Longer-Term Strategies
Gas-to-Liquid Fuel

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- What is gas-to-liquid Fuel?
- Gas Reserve – Proven/Undiscovered
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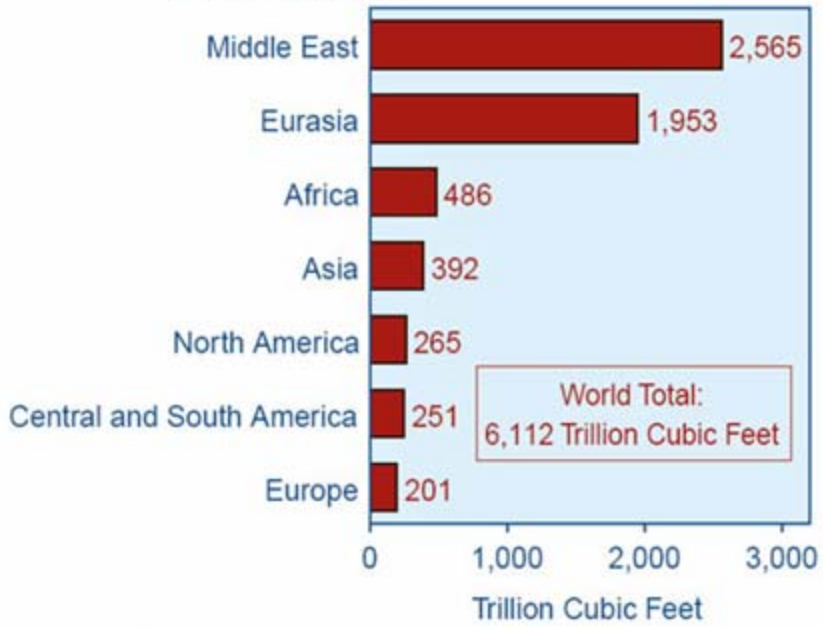
What is gas-to-liquid fuel?

- Diesel-like fuel except:
  - Non-detectable sulfur, aromatics, or metals
  - Low toxicity and biodegradable
  - High cetane number (74+)
- Produced from many raw materials
  - Natural gas (stranded gas)
  - Coal/petroleum coke
  - Biomass
  - Landfill waste
- Use as:
  - blends & neat fuel in existing engines
  - Enabler for catalyst-based add-on device

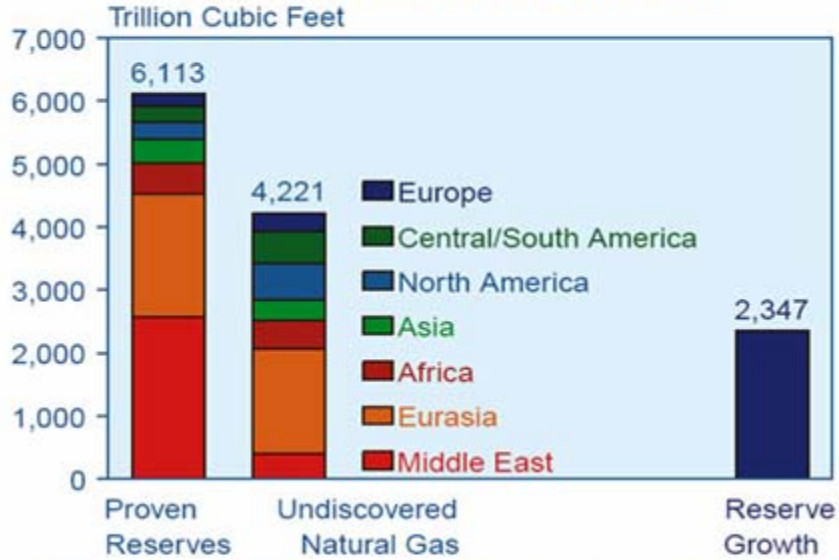
Natural Gas Reserve

Figure 37. World Natural Gas Reserves by Geographic Region as of January 1, 2006



Source: "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 103, No. 47 (December 19, 2005), pp. 24-25.

Figure 38. World Natural Gas Resources by Geographic Region, 2006-2025



Source: U.S. Geological Survey, *World Petroleum Assessment 2000*, web site http://greenwood.cr.usgs.gov/energy/WorldEnergy/DDS-60; "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 103, No. 47 (December 19, 2005), pp. 24-25; and Energy Information Administration estimates.

GTL Production Plants - Existing

	Location	Capacity (b/d)	Feedstock
Sasol	South Africa	175,000	Coal
Mossgas	South Africa	30,000	Natural gas
Shell Bintulu	Malaysia	12,500 – 15,000	Natural gas
Exxon Mobil	Louisiana	250	Natural gas
BP Amoco	Washington	70	Natural Gas
Synfuels	Texas	10	Natural gas
Synenergy	Calgary	4	Natural gas

Source: World LNG/GTL review

GTL Production Plant - Planned

	Location	Capacity (b/d)	Feedstock
Sasol & Qatar	Qatar	34,000	Natural gas
Chevron & Sasol	Nigeria	33,000	Natural gas
Reema Int.	Trinidad	10,000	Natural gas
Syntroleum	Australia	10,000	Natural gas
Rentech	Colorado	2,000	Natural gas
Conoco	Oklahoma	500	Natural gas
BP Amoco	Alaska	300	Natural gas

