Automotive Fuels – The Challenge for Sustainable Mobility

Directions in Engine-Efficienc

& Emissions Research

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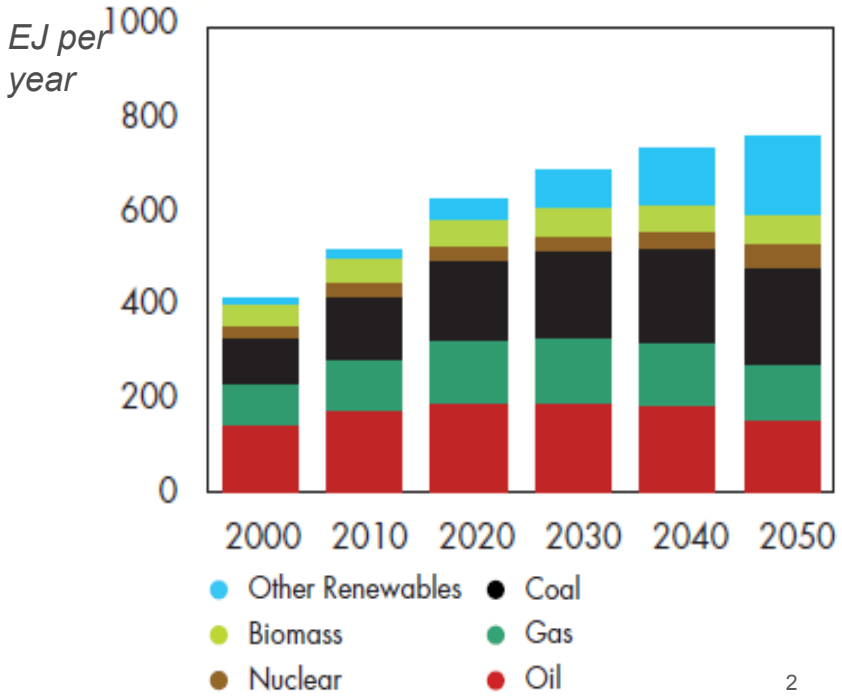
Dr.Wolfgang Warnecke,

