

# Updates from IEA Bioenergy Task 39 & The biorefining story: Developments at the University of British Columbia

W.E. Mabee<sup>1</sup>, J.N. Saddler<sup>1</sup>, presented by M. Wörgetter<sup>2</sup>

<sup>1</sup>University of British Columbia, Vancouver, Canada

([warren.mabee@ubc.ca](mailto:warren.mabee@ubc.ca))

<sup>2</sup>FJ-BLT Wieselburg, Austria (<http://blt.josephinum.at>;

[manfred.woergetter@josephinum.at](mailto:manfred.woergetter@josephinum.at))

IEA Bioenergy Task 38 “Greenhouse Gas Balances of Biomass and Bioenergy Systems”

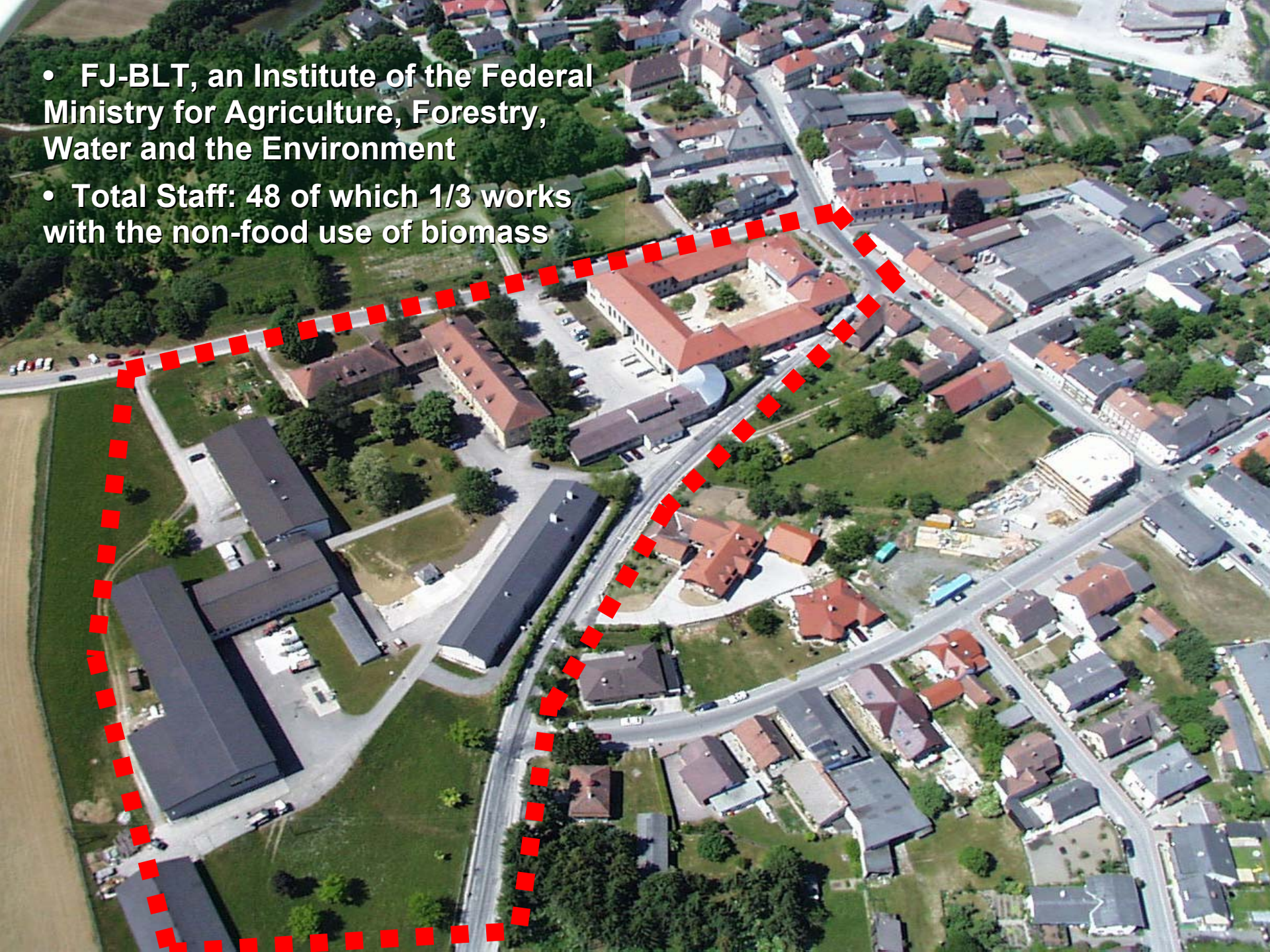
International Workshop on Transportation Biofuels: For greenhouse gas mitigation, energy security or other reasons?

