Shell Global Solutions

Verification of Shell GTL Fuel as CARB Alternative Diesel

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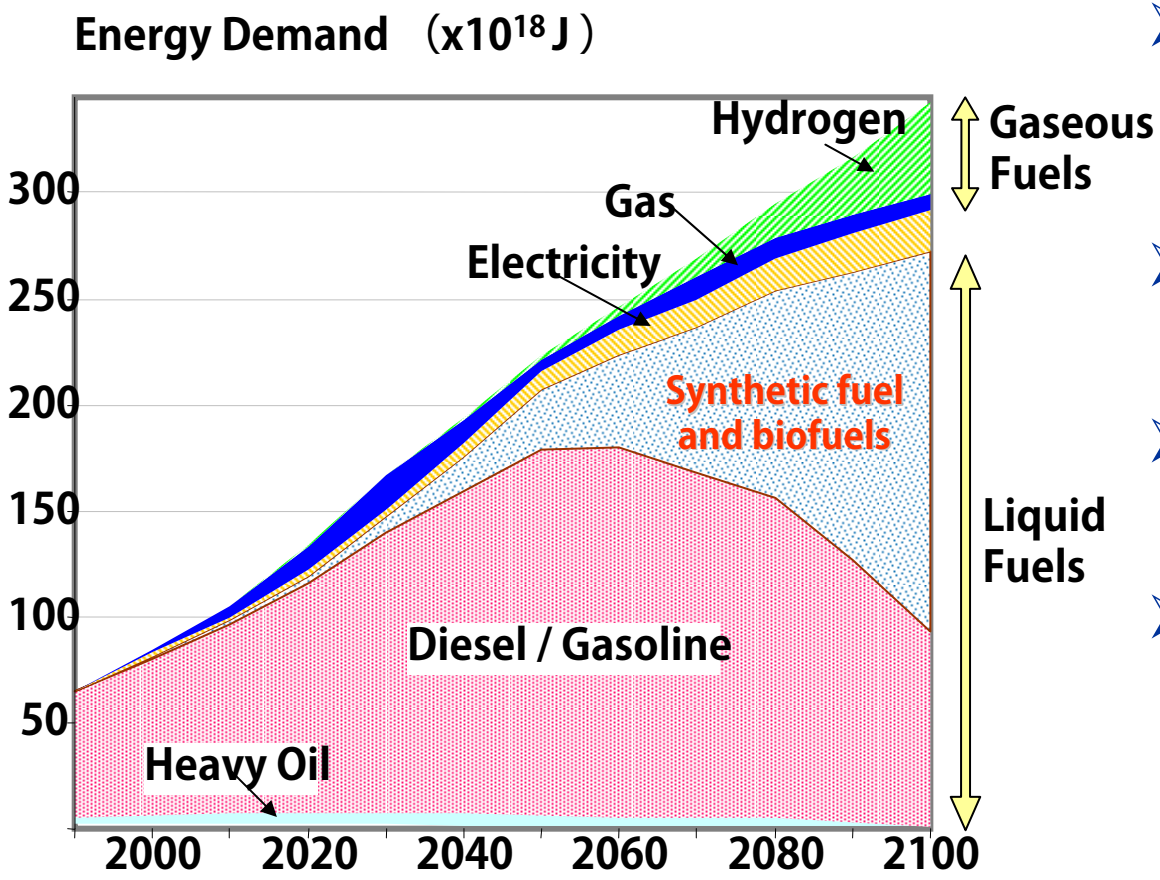
Outline

- Introduction
  - Future Fuel Demand
  - GTL as a Future Fuel
- GTL Demonstrations
  - CARB Verification Testing
  - Fleet Tests
- GTL Outlook