Chief Scientist Mobility

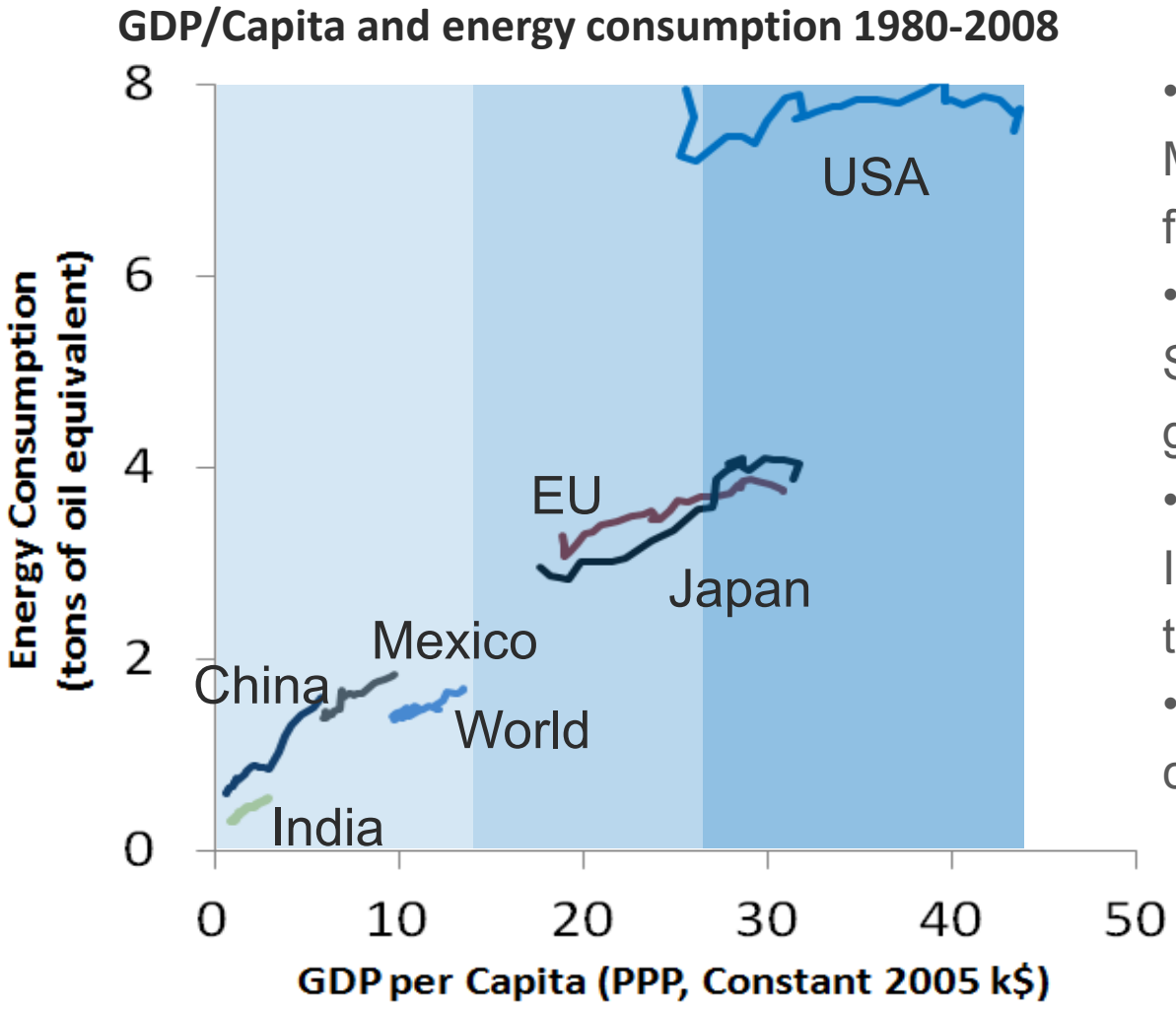
THE CHALLENGE - THE WORLD IN 2050

- 9 billion people
  - 2.5 billion more than today
- World population 70% urban
  - Every week equivalent of a new million-city is needed since doubling the urban population of developing countries
- 4 – 5 times richer
  - increased wealth in developing countries
- Doubling of energy consumption
  - Twice as much energy used
- Renewables play increasing role
  - 30% of energy supply will come from RES
- Hydrocarbons remain indispensible
  - About two thirds of global energy supply



* *(UN-Habitat 2006)*

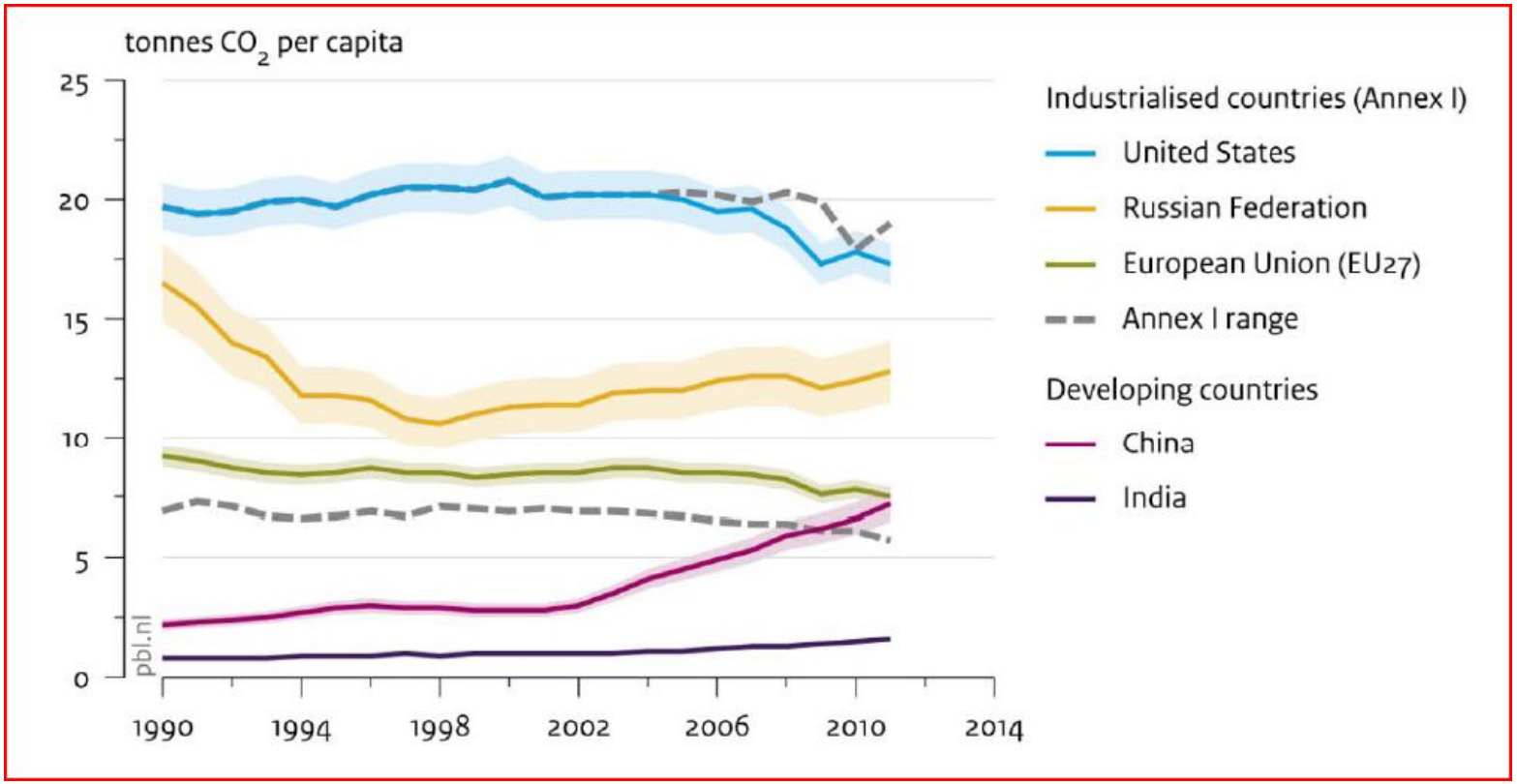
ENERGY DEMAND WILL INCREASE IN MANY REGIONS



