluding FSU

Region	BCF Flared
Africa	1,640
Middle East	923
Central and South America	569
North America	524
Far East	296
Europe	148

After World BankA. D. Little, Inc. Study (2000)

GTL-FT CAPEX Reduction Due to Improved Technology

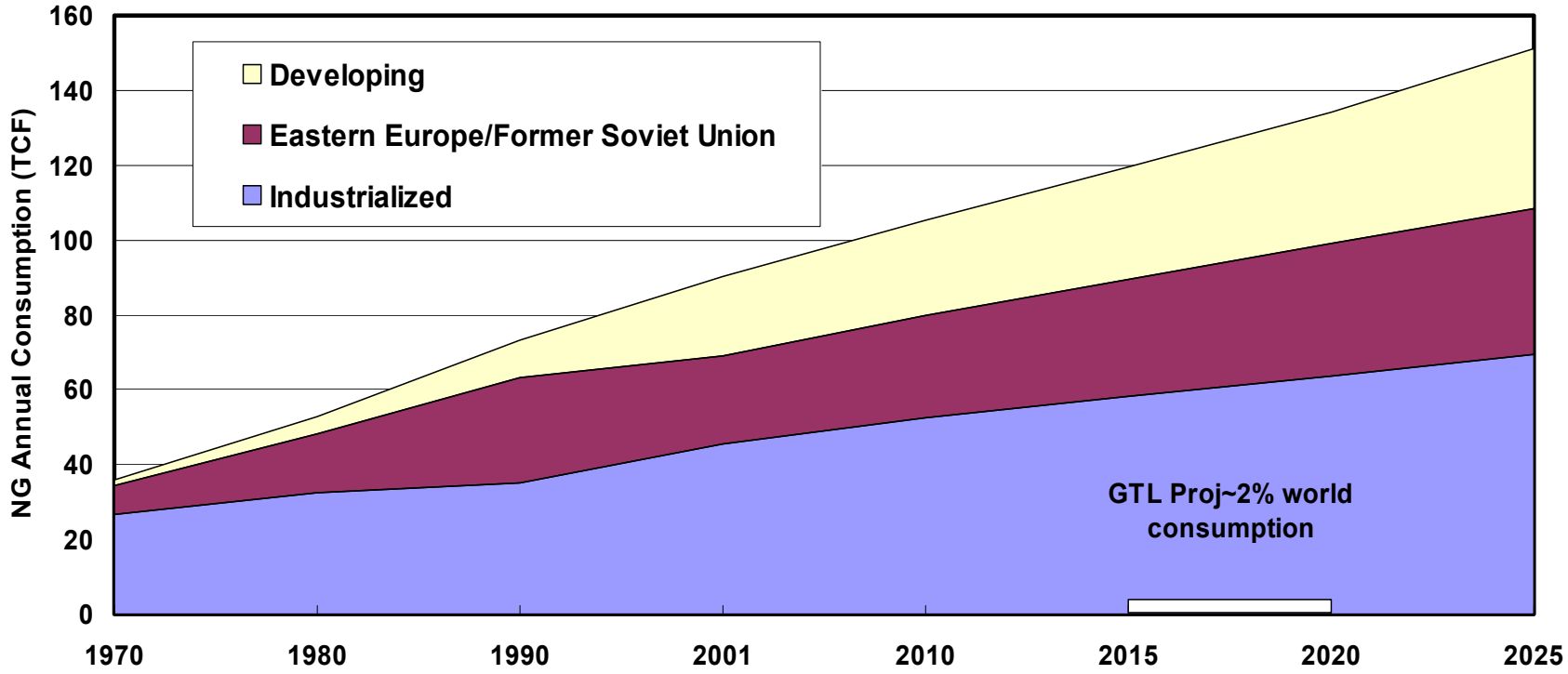


- Capacity differences
- Lube and wax manufacture v. no lube/wax
- Financing structure
- Short-term v long-term (increased capacity) case
- Technology differences
- Current claims in $25,000-35,000/Bbl range

Key Commercial GTL Plants in E&C

Company	Location	Size (BPD)	Comments
Sasol Chevron QP	Ras Laffan, Qatar ("Oryx GTL")	33,700	2006 completion; Technip-Coflexip; $850 MM; studying increase to 100 MBD by 2009
Sasol ChevronTexaco	Escravos, Nigeria	34,000	? completion; FW; $1,200 MM
Shell QP	Qatar ("Pearl")	140,000	2009 completion Two phases
ExxonMobil QP	Qatar	150,000	2011completion
Over 50 other projects (total capacity ~2 million BPD) at different phases (study, planning, preliminary design) in African, Americas, Middle East and Asia, and Australia.			