Tuesday, 5 February 2008, Salzburg, Austria

# Content

- **Introducing Myself**
- **Introducing the Liquid Biofuels Task**
  - Some results of the past periods
  - Objectives and projects of the current period
- **The Biorefining Story**
  - Developments at the University of British Columbia

- FJ-BLT, an Institute of the Federal Ministry for Agriculture, Forestry, Water and the Environment
- Total Staff: 48 of which 1/3 works with the non-food use of biomass



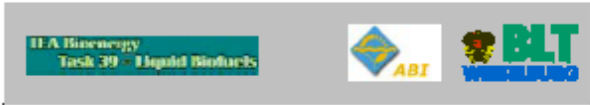
# Introducing FJ-BLT and myself

- An Institute of the Federal Ministry for Agriculture, Forestry, Water Management and the Environment, total staff: 48 of which 1/3 works with biomass
- Personal Profile
  - Leader of the Research Department
  - Advisor for the Ministry
  - Since 1975 with energy from biomass
    - 1975 Wood gasifier for farm tractors;
    - 1976 Vegetable oil as Diesel fuel
    - 1978 Biomass for heat production
    - 1980 Methyl ester as Diesel fuel
    - 1987 Biodiesel pilot project
    - 1994 IEA Bioenergy Liquid Biofuels Activities
  - 2003 Key Researcher in the private Austrian Bioenergy Centre [www.abc-energy.at](http://www.abc-energy.at)

## Some results of the past Task 39 period

- **Biofuels in the EU: An overview on the EU biofuels policy**
- **Biodiesel production: Technology and European providers**
- Biofuel implementation agendas: A review of Task 39 member countries
- Ethanol from lignocellulosics: Comparing biofuel technology options
- Second generation biofuels: A review from a market barrier perspective
- Biodiesel markets in Europe: Lessons learned for North America
- Biofuels today, tomorrow and in future
- Ethanol from lignocellulosics: Policy options for bioethanol production
- Best case studies on biodiesel production plants in Europe
- Ethanol from lignocellulosics: Views to implementation
- Review on biodiesel standardization world-wide
- Rapeseed oil as fuel for farm tractors
- Worldwide review on biodiesel production

Biodiesel results of past periods: [www.task39.org](http://www.task39.org)



## WORLDWIDE REVIEW ON BIODIESEL PRODUCTION

Prepared for  
IEA Bioenergy Task 39, Subtask „Biodiesel“

Prepared by  
Austrian Biofuels Institute, [www.biodiesel.at](http://www.biodiesel.at)

W. Körbitz<sup>a</sup>  
St. Friedrich<sup>b</sup>  
E. Wälgler<sup>c</sup>  
M. Würgetter<sup>c</sup>

<sup>a</sup> Austrian Biofuels Institute, Vienna  
<sup>b</sup> Institute for Technology, University of Economy, Vienna  
<sup>c</sup> Federal Institute for Agricultural Engineering, Wieselburg

IEA Bioenergy August 11, 2003



## BEST CASE STUDIES ON BIODIESEL PRODUCTION PLANTS IN EUROPE

Prepared for  
IEA Bioenergy Task 39, Subtask „Biodiesel“

Prepared by  
Austrian Biofuels Institute, [www.biodiesel.at](http://www.biodiesel.at)

W. Körbitz<sup>a</sup>  
Ch. Berger<sup>a</sup>  
E. Wälgler<sup>c</sup>  
M. Würgetter<sup>c</sup>

<sup>a</sup> Austrian Biofuels Institute, Vienna  
<sup>b</sup> Institute for Technology, University of Economy, Vienna  
<sup>c</sup> Federal Institute for Agricultural Engineering, Wieselburg

IEA Bioenergy February 11, 2004

Biodiesel results of past periods: [www.task39.org](http://www.task39.org)

IEA Bioenergy  
Task 39 - Liquid Biofuels



## REVIEW ON BIODIESEL STANDARDIZATION WORLD-WIDE

Prepared for

IEA Bioenergy Task 39, Subtask „Biodiesel“

Prepared by

BLT Wieselburg, [www.bl.bmfuw.gv.at](http://www.bl.bmfuw.gv.at)

Heinrich Prankl  
Werner Körbitz  
Martin Mittelbach  
Manfred Wörgetter

IEA Bioenergy

May 2004

IEA Bioenergy  
Task 39 - Liquid Biofuels



## RAPSEED OIL AS FUEL FOR FARM TRACTORS

Prepared for

IEA Bioenergy Task 39, Subtask „Biodiesel“

Prepared by

BLT Wieselburg, [www.bl.bmfuw.gv.at](http://www.bl.bmfuw.gv.at)

A. Ammerer  
J. Rathbauer  
M. Wörgetter

IEA Bioenergy

August 12, 2003

## BIOFUELS IN THE EU:

AN OVERVIEW ON THE EU BIOFUELS POLICY  
A REPORT TO IEA BIOENERGY TASK 39

**AUTHORS:**

Bolter, Inge  
Bacovsky, Dana  
Wörgetter, Manfred



Report T39-B7 10 October 2007

**Full Citation**

Bolter, I., Bacovsky, D., Wörgetter, M. (2007). Biofuels in the EU. An overview on the European biofuels policy. IEA Task 39 Report T39-B7, 37 pp.