Future Fuel Demand
A Forecast of Global Automotive Fuel Demand



（Source： a WEC scenario）

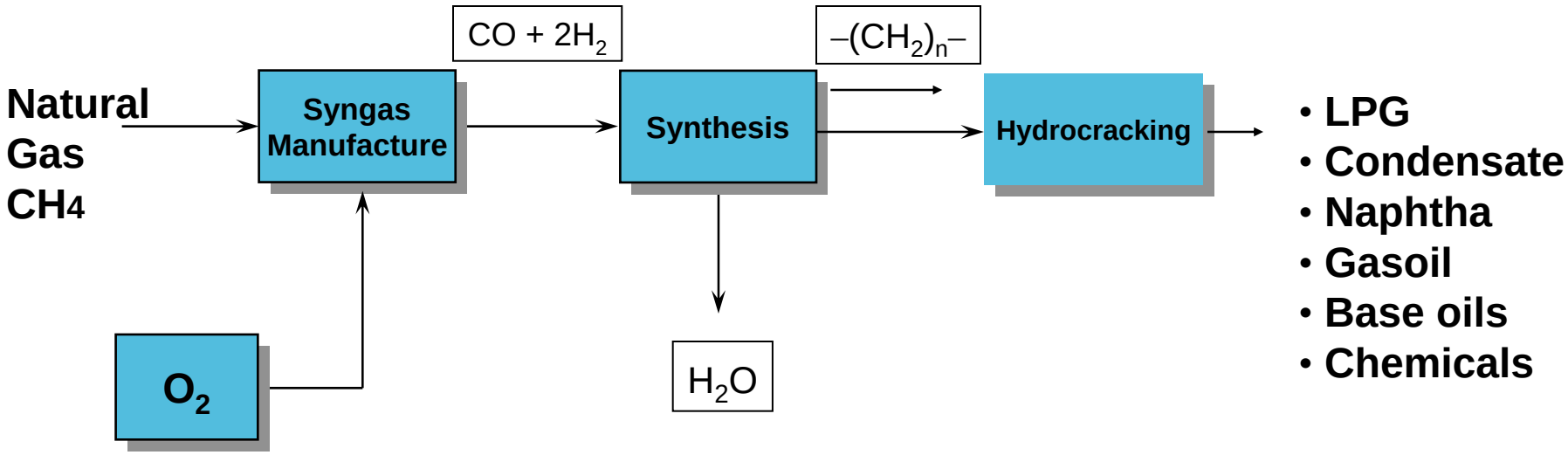
- Significant uncertainty in plateau of ‘conventional oil mountain’
- Increased environmental pressures
- Plethora of potential vehicle-fuel solutions
- Common denominator ought to be cost effectiveness.

GTL Fuel –Synthetic and Alternative Fuel

- **GTL Fuel is one class of Synthetic fuels, which refers to liquids from:**
  - **gas (GTL)**
  - **coal (CTL)**
  - **biomass (BTL)**
  - **waste (WTL)**
- **Alternative Fuels comprise synthetic fuels, biofuels, and fuels such as water-fuel emulsions, ethanol-diesel blends**

What is Gas to Liquids?

GTL is a process that converts natural gas to clean fuels and high quality products via the Fischer-Tropsch process



Shell's proprietary process: Shell Middle Distillate Synthesis (SMDS)