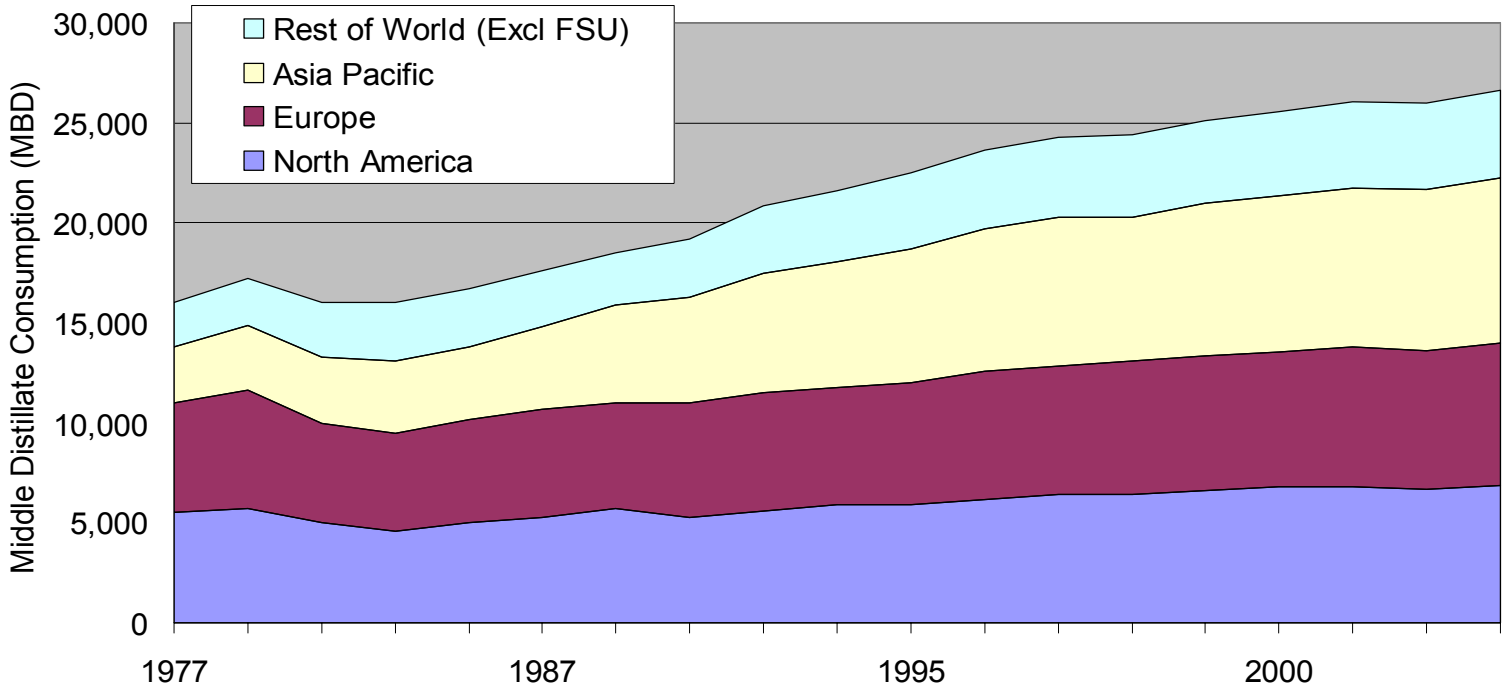
Projected Natural Gas used by GTL



GTL Diesel

Automotive Diesel/Mid. Dist. Market
Historical

- Global middle-distillate market: 27 MMBD
  Approx. 3% annual growth
  14 MMBD automotive diesel