- **>$25k/capita**:
  Marginal energy needed to fuel economic growth is small
- **>$15k/capita**:
  Services start to dominate growth of GDP.
- **>$5k/capita**:
  Industrialisation and mobility take off.
- Emerging countries are climbing the energy ladder

Source: Worldbank Database

Global Emission of Carbon Dioxide (CO_2)



Source: European Commission, JRC News Release, Ispra 18. July 2012

Global CO_2: + 3 % in 2012 vs 2011 (all-time high of 34 blnt in 2011)

- *China: avg. CO_2 emission increased by +9 % to 7.2 t per capita. China is now within the range of 6-19 t per capita emissions of major industrialized countries.*
- *EU: CO_2 emissions -3 % to 7.5 t per capita.*
- *US: remain one of the largest emitters of CO_2 (17.3 t per capita), despite a decline due to recession in 2008-2009, high oil prices& and increased share of natural gas.*

The Grand Challenge: **Elements defining Future Mobility**

Access to Energy/Fuels

- Which energy sources will meet the growing demand for mobility?

Total Cost of Ownership

- Which fuel/vehicle combination will allow mobility to remain affordable ?

World Population Growth & Urbanisation

- How will mobility & infrastructure concepts change mobility in Mega cities?

Reduction of GHG and local emissions

- Which fuel/vehicle combination will lead to the lowest amount of GHG and local emissions?

New Technology Options

- Vehicle Autonomous Drive, Continuous Connectivity, Safety Features (Night Vision, active braking, distance control, advanced stability control…)

Changing Consumer Values & Social Acceptance

- New consumer values – „Mobility on Demand“. Which factors drive social acceptance & the resulting uptake of new fuel/powertrain solutions?

Future Fuel Options

Dr. Wolfgang Warnecke

Chief Scientist Mobility

SHELL – FUTURE TRANSPORTATION FUELS

Premium Fuels	GTL Fuel	CNG/LNG	Biofuels	Hydrogen	Electricity
					
V-Power fuels: **Best performance in Latest engine technology** • In 60 markets since 1998 • VP-Diesel with unique GTL component • V-Power racing with 100 Octane and FMT-Technology • Shell Fuel Save for improved Fuel Economy	**Pioneer in the development of Gas to Liquid technology** Premium diesel containing GTL Fuel launched in: Austria, Germany, Greece, Italy, Netherlands, Switzerland and Thailand	**Natural gas will account for over half of Shell's total production in 2012** • Established CNG offers in dedicated markets • LNG for large engines (heavy duty on road / off-road, rail, marine)	**Leading in current and future biofuels** **First-generation** • 9,5 billion litres (2010) e.g. Brazilian Sugarcane Ethanol (COSAN JV) **Second-generation** IOGEN CORPORATION VIRENT CODEXIS	**World's largest public transport joint venture** Concentration of Demonstration projects in EU/D and USA, China	**Evaluation of Options**

