



Shell Global Solutions

Integrated Production of Energy and Other Products through the Concept of Biorefinery

BioRefintec, 24 April 2007, Amsterdam

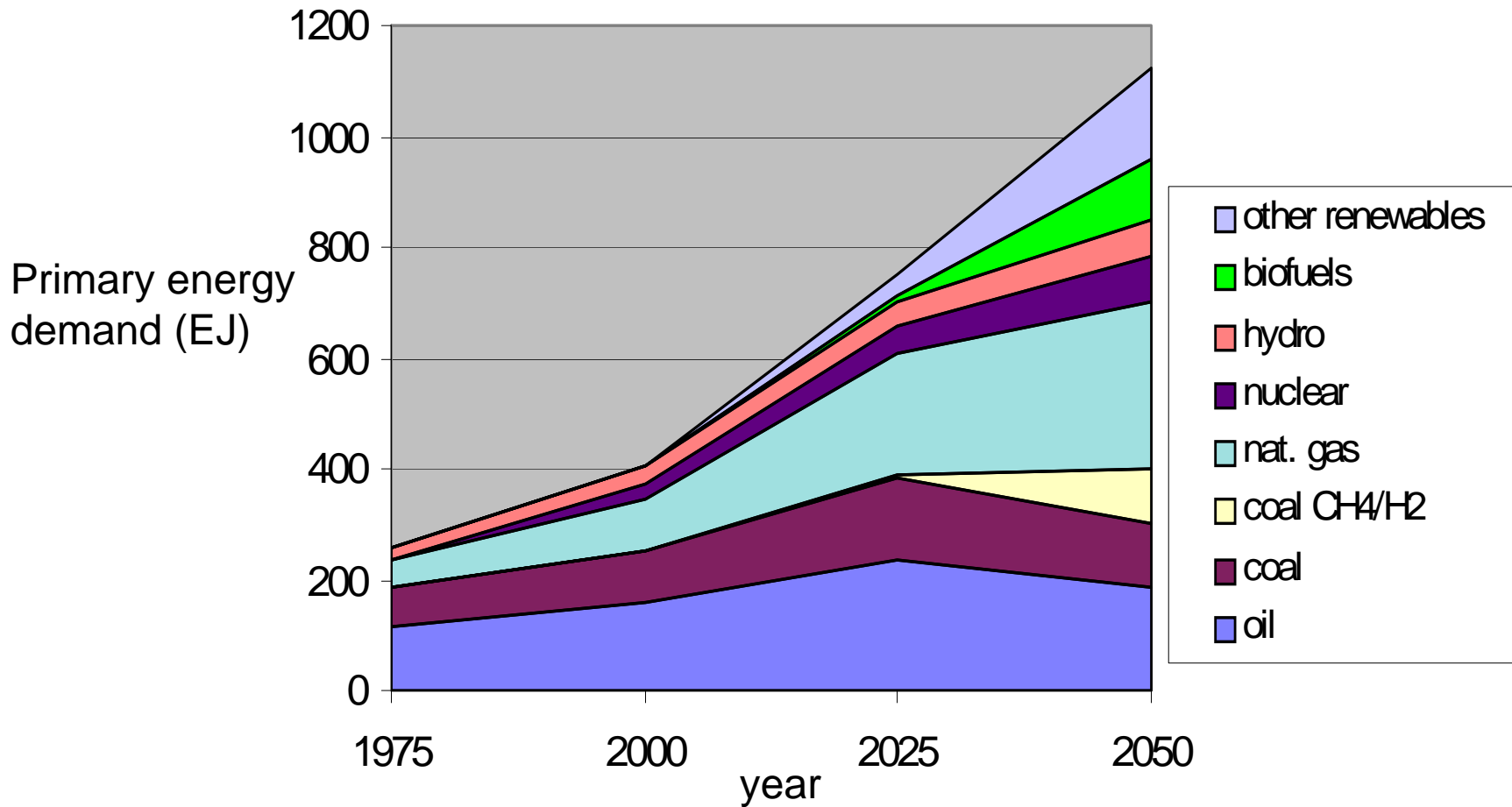
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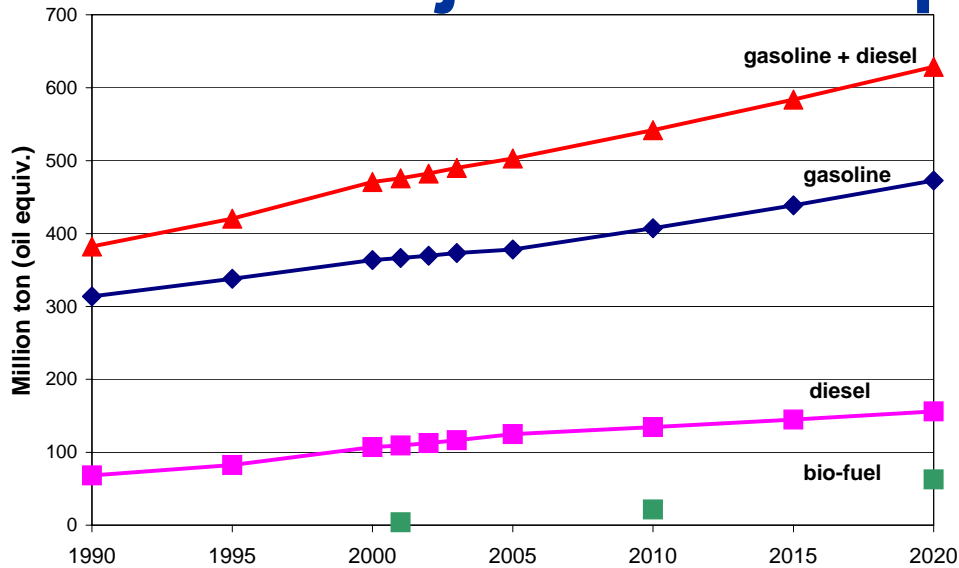


