CO₂ abatement in the Energy and Petrochemicals industry



Business as usual - total final consumption



Source: Shell International BV and Energy Balances of OECD and Non-OECD Countries ©OECD/IEA 2006

Energy sustainability drives mix- Blueprints

Total primary energy (EJ per year)



- Broad awareness of challenges at all levels, not only national
- Critical mass of parallel responses to hard truths
- Effective carbon pricing established early
 - Rerouted to renewables
 - Taxes on imported fossil fuels
- Efficiency standards
- Electrification of transport sector
- New infrastructure develops e.g. CCS emerges after 2020

■ Oil ■ Gas ■ Coal ■ Nuclear ■ Biomass ■ Solar ■ Wind ■ Other Renewables

GHG abatement: beyond business-as-usual 2030



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO₂e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play. Source: Global GHG Abatement Cost Curve v2.0

Global GHG Emissions



* The estimate of behavioral change abatement potential was made after implementation of all technical levers; the potential would be higher if modeled before implementation of the technical levers. Source: Global GHG Abatement Cost Curve v2.0; Houghton; IEA; US EPA

Technology Challenges

MORE ENERGY

- Recovery and Upgrading of unconventional hydrocarbons
- Energy from contaminated gas (H_2S, CO_2)
- Transportation fuels from sustainable sources of biomass

LESS CO₂

- Process intensification (energy efficiency, capex)
- Capture / use of low value process heat (60 200 °C)
- CO₂ capture and storage

In-Situ Upgrading Process (IUP)

STANDARD IN SITU RECOVERY



Gas Separation - Technology 1

Conditions

- -62 deg C < T < -20 deg C
- Pressure 10 30 bara
- Separates CO₂ as a liquid



Gas Separation - Technology 2







BIOMASS: moving to the next generation



TO BIO-ENERGY AND WASTE ORGANIC FEED STOCKS

Application: Cellulosic Ethanol





Application: **BTL**





Application: Algae Diesel



Cellana (Shell/HR Biopetroleum)



Process Technology Challenges

MORE ENERGY

- Recovery and Upgrading of unconventional hydrocarbons
- Energy from contaminated gas (H_2S, CO_2)
- Transportation fuels from sustainable sources of biomass

LESS CO₂

- Process intensification (energy efficiency, capex)
- Capture / use of low value process heat (60 200 °C)
- CO₂ capture and storage

Improvement of GTL catalyst performance



Gasturbine Efficiency Improvements



Power generation Efficiency: Refinery Trend





Carbon Capture and Storage Technologies



Efficiency Improvements

Of both energy using equipment and processes

Cleaner Generation

Fuel switch

Technology Challenges

- Novel Catalyst/Reactor Combinations
- Novel Separations
- Equipment development
- Reduction in CAPEX Intensity
- Reduction of Environmental Footprint
- Smart Fields, Plants and Sites
- Distributed Manufacturing

BIG IMPACT: from small innovations