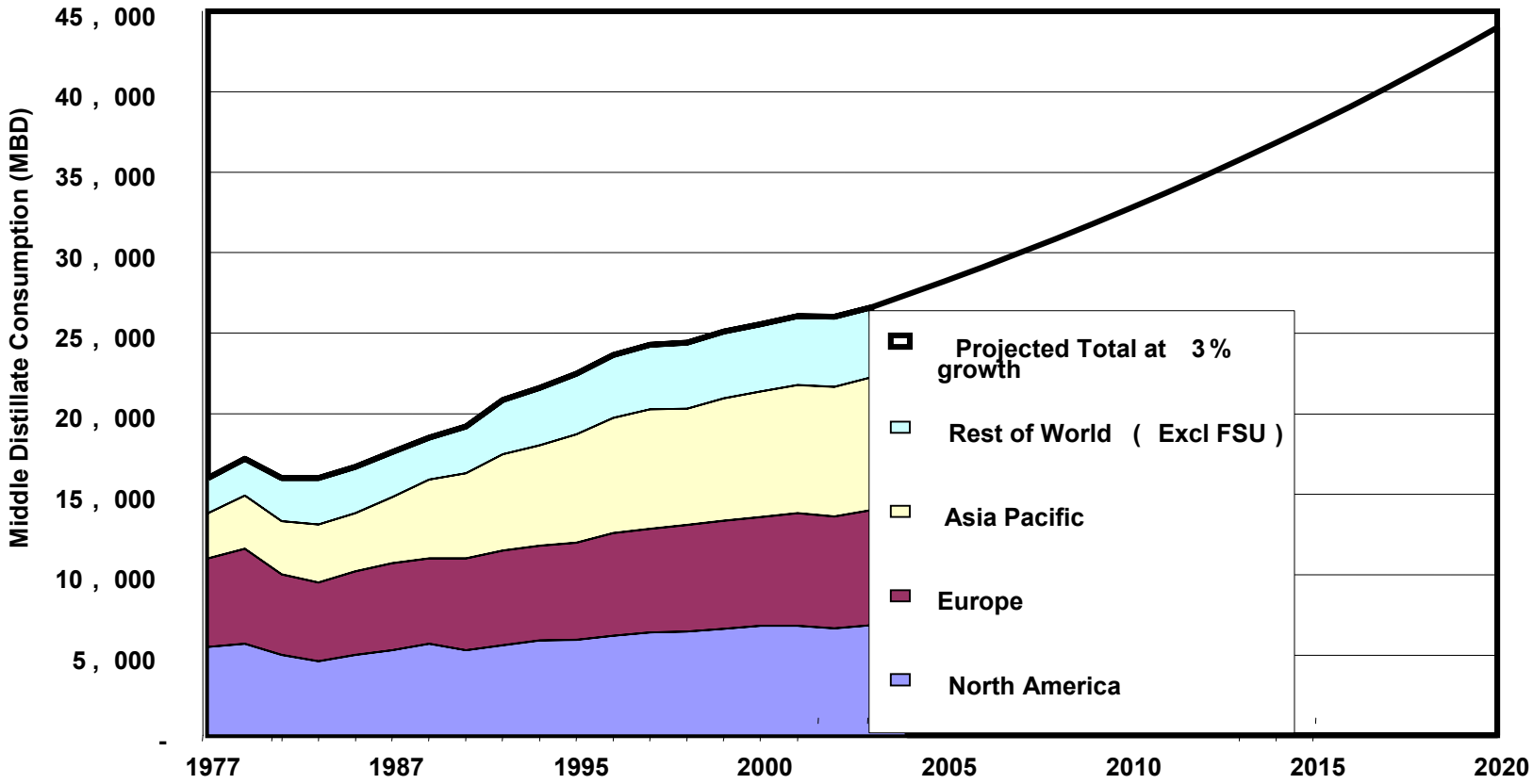
Growth Projections (1)

- Europe: increase in diesel-powered autos
  - Currently over 60% of auto sales in France and Austria
  - Emission mandates, jurisdictional tariff strategies, improved auto designs, increased low-emission fuel availability
- US: driven by commercial sector and tied to overall economy growth (average about 5% annual)
  - Light diesel vehicles 4% of total market
  - Regional and regulatory efforts are likely to increase diesel auto usage
- Asia-Pacific: rapid yet uncertain growth
  - China factor: 8-10% annual economic growth; loosely correlated to diesel fuel usage

Growth Projections (2)

- Globally: diesel powered autos at about 30%
  - Projected to grow to about 40% by middle of next decade
  - Followed by partial replacement with hybrids
- Overall:
  - Projected middle distillates demand to grow by 3% annual
  - To 44 MMBD in 2020
  - 22.5 MMBD automotive diesel

Global Middle Distillates Projection



Question: what is the potential impact of GTL on this market?