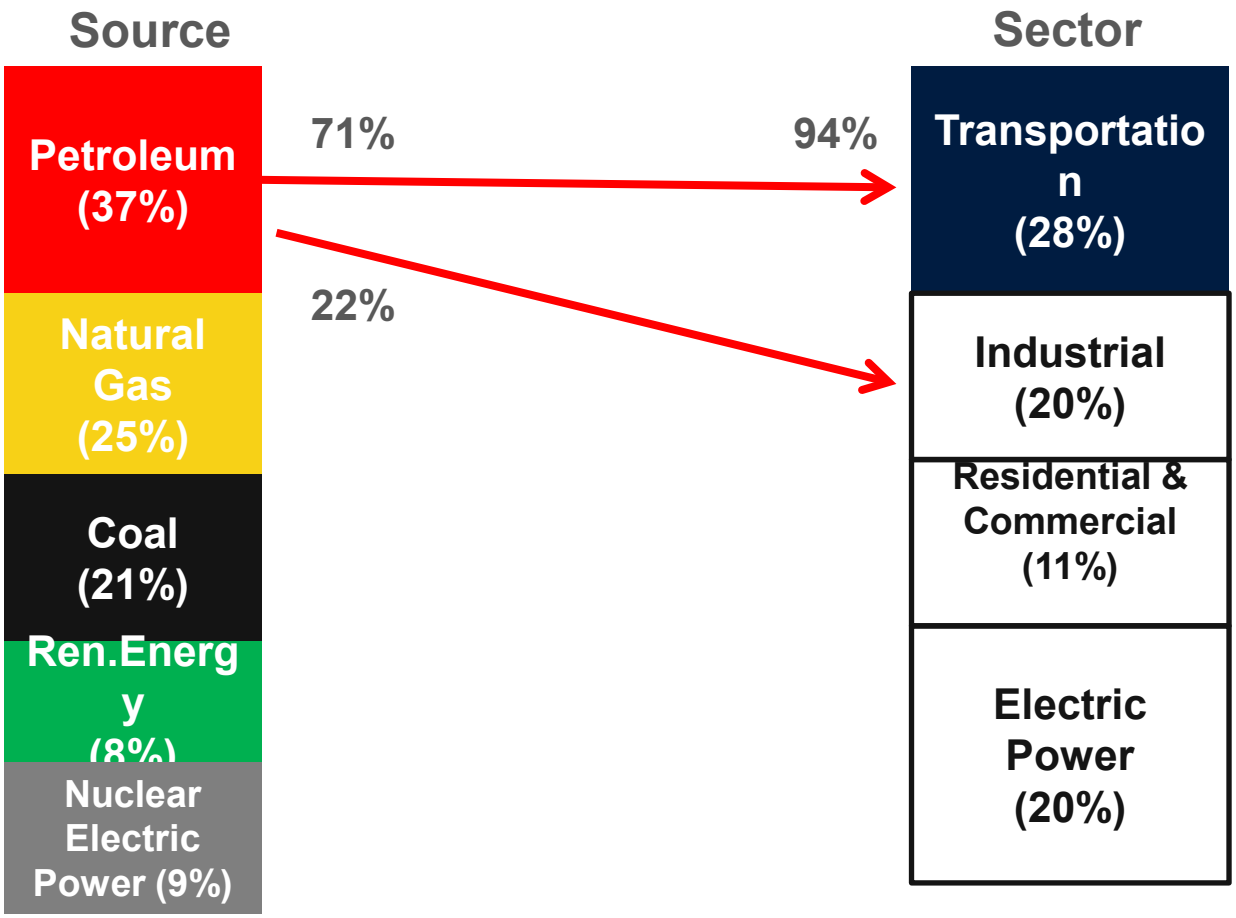
Performance fuels

Energy Diversification

... based on CO_2 solutions

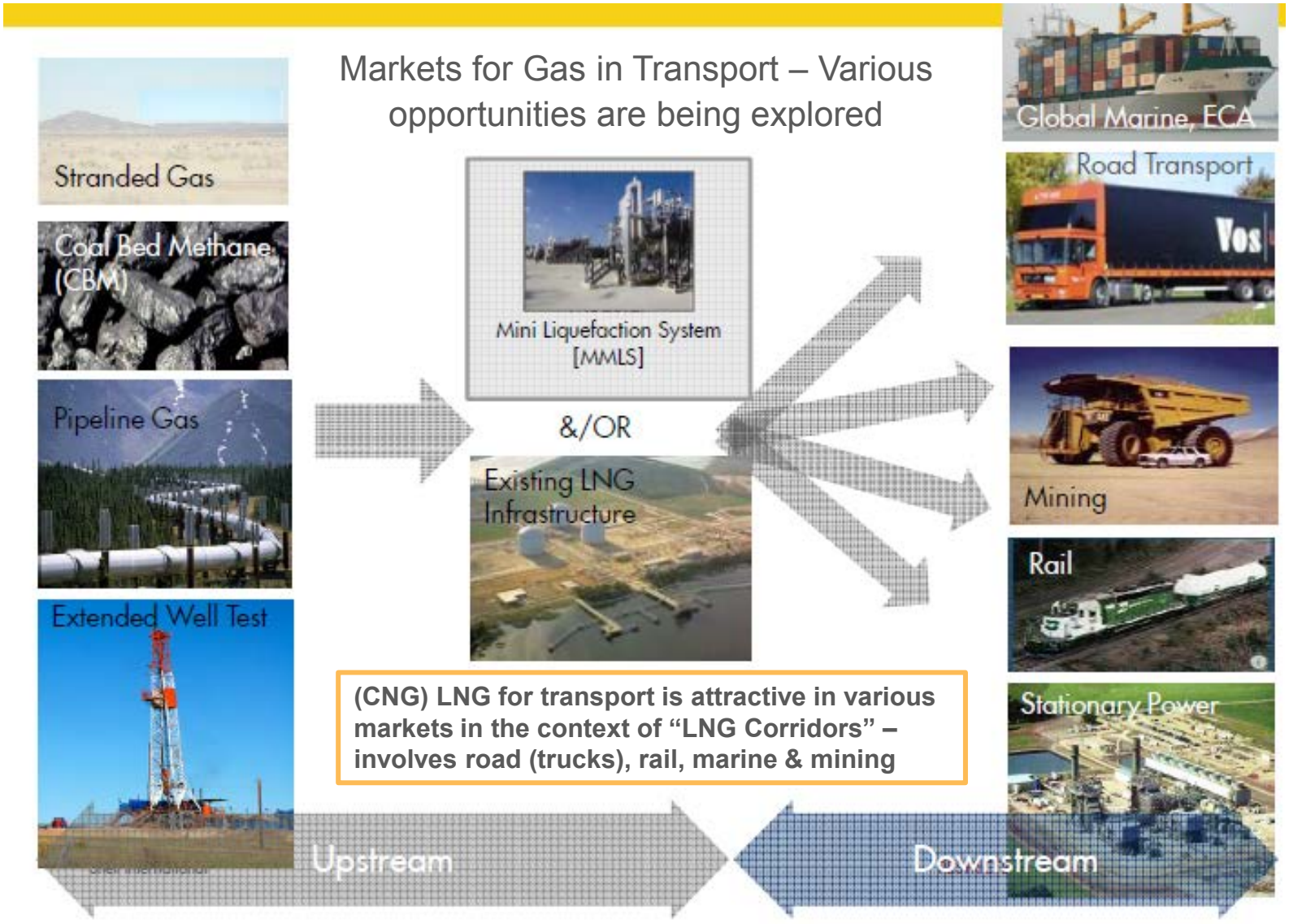
US MARKET ENERGY SUPPPLY & DEMAND

Transportation Fuels Today: 94+ % are crude oil based fuels



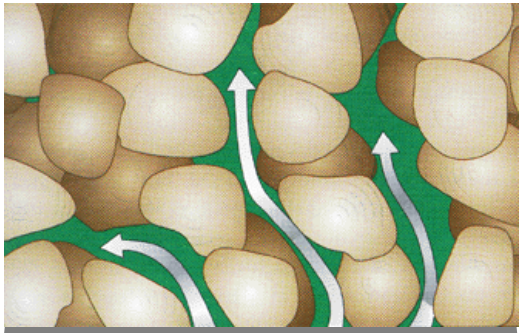
Source: EPA

ATTRACTIVENESS FOR 'MORE GAS'