This report describes the development of the EU biofuels policy, including steering instruments and established lobby organizations. Furthermore it delivers abstracts of the respective EC documents, and links the reader to the full documents and other relevant websites in the world wide web.





## BIODIESEL PRODUCTION: TECHNOLOGIES AND EUROPEAN PROVIDERS

A REPORT TO IEA BIOENERGY TASK 39

AUTHORS (in alphabetical order)

Baovovsky, Dina  
Körbitz, Werner  
Mittelbach, Martin  
Wörgetter, Manfred



BLT  
WIESELBURG  
BLT Wieselburg



Austrian Biofuels Institute



Karl Franzens University Graz

Report T39-B6 06 July 2007

Full Citation

Baovovsky, D., Körbitz, W., Mittelbach, M., Wörgetter, M. (2007).  
Biodiesel Production: Technologies and European Providers. IEA  
Task 39 Report T39-B6, 104 pp.

## BIODIESEL MARKET DEVELOPMENT IN EUROPE: LESSONS LEARNED FOR NORTH AMERICA

PHASE 1

Prepared For:

IEA Bioenergy  
Task 39

Prepared By

(S&T)<sup>2</sup> Consultants Inc.  
11657 Summit Crescent  
Delta, BC  
Canada, V4E 2Z2

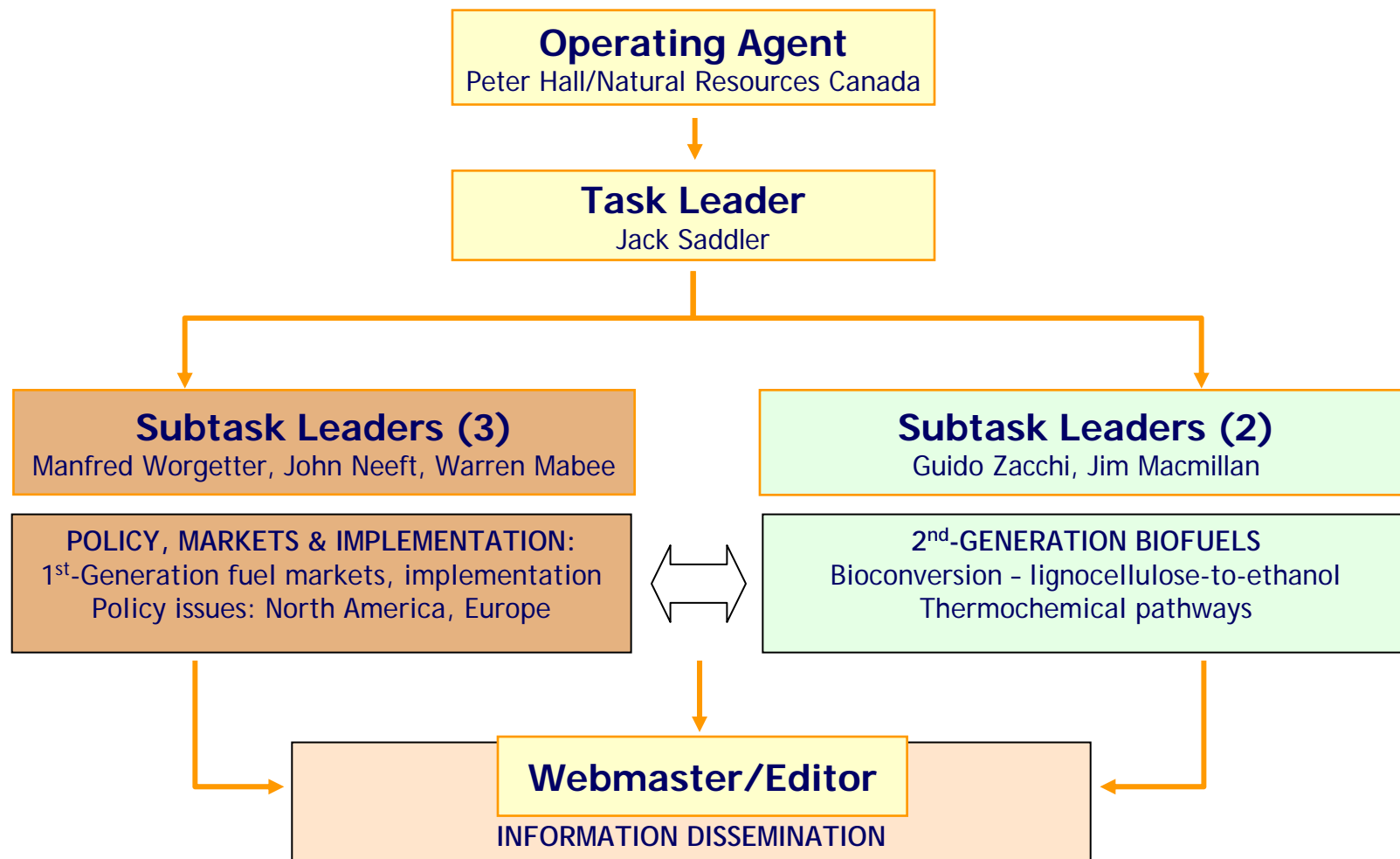
Not public available today

# IEA Bioenergy Task 39

## Commercializing 1<sup>st</sup>- and 2<sup>nd</sup>-Generation Liquid Biofuels from Biomass

Task Leader: Jack Saddler, University of British Columbia