GTL Diesel Supply Projections

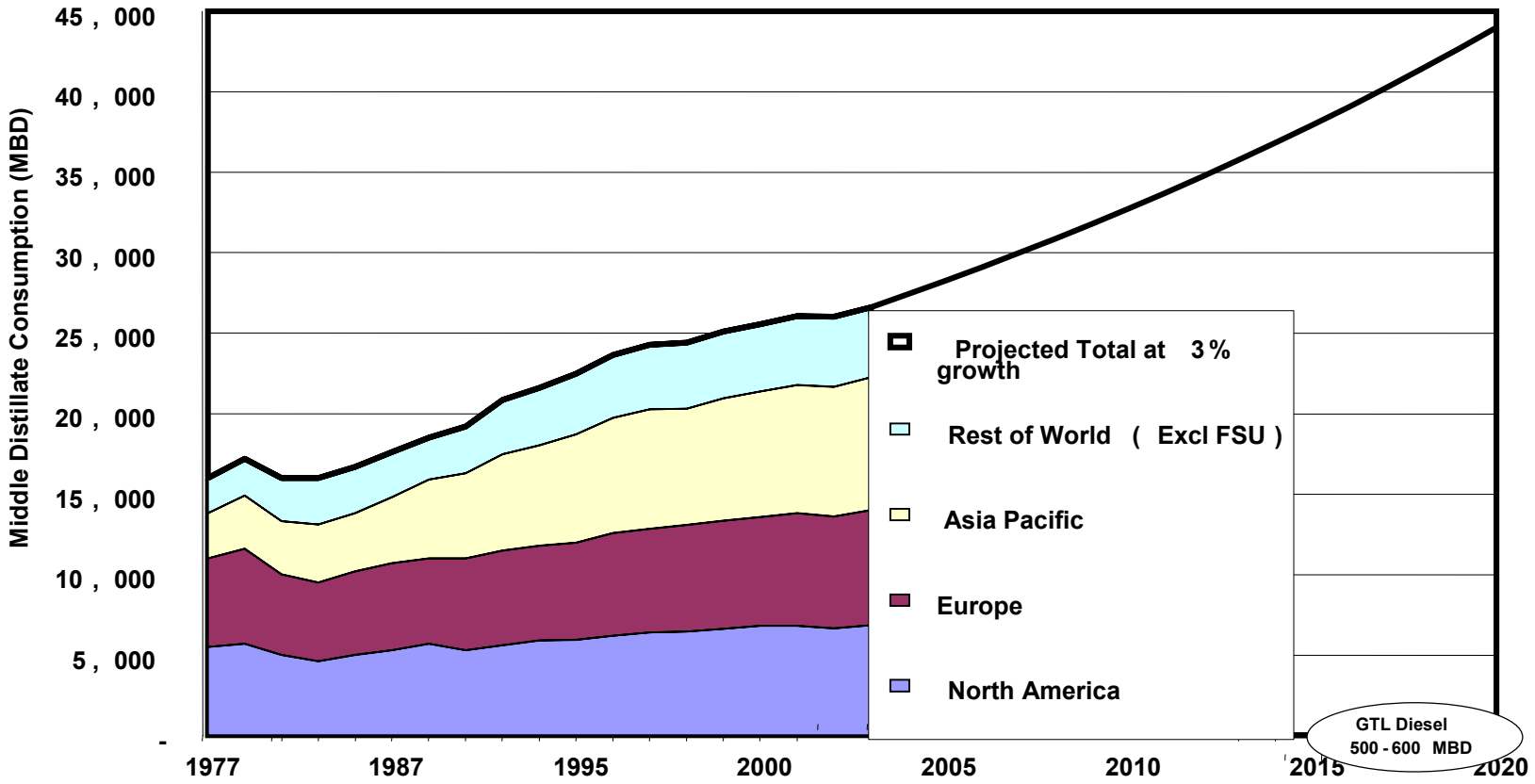
- A large number of potential projects
- Only a small fraction are likely to be built short-term