UNCONVENTIONAL GAS DEFINITIONS

TIGHT GAS

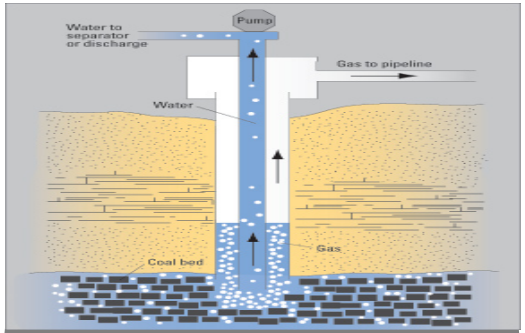


- Occurs in ‘tight’ sandstone
- Low porosity = Little pore space between the rock grains
- Low permeability = gas does not move easily through the rock

SHALE GAS

- Natural gas trapped betweens between layers of shale
- Low porosity & ultra-low permeability (0.02-0.1 mD)
- Production via natural fractures

COALBED METHANE



- Natural gas in coal (organic material converted to methane)
- Permeability low
- Production via natural fractures (“cleats”) in coal
- Recovery rates low

UNCONVENTIONAL GAS – GLOBAL GAS MARKET INFLUENCE

Source: Federal Energy Regulatory Commission (FERC)

Small Scale LNG – Upstream and Downstream drivers

Gas Supply

Means of Production and/or Means of Supply

LNG Demand

Stranded Gas

Coal Bed Methane (CBM) and other unconventional

Extended Well Test and flare gas

Pipeline Gas

Small Scale LNG

Existing Infrastructure

Pipeline Grid

Road transportation and rail

ECA Marine and inland water

Stationary Power

Mining and drilling rigs

BIOFUELS - THE SOLUTION IN TRANSPORT?

TODAY'S ROAD TRANSPORT BIOFUELS

Organic raw material	Process	Product
 Sugar cane	Fermentation	Ethanol (blend with gasoline)
 Corn		
 Wheat		
 Rape seed	Transesterification	FAME (blend with diesel)
 Palm oil	Hydro-treating	HVO (blend with diesel)
 Soya bean		