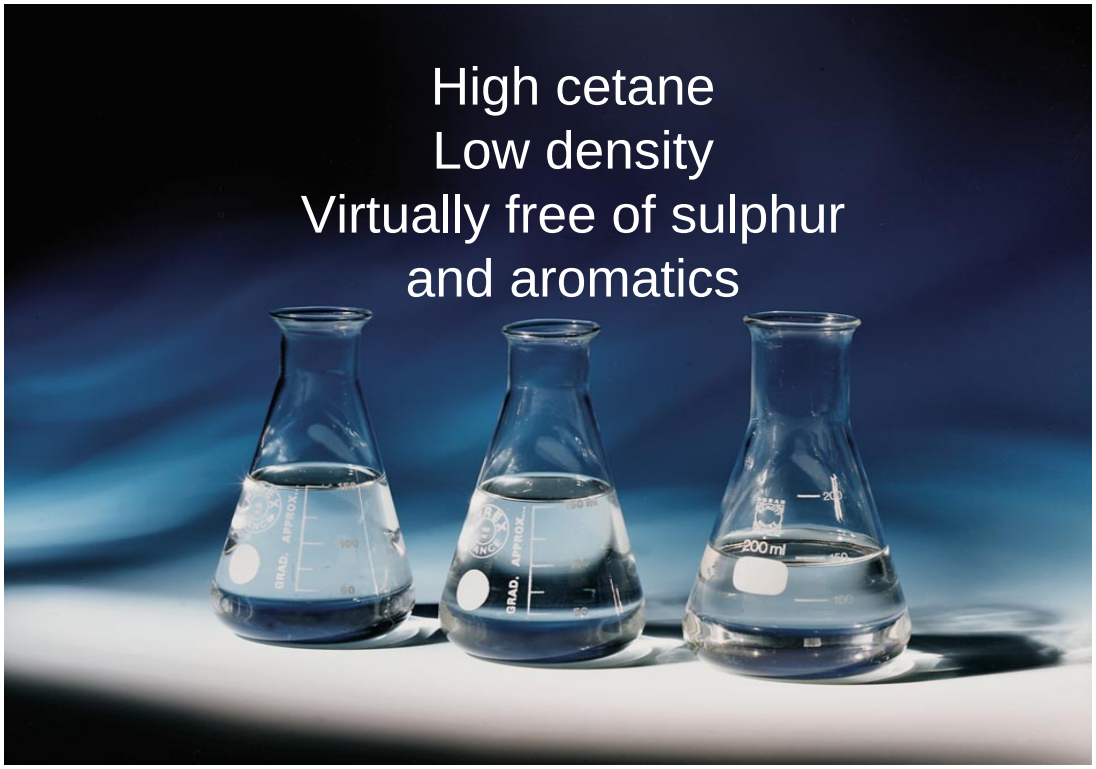
Why -- Shell GTL Fuel

- Strategic **diversification** of energy supply
- **Compatible** with existing infrastructure
- GTL provides a **bridge** to Biomass to Liquids and Coal to Liquids technologies

- Life cycle analysis: GTL vs. Refinery system
  - GTL less impact on on air acidification and smog formation
  - Comparable greenhouse gas emissions

- More cost effective in reducing **emissions** than competing fuels [B2, B20, LNG, CNG]
  - Derived from independent WTW study by TIAX (8/2003)

Shell GTL Fuel – a premium quality diesel fuel



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CARB Verification as Alternative Diesel Fuel

- Recognized protocol for demonstrating emission benefits of alternative fuel
- Rigorous testing and data review process
- Allows demonstration of emission benefits over and above ULSD CARB diesel, which has been considered the ‘optimum’ for clean diesel in the U.S.

CARB Protocol– Emissions Reduction Testing

Fuels

- Two candidate fuels
  - 100% Shell GTL Fuel
  - 55% Shell GTL Fuel / 45% CARB diesel
- Reference fuel
  - Commercial CARB ULSD

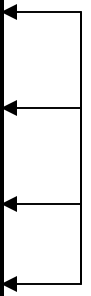
CARB Protocol – Emissions Reduction Testing

Test Protocol

- Hot-start transient emissions test (CFR 40, Part 86, Subpart N)
- Alternative 3 protocol (CARB Interim Procedure for Verification of Emission Reductions for Alternative Diesel Fuels)
- 1991 DDC Series 60 heavy-duty diesel engine
- HC, CO, CO_2, NO_x, PM and SOF