# Task Structure



## European Commission

*Kyriakos Maniatis*

### Norway

*Lars Sorum, Karin Oyass, Roger Khalil*

### Finland

*Tuula Makinen, Niklas von Weymarn*

### Sweden

*Guido Zacchi, Bärbel Hahn-Hägerdal*

*Alice Kempe*

### Denmark

*Birgitte K. Ahring, Lisbeth Olsson*

### Germany

*Axel Munack*

### Austria

*Manfred Wörgetter*

### The Netherlands

*John Neeft, René Wismeijer*

### United Kingdom

*Tony Sidwell*

### Ireland

*Jerry Murphy*

### Japan

*Shiro Saka, Y. Kobe*

### Canada

*Jack Saddler, Warren Mabee*

### United States

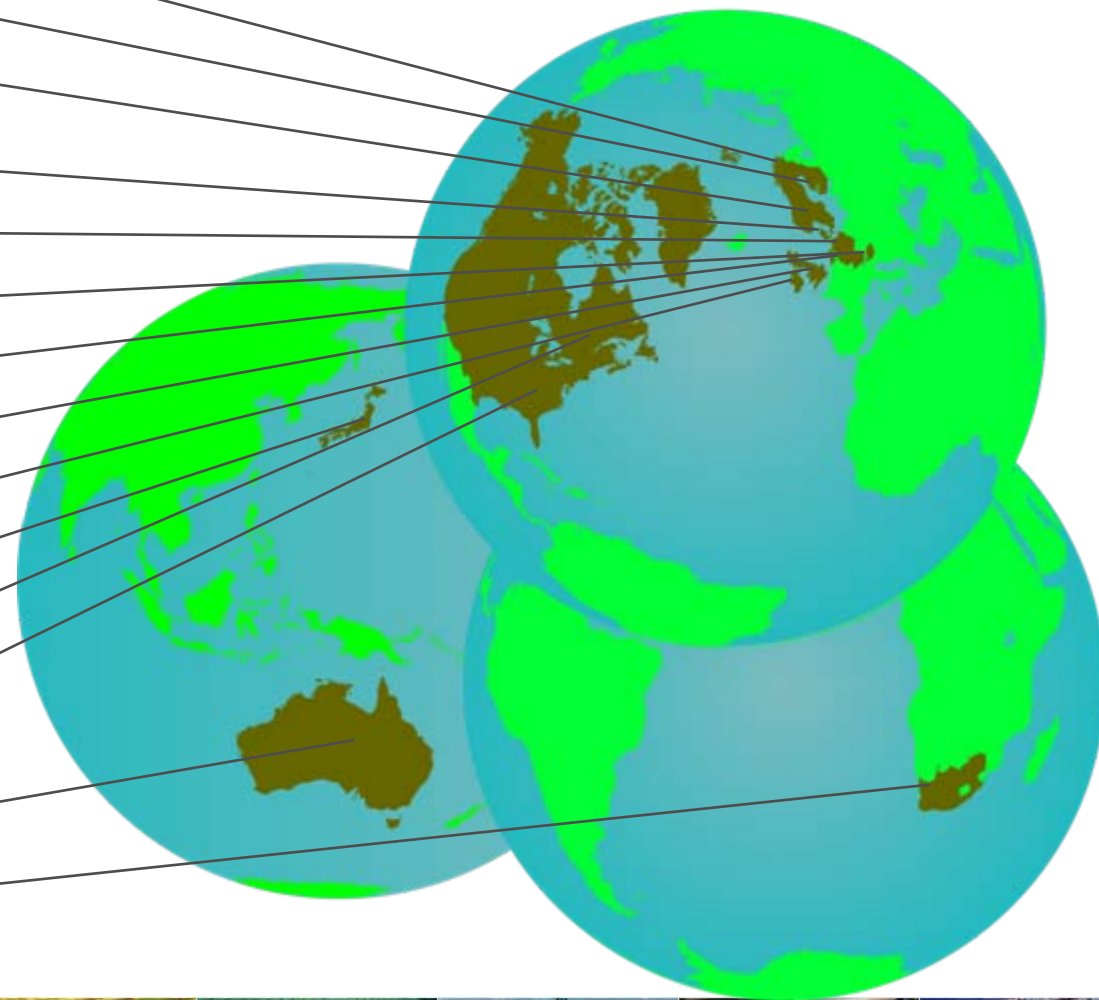
*Jim McMillan, Mike Himmel*

### Australia

*Les Edye*

### South Africa

*TBC*



# Goals and Objectives

- ▶ Provide information and analyses on policy, markets and implementation issues by continuing the deployment of 'first-generation' fuels and supporting development of 'second-generation' biofuels.
- ▶ Catalyze cooperative R&D projects that will help participants develop processes for 'second-generation' liquid biofuels.
- ▶ Provide information dissemination, outreach to stakeholders, and coordination with other related groups.