Future energy scenarios

“Spirit of the Coming Age” Scenario – see www.shell.com/scenarios



Projected transport fuels demands



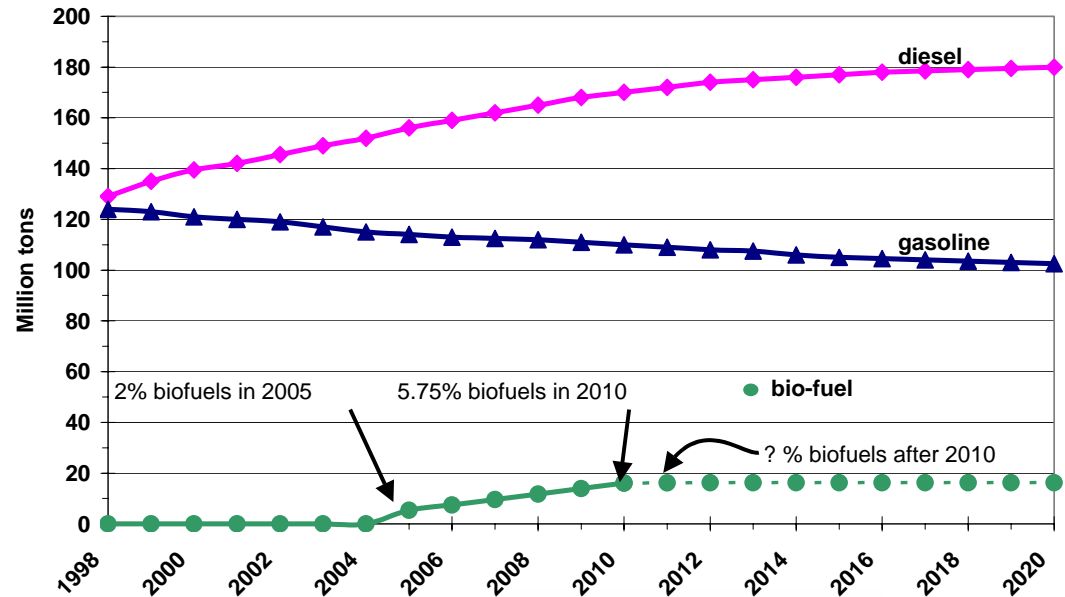
USA

bio-fuel based on Vision for bio-energy and bio-based products in the USA



EU15

bio-fuels based on EU directive



Source:Harts fuel conference, May 2001

Future Energy: Renewable options

- Biomass - different types, sources of biofuels and power - potentially very large resource but transportation and logistics issues
- Hydropower - advantage of peak load capability
- Solar – photovoltaic and solar thermal
- Wind – doubled every 3 yrs for past decade – government support necessary. More political than technology hurdles ?
- Geothermal – hot fluids that can be reached economically
- Tidal schemes – localized solutions, but highly predictable
- Nuclear

Most require stable investment and political climates and subsidies/tax credits

Biofuels: Drivers

Shell is currently the leading distributor of biofuels, ca. 3 billion liters in 2005. All based on first generation biofuels, i.e. corn ethanol, and FAME.

- Crude oil replacement
- Fits with Shell's Sustainable Development strategy, improved feedstock flexibility
- EU directive EC 2003/30/EC:
 - 2 % by 31 December 2005
 - 5.75 % by 31 December 2010 on energy content basis of "all petrol and diesel for transport purposes"
- **Mandatory blending** from 2007+ in Austria, Belgium, Czech Republic, (France), Germany, Holland, Sweden, Brazil, Phillipines and Thailand
- US Renewables Fuels Standard targets and UK Renewable Transport Fuel Obligation
- Fossil-fuel based CO₂ emission abatement

Shell's biofuels/biorefining activities

Aim: to develop second generation bio-based components via partnerships

- logen: ethanol from straw
- CHORen: paraffins via gasification and FT synthesis
- R & D on (co)processing triglycerides
- BIOCOUP: pan-European consortium on pyrolysis oil upgrading
- Others

Biomass resources

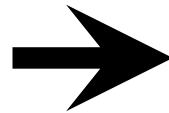
Current biomass resources

Sugar & starch

Maize, wheat, sugar beet/cane

Vegetable oils

Rapeseed oil, palm oil, etc.



Future biomass resources

Should not compete with food & fibre

Residues:

from agriculture & forestry:

Straw, bagasse, thinnings

Non-edible oils (Jatropha, animal fats)

Energy crops (expected later):

Switch grass, Willow, etc.

Global potential of ligno-cellulose co-products: > 5 GT/a

Sourcing must be done in a sustainable way !

Various biofuels options

For gasoline:

- Bio-ethanol from fermentation of glucose to ethanol by *S. Cerevisiae* using sugar cane (Brazil), sugar beet, corn stover (USA)
- **logen**, Abengoa, NREL etc
- ETBE
- Ethyl ethers of Light Cracked Naphthas
- others