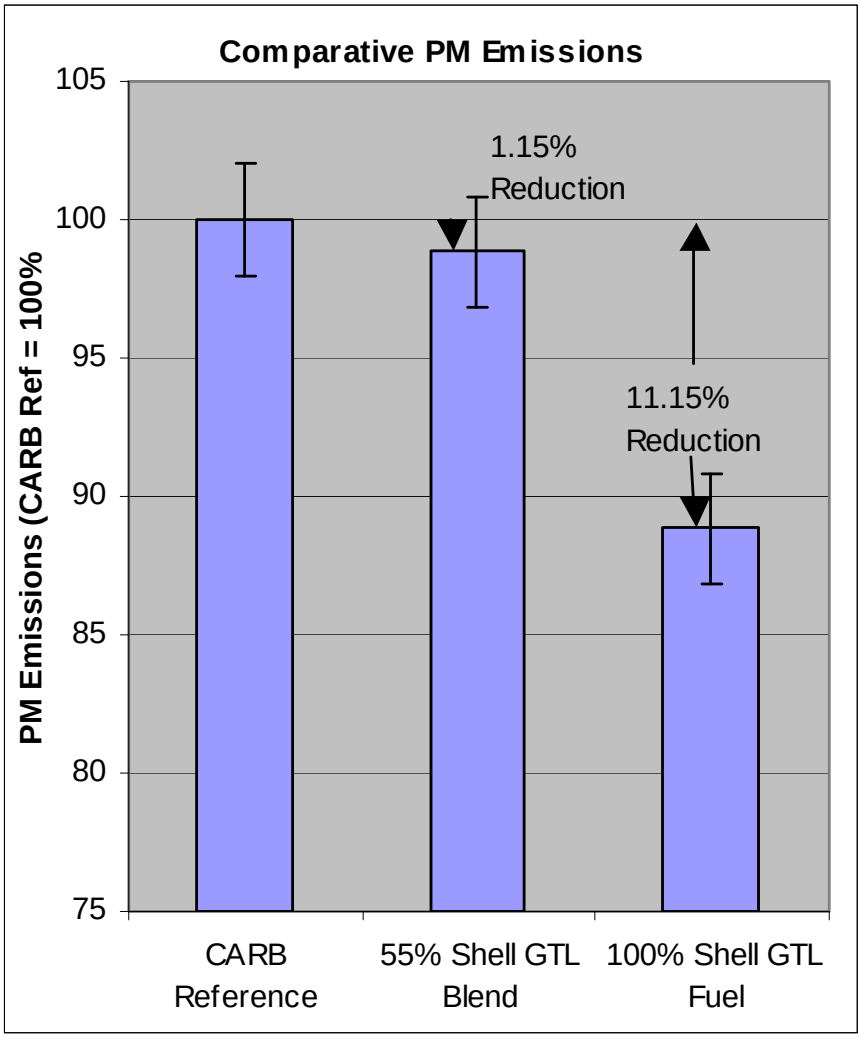
Properties of Fuels Tested
Shell GTL Fuel vs CARB Reference Fuel

			Shell	CARB
			GTL Fuel	Ref Fuel
Parameter	**units**	**method**		
API Gravity	API@60 ºF	D287	48.8	41.6
Cetane Number	rating	D613	**>76**	**50.7**
Sulfur	mass ppm	D5453	0.3	0.6
Nitrogen	mass ppm	D4629	<1.0	12.8
Total aromatics	mass %	D5186	**2.9***	**22.3**
PAH	mass %	D5186	1.6*	1.5
Distillation, T90	deg F	D86	627	561



