Outline

• Challenges for Fuels
• Energy Resources and Security
• Energy Options
• Pathways
• Biomass to Fuels
  – Short Term
  – Longer Term
• BP’s Biofuels Activity
• Fuels Perspective
What are the challenges for fuels?

Three key drivers of sustainable mobility solutions

• Air quality – particularly in developing markets
• Energy diversification and supply security
• Climate change

Economics & customer preference set the pathway
Heavy-duty diesel highway regulations force PM & NOx control.

PM, g/kW-hr; ESC test

NOx, g/kW-hr; ESC test

Euro VI
2010?

DPF+NOx

Euro V
2008

US2007
DPF+EGR

2005
SCR

Japan 2008
DPF+NOx

US2004
(2002)

DOC

Euro IV
2005

SCR

Japan 2005 DPF

US2010
DPF+NOx

Euro III
2000
nothing

From Corning, Inc.
Energy resources & security of supply

- Transport sector dependent on oil
- Oil availability sufficient out to ~2030
- Gas reserves somewhat more geographically dispersed than oil
- Huge coal reserves aligned with demand centers
- Renewables have large theoretical potential and generally more dispersed
- Regional drivers vary widely (LAQ, Security, GHG)
energy security - import dependence

**Oil**

- **Importers**
  - US
  - Other Dev.
  - China
  - FSU
  - Iraq
  - ME OPEC (excl Iraq)

- **Exporters**

**Natural gas**

- **Importers**
  - EU
  - US
  - Asian LNG (Japan, Korea, Taiwan)

- **Exporters**
  - Pacific/ME LNG
  - Other Europe pipeline
  - Canada
  - Russia ex FSU
Climate change and GHGs

Projection of CO₂ and Temperature to 2100

Source: Based on data from the Intergovernmental Panel on Climate Change
Options beyond Peak Oil

- **Heavy Oil / Tar Sands**
  - 300 billion barrels Canadian resource with current economics
  - 1 trillion barrels ultimate Canadian resource
  - Venezuelan deposits comparable magnitude

- **Shale Oil**
  - US Resource Base 1.2 trillion barrels
  - Renewed DOE and Shell publicity

- **Fischer Tropsch Liquids**
  - 1 Million BSD announced Gas to Liquids Projects in Qatar
  - Wyoming / Rentech study of Coal to Liquids ($40 / bbl)
  - China: Fischer Tropsch or DiMethyl Ether from Coal
Renewable Fuels Options

- **Biomass**
  - Direct conversion to liquids
  - Gasification

- **Food Crops**
  - Sugar Based Ethanol
  - Oil Based Biodiesel

- **Renewable Hydrogen**
BP fuels pathway to the future

Zero carbon

Low carbon

Intensive carbon

Fuel technology/ GHG emission reduction

Use of existing Fuel distribution infrastructure

New infrastructure

Internal Combustion Engine

Hybrid

Internal Combustion Engine

Fuel Cell

Renewable or low carbon hydrogen

Future evolution of gasoline and diesel

Future biomass conversion technologies

Clean conventional fuels including increased dieselisation

Conventional biocomponents

Vehicle Technology/ Time
WTW GHG Benefit vs. Cost

- High Benefit, Moderate Cost
- High Benefit, High Cost

% GHG Benefit vs. Gasoline/diesel baselines

- Conventional Biofuels
  - Ethanol, wheat
  - CNG
  - GTL Diesel

- Advanced Biofuels
  - FT Diesel, Ex wood
  - LC Ethanol, Ex wood
  - Biodiesel, RME

- Renewable & low carbon Hydrogen
  - H2-Renewable fuel cell
  - H2 from Natural Gas/fuel cell

Cost for Substitution
€/100km

Biofuels Overview - the carbon cycle

$\text{CO}_2$

one carbon atom as CO$_2$ removed from atmosphere during photosynthesis

Carbon in crop or crop residue

$\text{-C-}$ in cellulose/sugar/starch

Biomass growth

Processing to produce biofuel

$\text{-C-}$ in fuel molecules

Biofuel

Use in vehicle

$\text{CO}_2$

Same carbon returned to Atmosphere as CO$_2$

$\text{-C-}$

WTW GHG emission result for biomass pathways. Contribution from above closed cycle is zero

External energy and associated GHG emissions for farming (eg from fertiliser use)

External energy and emissions for fuel production process

External energy for distribution & transportation
Biofuels – Pathways

Sugar & starch crops -> Ethanol for gasoline

Oil crops -> Esters for diesel

Lignocellulosics etc. -> Other blend components or precursors -> Superior Fuel Molecules

Further conversion
Two technologies look to offer greatest promise

Sugar Platform

Biological Conversion

Low intensity Biomass (waste, cellulosics)

Syngas Platform

FT or other conversion

Fuel Molecules
What is needed?

- Fuels that can be produced from domestic, renewable resources in high volume and reasonable cost.
- Fuels that can be used in existing vehicles and existing infrastructure.
- Fuels that offer good value to consumers.
- Fuels that meet the evolving demands of vehicles.
BP’s Biofuels Activity

Europe
- British Sugar plant in UK for biobutanol production
- First major to introduce 5% FAME blend in Germany
- Across Europe ETBE replaces MTBE
- EBI Institute University TBD

India
- $9.4M project of Jatropha “oil bearing crops” for diesel fuel
- E85 introduction in selected markets by end of 2006
- EBI Institute University TBD

US
- Largest user of Ethanol in gasoline
- 20 new markets added in 2005
- Biodiesel to small number of B2B, evaluating more widespread customer offer
- EBI Institute University TBD
- E85 introduction in selected markets by end of 2006

Asia
- Round table sustain Palm Oil

ANZ
- Supplying Ethanol to retail sites in QLD
- Renewable diesel via tallow
BP’s New Biofuels Business

• Formed a new Biofuels business in June
• Announced plans to invest $500 M in new Energy Biosciences Institute to provide a pipeline of biofuels technology for the business
• Will partner with science company DuPont to develop advanced biofuels-the first introduction is biobutanol.
• BP & DuPont collaborating with British Sugar to convert an ethanol fermentation facility to produce biobutanol
• Initial production targeted in the UK during 2007
• Need consumer’s acceptance
  – Reliable, consistent, convenient
  – Cost-Effective
  – Quality & Fit for Purpose

• Societal Requirements
  – Energy efficient, wells-to-wheels analysis
  – Low carbon/no carbon, reduce GHG
  – Impact on environment
    – Air
    – Water
    – Soil
  – Safe
  – Infrastructure
  – Vehicle requirements
    – Systems Approach
    – Fuel + Vehicle + Engine + After treatment
Public Policy Framework

• Focus on goals
  – Give the market room to develop innovative solutions

• Emphasize solutions that can be used in existing vehicles and delivered through existing infrastructure
  – These will provide the quickest results at the lowest cost

• Make room for innovation
  – Yesterday’s molecules may not be the best answer for today’s vehicles
  – Research can produce improved solutions for tomorrow – but only if they are allowed room to compete in the marketplace
Conclusion

• BP sees an exciting and challenging future
  – Continuous improvement in conventional vehicles, engines & fuels
  – New opportunities in Alternative Fuels
    – Biomass based
    – Sugar & Gasification
    – New Molecules
  – Route to hydrogen
    – Work with USDOE and European Governments
  – Customer requirements