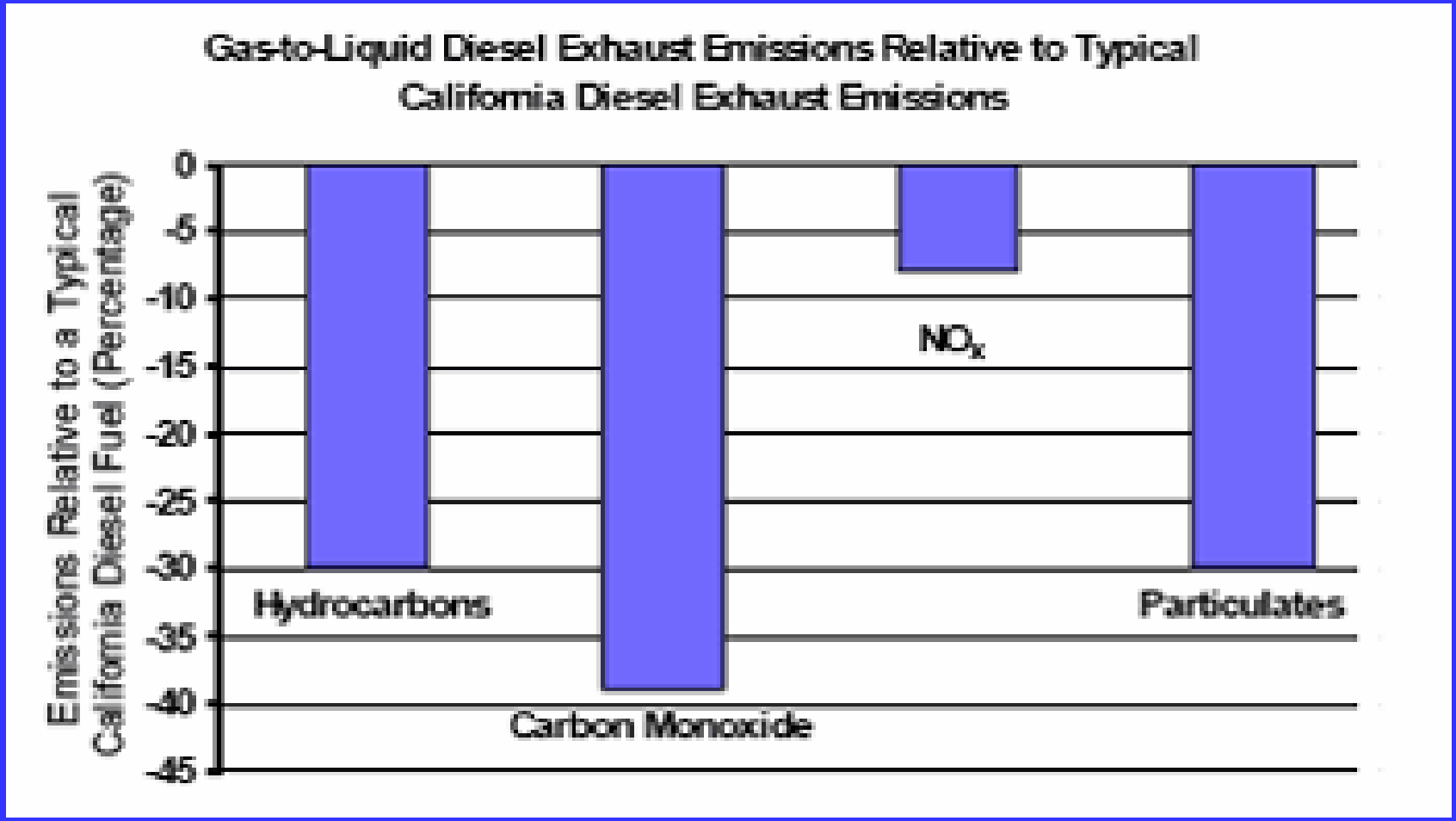
Source: World LNG/GTL review

GTL Production Plant - Announced

	Location	Capacity (b/d)	Feedstock
Exxon & Qatar	Qatar	100,000	Natural gas
Shell	Argentina	75,000	Natural gas
Shell	Trinidad	75,000	Natural gas
Shell & Egyptian	Egypt	75,000	Natural Gas
Shell	Australia	75,000	Natural gas
Shell & Nat. Pet	Iran	70,000	Natural gas
Shell	Indonesia	70,000	Natural gas
Alaska Nat. Gas	Alaska	50,000	Natural gas
Exxon Mobil	Alaska	50,000	Natural gas
Exxon Mobil	Angola	50,000	Natural gas

Source: World LNG/GTL review

Emission benefit without engine modification



Why Longer-Term Strategy?

- Production cost
  - Natural gas
  - Capital cost
- Transportation, distribution, and marketing cost
- Incentive

Gas-to-Liquid Projects

- Demonstration of Fischer Tropsch Fuel in Unmodified HD Trucks with Johnson Matthey PM Traps
- Development/Demonstration of Fischer-Tropsch Fueled HD Engines with PM/NOX Aftertreatment
- Demonstration of GTL in Transport Refrigeration Units w/Add-on Control
- California GTL Bus Demonstration

	CO	NO_x	HC	PM
GTL Fuel, No Filter	11%	13%	46%	21%
GTL Fuel, With CCRT Filter	>99%	22%	>99%	>99%

Fuel	NO_x	HC	PM
Diesel (g/hp-hr)	2.08	0.33	0.125
GTL (g/hp-hr)	1.17	0.04	0.005
% Reduction	43.9	87.3	96.1