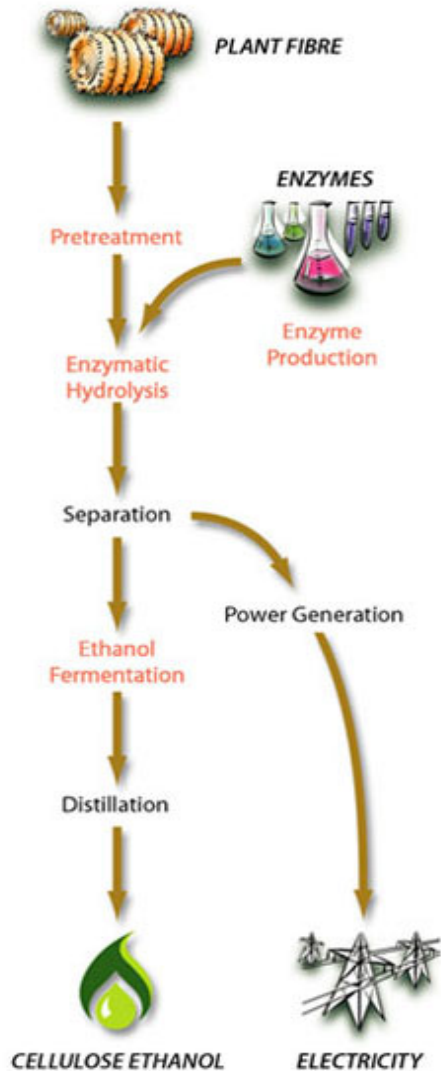


For diesel:

- FAMEs from trans-esterification of vegetable oils
- **CHORen BTL**
- Hydrotreated vegetable oils (e.g. Neste NExBTL, Petrobras H-Bio, BP etc)
- DME (Volvo)
- others



logen: ethanol from ligno-cellulosic biomass



- logen concept can also produce energy carriers such as ethanol, and lignin for heat and power
- Shell took minority share in logen (~US\$ 30 mln)
- Higher CO₂ reduction potential (90%)
- April 2004 start of eco-ethanol production
- Full scale commercial plant expected 2008/9
- Capacity 100-200 million litre; 350 – 700 kton_{dm} wheat straw
- US DoE gave an up to \$80 million grant

Photos: logen



CHOren: BTL from lignin or ligno-cellulosic biomass

- Shell took minority share in CHOREN
- Higher CO₂ reduction potential
- Carbo-V[®]- process for syngas production; FT-synthesis from Shell
- Pilot plant in Freiberg is running
- Small scale demonstration plant: 18 million litre BTL capacity; start up in 2007 in Freiberg/D (67 kton biomass feedstock/a)
- Large scale industrial plant: 200 kton BTL/a, planned for 2009/10 in Germany; 1 million ton/a feedstock requirement



Biorefining

- (Co)processing triglycerides in standard refinery units
- Anonymised” products - removal of O has fuel energy density benefits
- Complementary to the blending of discrete bio-components
- Seamless integration of products in diesel supply chain and allows phased implementation
- Technical and economic challenges