## Commissioned reports :

- ▶ Evaluation of 2nd-generation biofuels (for IEA Headquarters)
- ▶ Forests and Energy in OECD countries (for FAO, UNECE, OECD)

## Implementation & Policy subtask:

- ▶ European lessons for biodiesel policy in North America II
- ▶ Biofuel implementation agendas
- ▶ Impacts of policies for biofuels in Task 39 countries
- ▶ Presence and status of demonstration plants
- ▶ Sustainability of biofuels as related to biomass availability, biofuels markets and incentives for biofuel production
- ▶ Vision for realistic biofuel use over future timeframes

## Technical subtask:

- ▶ Review of biodiesel technology providers (CD available)
- ▶ Update on biomass-to-energy options
- ▶ Biorefining applications specific to technical platforms (proposed)
- ▶ Carbon and energy balance issues (proposed)

## Meetings:

Vancouver, Canada - 27-30 August 2006 (*Joint conference/business*)

Peterborough, UK - 15-16 January 2007 (*Planning Session*)

Denver, USA - 28 April 2007 (*Planning Session*)

Denver, USA - 1 May 2007 (*Special Session*)

Rotterdam, the Netherlands - 9-10 January 2008 (*Planning/Tech'I Session*)

- ▶ Salzburg, Austria - 5 February 2008 (*in Task 38 Meeting*)
- ▶ Oslo, Norway - May 2008 (*Joint Workshop*)
- ▶ Copenhagen, Denmark - May 10 2008 (*Commercialization*)
- ▶ Cork, Ireland - September 2008 (*Planning/Technical Session*)
- ▶ San Francisco, USA - May 2009 (*Planning/Special Session*)
- ▶ Potsdam, Germany - June, 2009 (*Policy workshop*)
- ▶ Örnsköldsvik, Sweden - August 2009 (*Planning/Technical Session*)

# Joint project with Task 38

A proposal to IEA Bioenergy ExCo to access Strategic Funds

*“Examination of the potential for improving carbon/energy balance in Biofuels”*

- ▶ Evaluate the current state of starch ethanol plants with respect to energy and environmental performance
- ▶ Describe the advances made over the past two decades
- ▶ Investigate the potential for future improvements
- ▶ Provide recommendations for applying ‘best practices’

Task 39 membership have now had a chance to discuss and would like to proceed, using Don O’Connor as consultant. We will liaise with Josef Spitzer. Look forward to comments on how our Tasks might work together.



# The Biorefining Story

*Developments at the University of British Columbia  
and updates from IEA Bioenergy Task 39*

**W.E. Mabee, J.N. Saddler**

IEA Bioenergy Task 39 'Liquid Biofuels from Biomass' /  
Forest Products Biotechnology, University of British Columbia  
2424 Main Mall, Vancouver, BC, Canada V6T 1Z4

[warren.mabee@ubc.ca](mailto:warren.mabee@ubc.ca)