- Qatar: self-described GTL capital
  - Oryx I: 2006 start up
  - Shell Pearl: 2009
  - ExxonMobil: 2011

- California Energy Commission estimate:
  - 2010: 75 MBD global GTL diesel capacity (seems low)
  - 2015: 388 MBD
  - 2020: 800 MBD

- Sasol Chevron estimate: 600 MBD by 2016-2019

GTL Diesel v. Global Middle Distillates



- Small as fraction of total diesel supply (less than 3% by 2020)
- Unlikely to impact global market greatly

Potential Impact on Local Diesel Markets

- GTL supply could potentially form a significant portion of a region's diesel
  - Example: Shell estimates one large GTL plant would fully satisfy the city of London and 10 plants would satisfy PADD V
- Possible to develop a critical mass of GTL diesel as blendstock for a small market
  - Example: Shell Bintulu has offered 30% Pura throughout Thailand
  - Also sold as blendstock in Greece, Germany, and South Africa

Comments on GTL Diesel Quality

- Virtually no sulfur
- Very low aromatics
- Highly paraffinic ➔ typical cetane numbers in 70-80
- Lower density than refinery diesel
  - 0.77-0.80 Kg/L v. 0.83-0.85 Kg/L
  - ➔ Density premium
  - ➔ Perceived lower fuel efficiency (in MPG)
- Relatively poor cold-start; low lubricity
- A number of studies (90s) show a premium of 5-10 ¢/gal

GTL Diesel Quality & Effect of Regulatory Environment

- Regulations on
  - Fuel composition
  - Emissions
  - "Alternative" fuel content (*e.g.*, biofuels)

- Fuel composition regulations:
  - Tightening standards for light and heavy-duty diesel vehicles
  - Expected to continue to tighten
  - Sulfur, aromatics, PNAs
  - US, WE, Japan: sulfur down to 10-50 ppm
  - Developing world: mandates down to 200-1000 ppm

The Evolving Diesel Sulfur Content Regulations

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
USA	500										15					
EU	500				350					50				10		
Japan	500									50		10				
Australia	2000						500				50					
Bangladesh							5000									
Cambodia					2000											
PRC	5000		2000													
Hong Kong	2000	500			50											
India	5000				2500					500					350	
Indonesia	5000															
ROK	2000		500				430									
Malaysia	5000		3000				500									
Pakistan	10000						5000									
Philippines	5000				2000				500							
Singapore	5000		500													
Sri Lanka	5000						3000									
Taiwan	500					350										
Thailand	2500			500												
Vietnam	10000							2000		500						

Key	>5000 ppm	3001-5000	501-3000	51-500	16-50	<50

Source: Pytte (22)

GTL Diesel Emissions

- A number of studies demonstrated tailpipe emission benefits
  - Neat or in blends
  - Compared to both conventional as well as reformulated
- Typical examples of tailpipe emission results:
  - 40-50% reduction in HC, 9% in NOx, 30% in particulates when compared with low-sulfur refinery diesel
  - Benefits with current as well as new engine technologies (Euro-4 and Euro-5) using neat and blend GTL diesel
- Well-to-Wheel: no great benefit for GTL diesel
  - Shifts CO_2 emissions from auto to plants (away from population centers; potential for sequestration)

Likely GTL Diesel Scenario

- Pure GTL diesel would require separate infrastructure and auto modifications
- In jurisdictions with very tight specifications, volume of GTL required would be very high
- Most likely use: as a premium blendstock to bring slightly off-spec diesel into compliance
- Competition:
  - HT in refineries, improvement in FCCs and other units
  - Biofuels
  - ➔ GTL diesel sulfur premium might erode
  - ➔ Some observers: GTL diesel premium will be primarily due to its high cetane and low aromatics

In Summary

- After many decades of discussion and R&D GTL new GTL plants will on stream within the decade
- GTL is capable of producing high quality diesel as well as lubes and waxes
- GTL is unlikely to have a major impact on the global diesel markets
  - Can be a positive component in meeting high quality blend-stock demands
- GTL lubes (and waxes) can have a significant effect on the worldwide pool

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