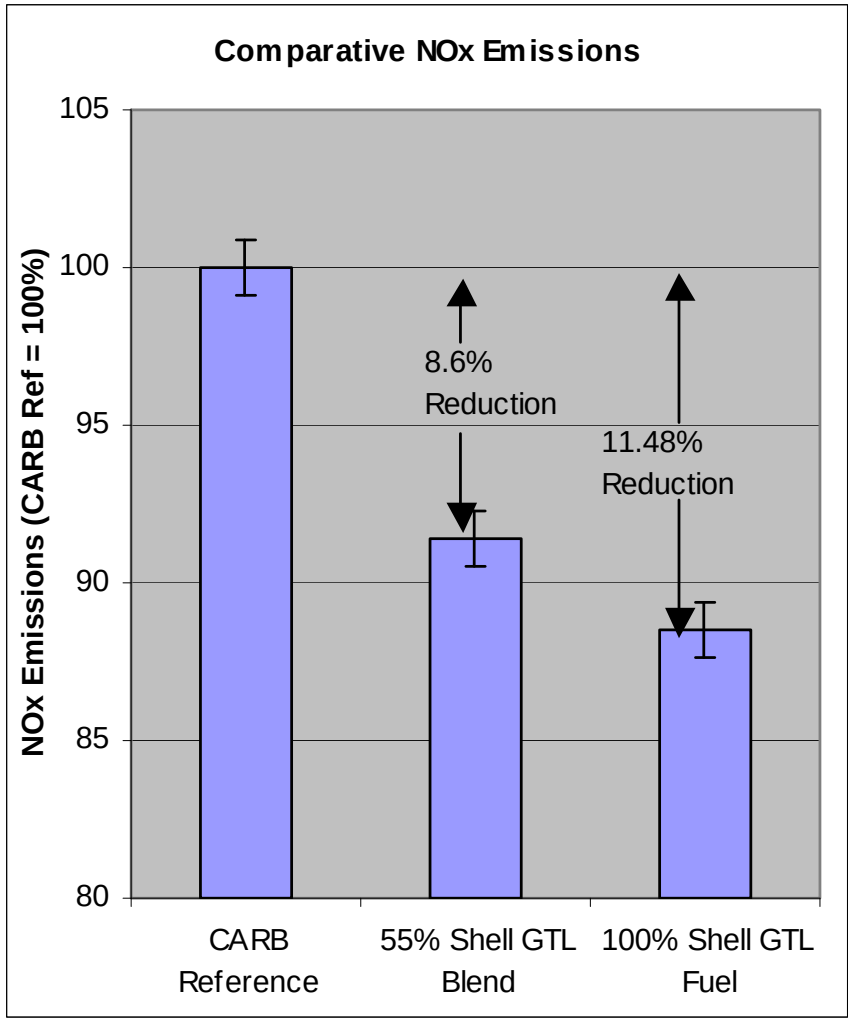
*Historical plant QA value for total aromatics is 0.1m%, for PAH < 0.1m%

CARB Protocol – Emissions Reduction - PM



- Shell GTL Fuel provides a significant PM emissions reduction over CARB ULSD reference fuel

CARB Protocol- Emissions Reduction - NOx



- Shell GTL Fuel provides a significant reduction in NOx compared to ULSD CARB reference fuel
- Consistent with both CARB and EPA Emissions Models, which predict reduced NOx for fuels with higher cetane number, lower aromatics

CARB Protocol–Emissions Reduction– Results
100% Shell GTL Fuel and 55% Shell GTL Fuel Blend

	% Benefit					
	CO	CO_2	HC	SOF	NO_x	PM
100% Shell GTL Fuel	10.58	2.39	52.15	18.2	11.48	11.15
55% Shell GTL Fuel Blend	5.33	2.12	39.19	22.0	8.60	1.15

Shell's GTL Fuel marketing activities have demonstrated the product is robust in all scenarios.

London
Bus trial with Daimler-Chrysler

London
Toyota trial

Greece
Shell Diesel 2004

China
Michelin Bibendum Challenge

China
Bus trial Shanghai

USA
Dept. of Transport
Yosemite Water

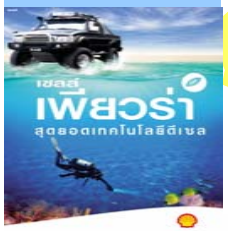
Japan
Aichi hybrid bus

USA & France
Audi Le Mans racing

Germany
Fleet trial with Volkswagen

Germany, Austria, Netherlands, Italy, Switzerland

Thailand
Shell Pura Diesel



Japan
Fleet trial

100% GTL Fuel

Diesel/GTL Fuel blend

GTL Consumer Groups: Fleet Users

Early targets are commercial fleets, operating within a city environment:

- ***Buses***
- ***Taxis***
- ***Waste collection vehicles***
- ***Light and heavy duty delivery vehicles***

Home base refuelling (not retail stations)

Shell GTL Fuel from Bintulu has completed fleet trials in California.