Forest Products Biotechnology at UBC

IEA Bioenergy Task 38 Workshop  
Salzburg, Austria, February 5 - 6, 2008

IEA Bioenergy

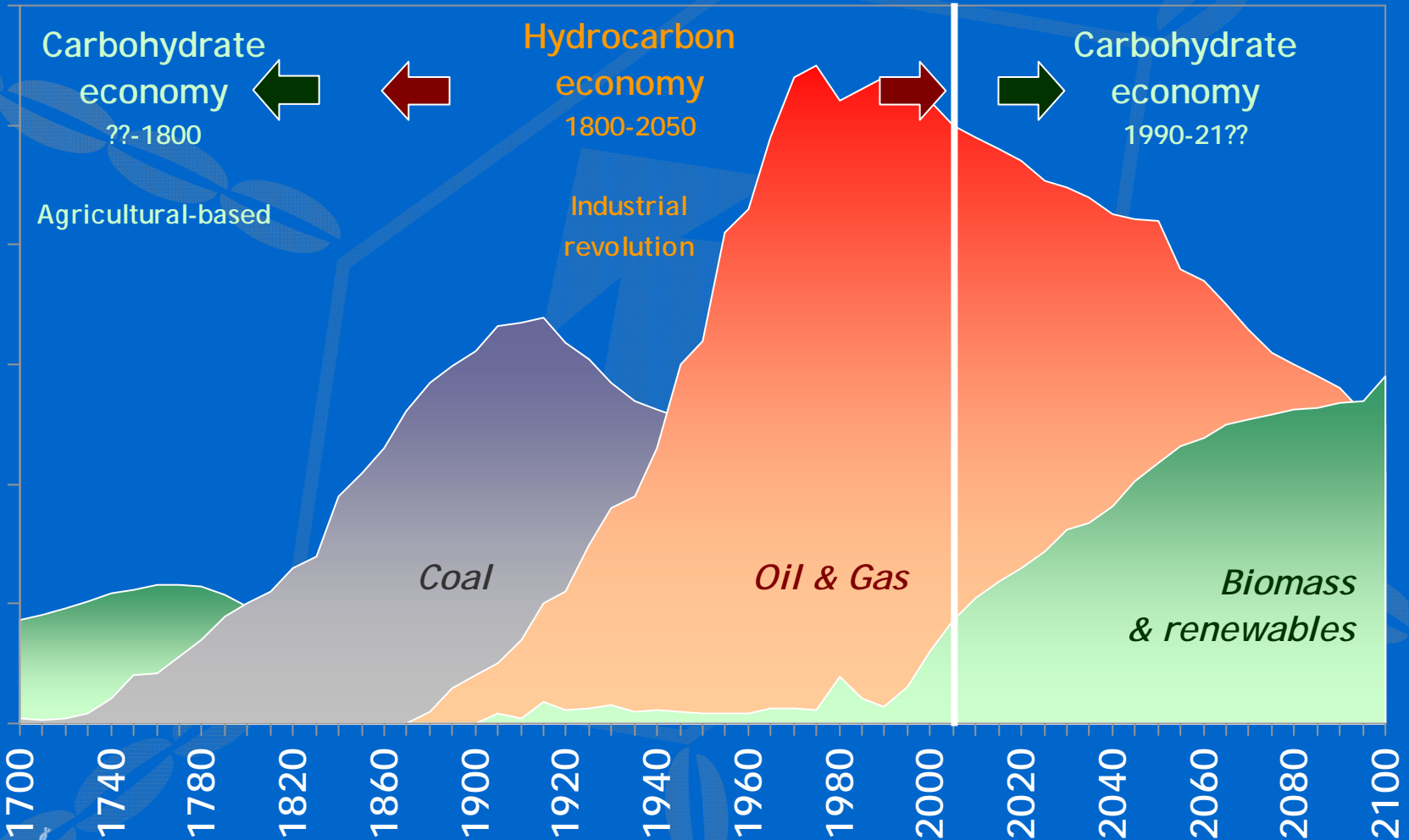
# Overview

1. **Historical perspective**
2. Biorefining platforms
3. Demonstration facilities (primarily USA)
4. Take-home messages