ALTERNATIVE FUEL VEHICLES TECHNOLOGY OPTIONS

Spark Ignition engine based

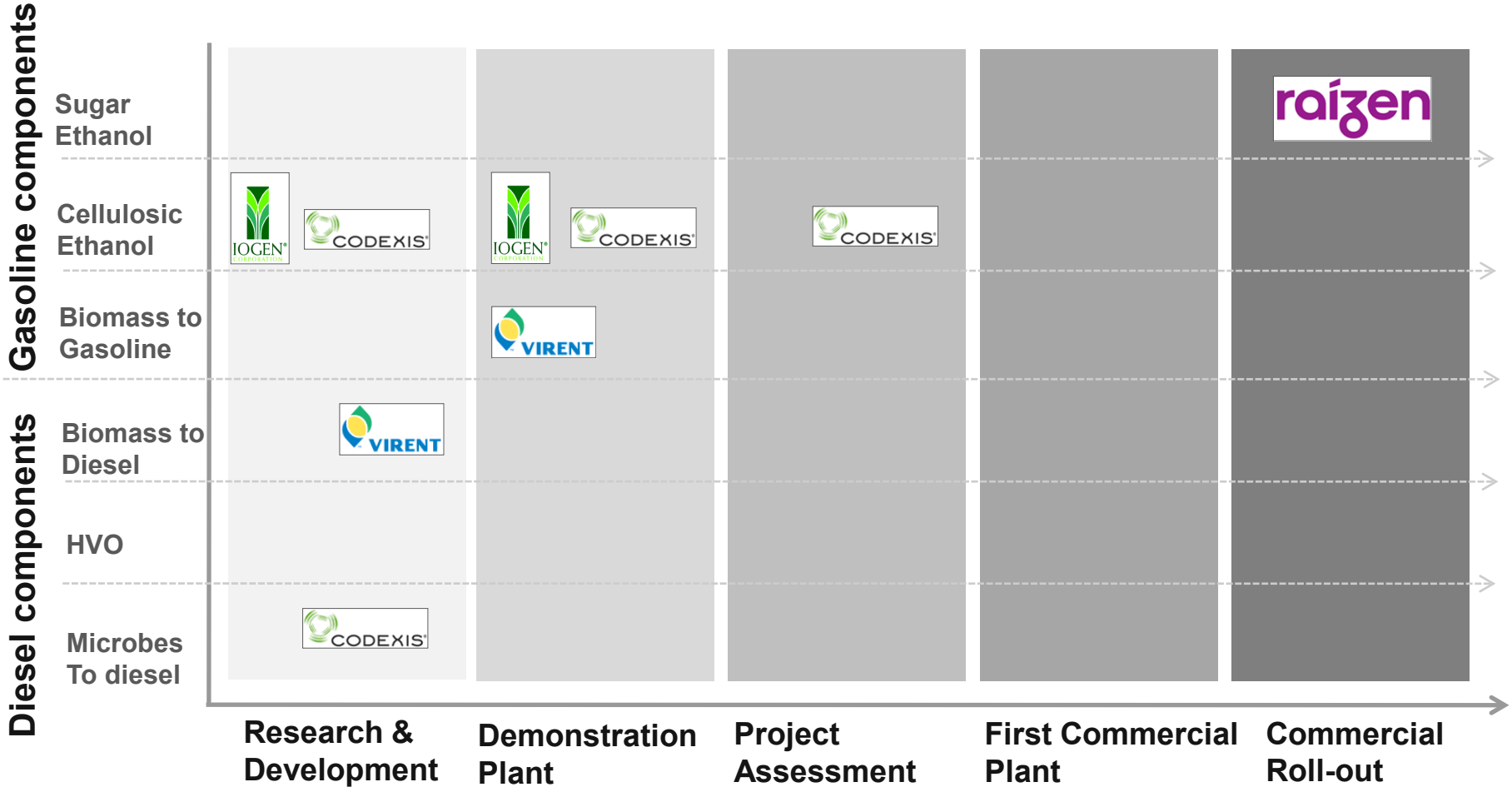
- **E20/25 or E85**
- CNG/ LNG
- LPG: local options
- Advanced Gen.Bio SI

Compression Ignition engine based

- **FAME**
- GTL
- **HVO**
- Advanced Gen.Bio CI

SCALING UP ADVANCED BIOFUELS

- Progressing new technologies from lab-based process to demonstration phase and towards commercial scale-up



HYDROGEN FOR TRANSPORT

Important role as an option to diversify road transport fuel

Hydrogen is used in hydrogen fuel cell vehicles

Enabling Emission Free Mobility (renewable H_2)