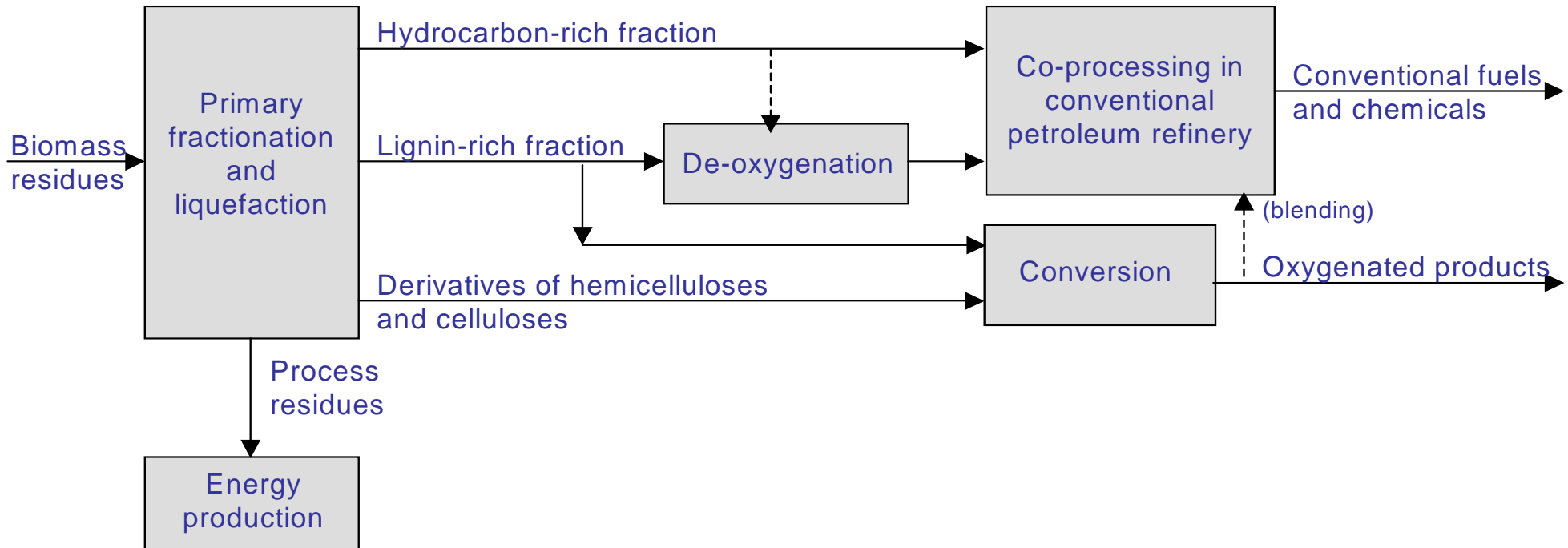
Third generation biofuels

BIOCOUP: Co-processing of upgraded bio-liquids (i.e. pyrolysis oil) in standard refinery units

Started 1 May 2006 for 5 years (EU subsidy M€7.6)

Pan-European Consortium (16 partners)

VTT is project coordinator; Schaverien is Head of Supervisory Board



Why pyrolysis oil/liquefaction ?

- Precursors do not compete with food chain
- Offers a plentiful, and potentially, inexpensive source of bio-liquids
- Liquids – allow easier handling and distribution
- Potential of biomass pre-treatment step cheaper than existing 2nd generation biomass pre-treatment steps
- Fast pyrolysis technique already established (Ensyn, DynaMotive, BTG) with designs for medium size units (50 – 200 tons/day)
- Multiple products accessible (energy, fuels, chemicals)
- Technical and economic challenges

BIOCOUP Consortium

VTT Processes	Finland	Solantausta
Biomass Technology Group	Holland	van de Beld
University of Twente	Holland	Prins, Kersten
Shell Global Solutions	Holland	Schaverien
CNRS-IRC	France	Mirodatos
Arkema	France	Bortzmeyer
UHPT	Germany	Bork
Albemarle	Holland	Langereis
Metabolic Explorer	France	Gonzalez
STFI Packforsk	Sweden	Axegård
University of Groningen	Holland	Heeres
Technical University of Helsinki	Finland	Krause
Institute of Wood Chemistry	Germany	Meier
Slovenian Institute of Chemistry	Slovenia	Grilc
Boreskov Institute of Catalysis	Russia	Yakovlev
Chimar	Greece	Athanassiadou
Alma Consulting Group	France	Bernadini

Some of our issues and concerns

- “Biorefinery” can mean many different things, depending on perspective

Multiple platforms: sugars, thermo-chemical, gasification (scale)

- Overall energy efficiency of biofuels.
- Not all biofuel components generate the same CO₂/GHG benefits.
- There should be internationally recognised systems to determine this - it might be worth considering biofuel legislations based on CO₂/GHG benefits.
- Biofuel sustainability is a key concern for Shell - by sustainability we mean environmental and social dimensions involved in the production of the biofuel components, from biomass to end-product.

Conclusions

- Renewables will remain a complex and varying mix – real winners not yet clear but biofuels expected to be a major contributor
- Biofuels are real, Shell is actively involved in developing/investing in biofuels initiatives
- 2nd generation biofuels development is more complex than 1st generation and will be introduced only gradually into overall biofuel mix.