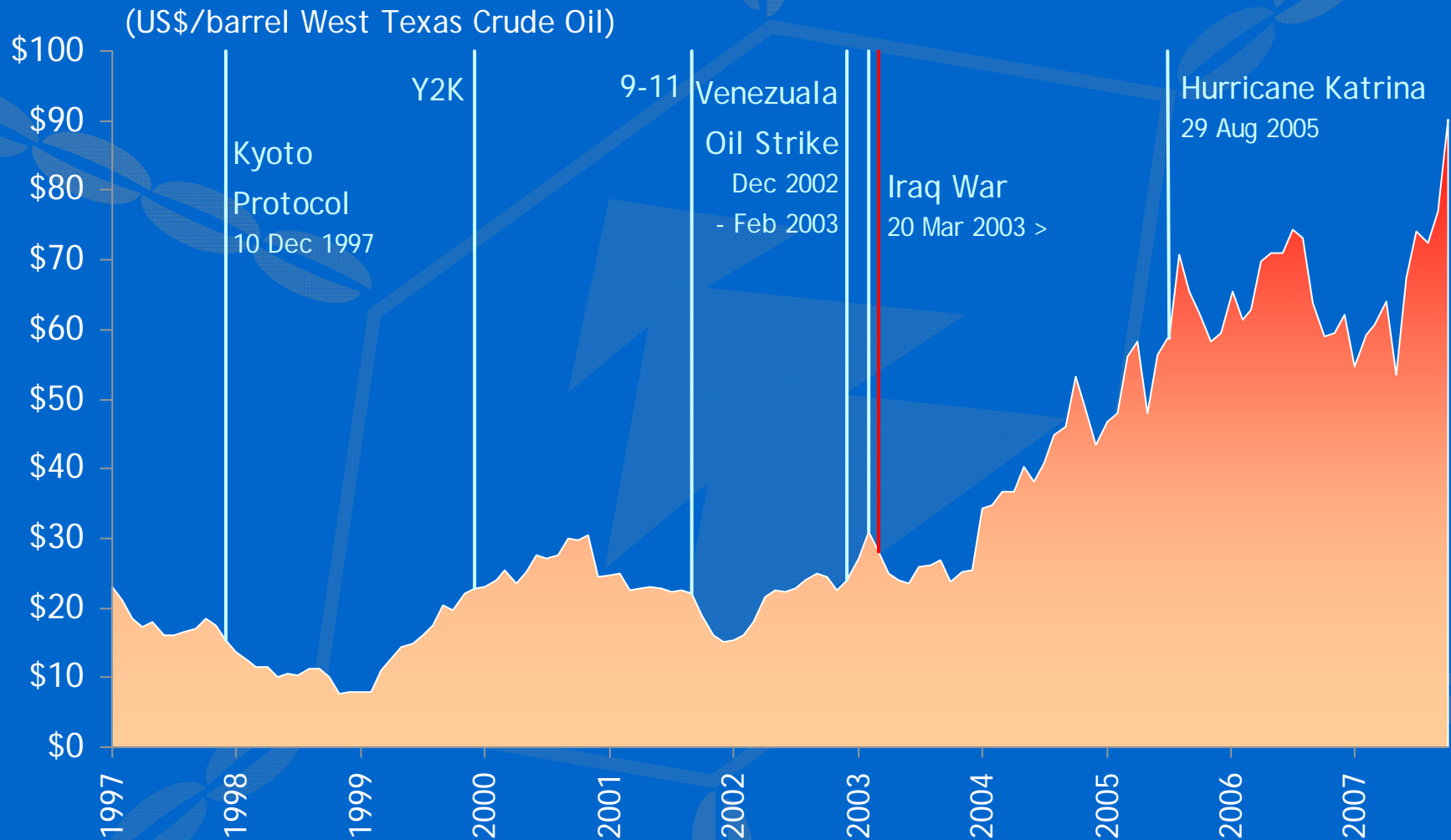


# Looking back and forward...

*log (primary energy use) by category*



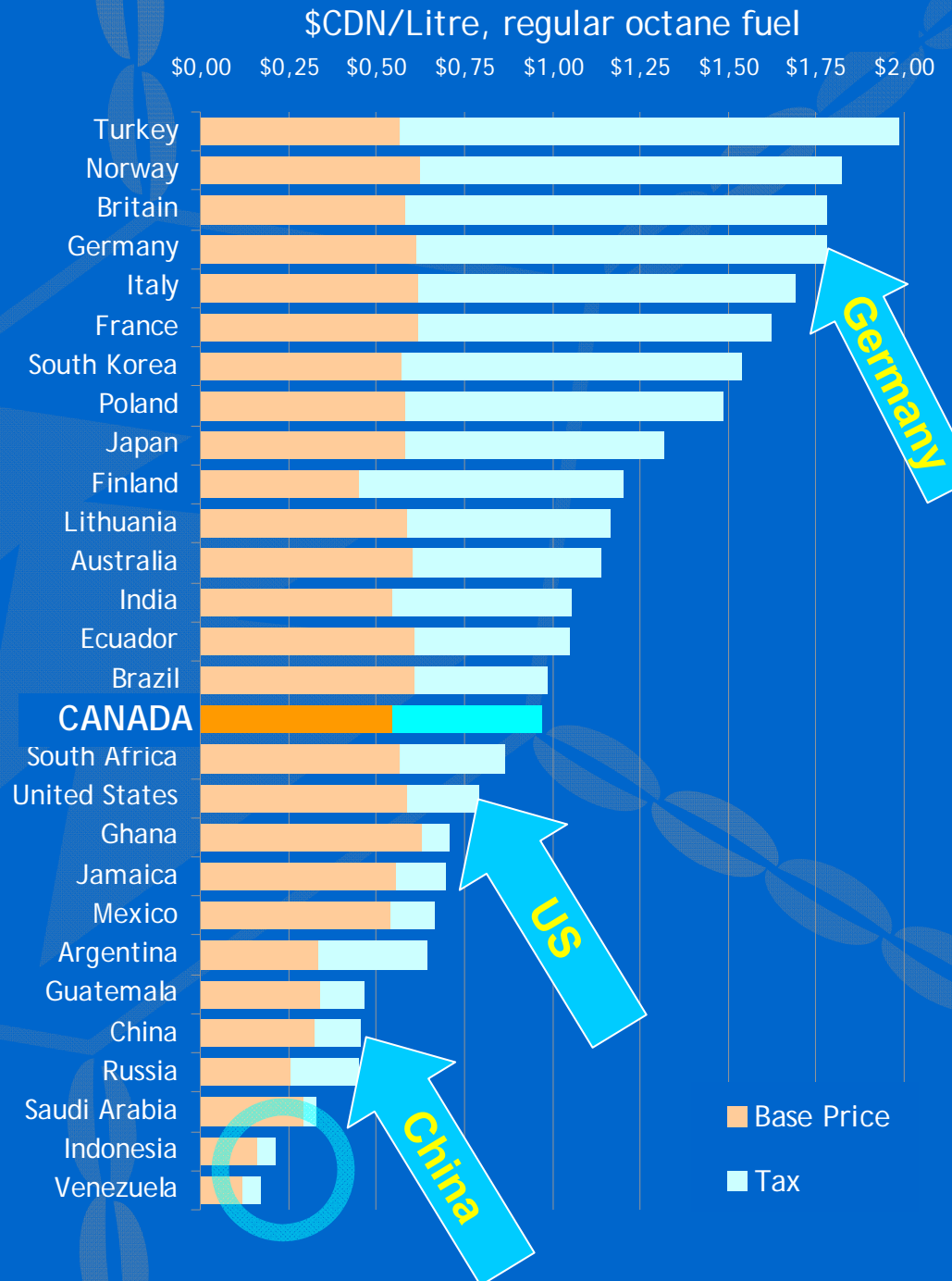