CO_2 benefit depends on how the hydrogen is produced

95% of hydrogen is currently produced from natural gas or gasifying coal

Requires new infrastructure

Industry cannot fund commercialisation

Government facilitated initiatives required to overcome market failure

OUTLOOK

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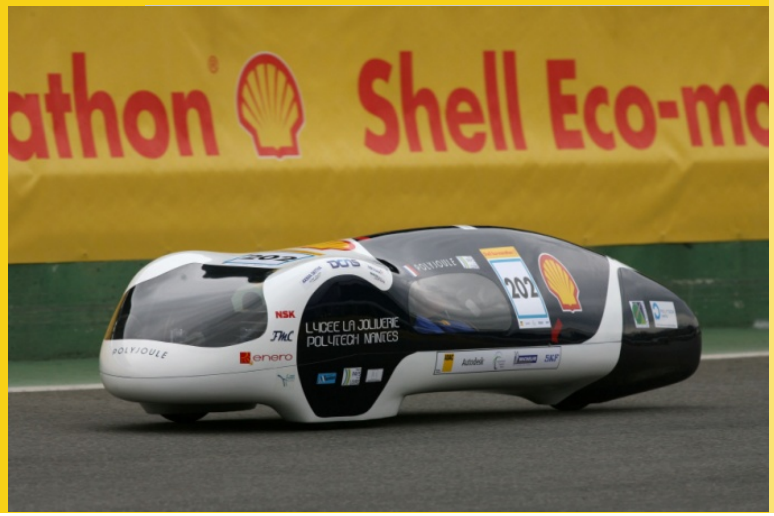
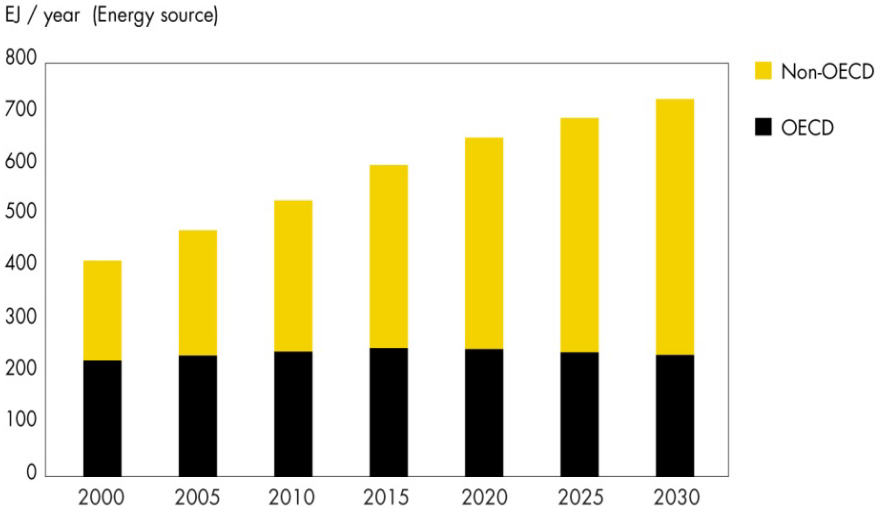
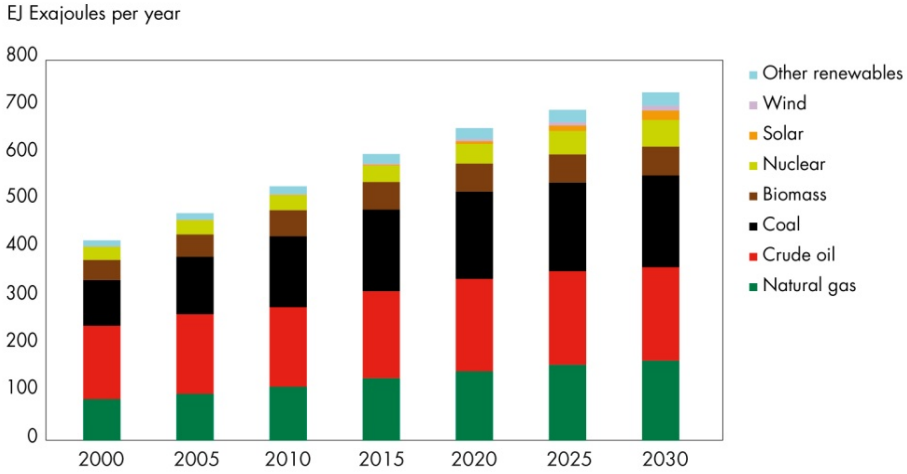


…ENERGY UNTIL 2030

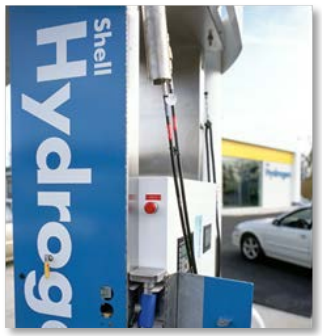




- Shift to the East continues
- Non-OECD demand climbs as economic growth continues to outstrip OECD nations
- Demand remaining strong in Middle East
- Gas % increases in the energy mix to 2030 driven by:
  - Economic development in emerging nations
  - Demand for lower carbon energy solutions

NO SINGLE ALTERNATIVE TO LIQUID FOSSIL FUELS

- All fuel options will be needed
- A range of drivers affects regional choice of fuel for mobility
- The internal combustion engine will continue to play an important role
- Natural gas (CNG, LNG & GTL) will continue to find further application in transport
- Improvements in CO_2 emissions through vehicle efficiency, fuel technology and driving habits
- Use of today‘s biofuels and that of advanced biofuels will be needed
- Electric and Hydrogen will play an important role - if technical, consumer and infrastructure challenges can be overcome



THE FUTURE IS HERE TODAY…