A Yosemite Waters truck, operated on Shell GTL Fuel

GTL Fleet Trials in California (1)

Partners California Department of Transportation, Sacramento
Shell

Timing Completed May 2002

Purpose Durability, seal compatibility

Structure Blind 30-day switch from CARB LSD to GTL Fuel

Key Findings

- *No leaks* of fuel from any of the vehicles
- *No increases in maintenance* for any of the vehicles
- *No performance issues related to fuel* in terms of power and performance
- *Fleet operator and drivers very happy with the performance of the fuel*

GTL Fleet Trials in California (2)

Partners Yosemite Waters, DOE NREL, SCAQMD, Johnson Matthey, International Navistar, Shell

Purpose

1. Demonstrate technologies robust under real operating conditions
2. Scientifically evaluate the emission reductions that can be achieved
3. To provide key data to legislators, commercial users and the public, for important air quality decisions and legislation

Key Findings (SAE 2005-01-3769)

- *Statistically significant reductions of NOx, PM, HC and CO with Shell GTL Fuel and JM CCRT DPF*
- *20,000 miles accumulated to demonstrate durability*
- *Test vehicles running with GTL Fuel reported to be indistinguishable from control vehicles in terms of performance*
- *Test vehicles running on GTL Fuel experienced no additional maintenance requirements compared to control vehicles*

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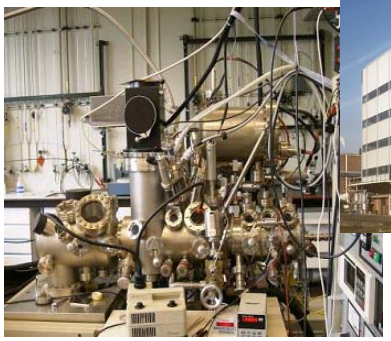
Shell GTL development

→ **Integrated world scale Qatar project based on proven technology**

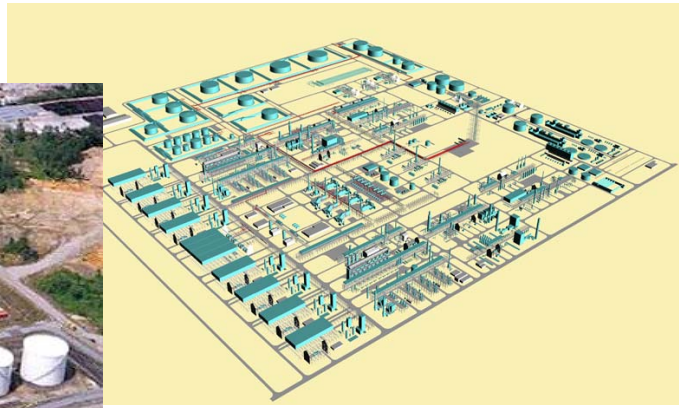
→ **A platform for exciting new industry based on unique new products**



Laboratory
1973

Pilot plant
1983

Bintulu Malaysia
14 700 b/d
1993



World-scale plant:
Shell Qatar GTL
140,000 b/d
around the end of the decade

Long lead times & entry hurdles characterize GTL development

In Summary

- Shell is building a world-scale GTL plant in Qatar
- Shell GTL Fuel is a premium quality diesel fuel
    - •High cetane
    - •Low density
    - •Virtually free of sulphur and

- Performance has been demonstrated in fleet trials conducted in the US and other parts of the world

- Emissions benefits compared to CARB ULSD have been demonstrated by CARB Verification Testing