# Oil & World Events



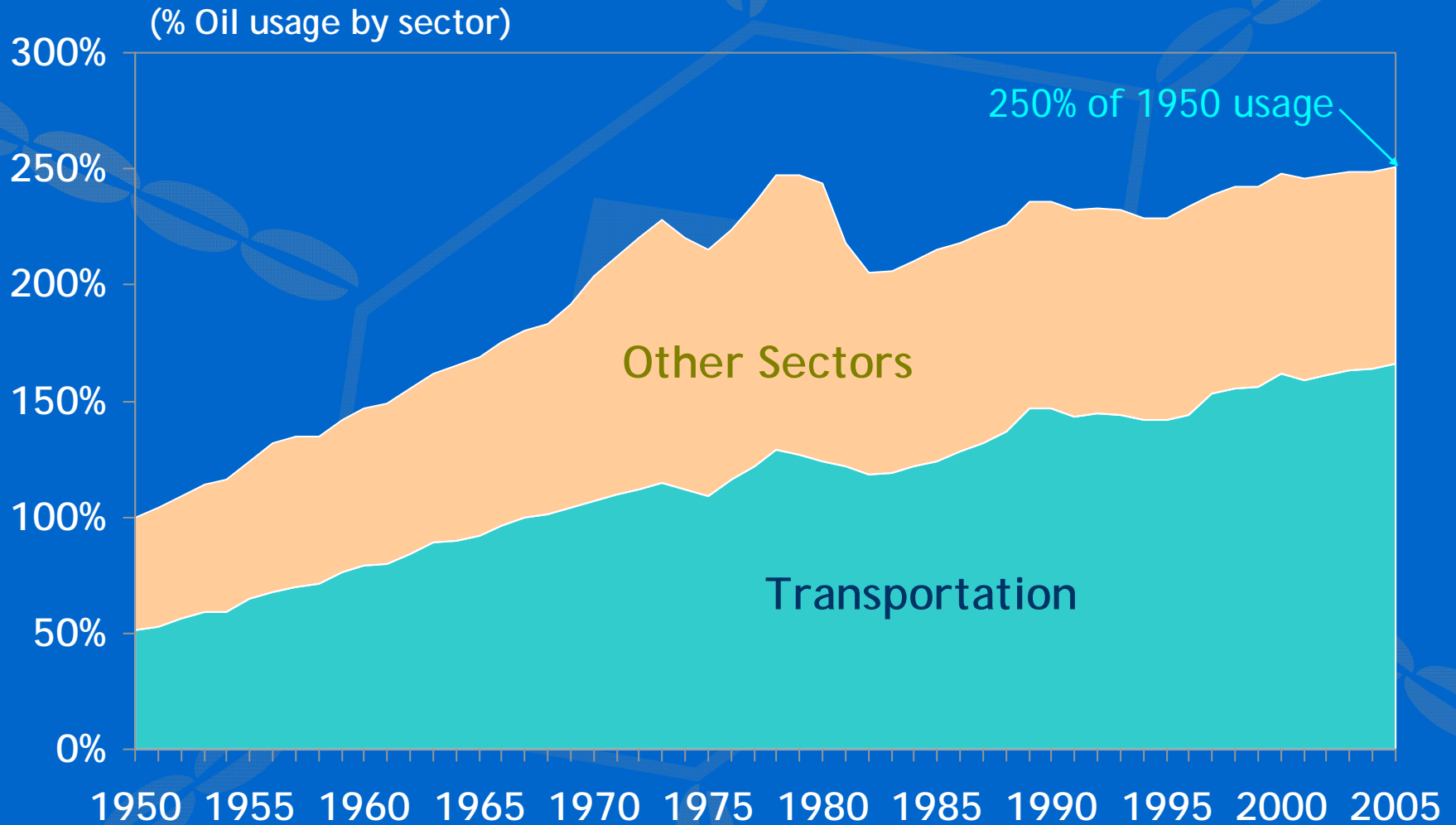
# Gasoline Prices

April 2006

- ▶ Turkey: ~\$2.00 CDN/L  
(~\$6.70 US/gal.)
- ▶ Venezuela: ~\$0.17 CDN/L  
(~\$0.60 US/gal.)
- ▶ Canada: ~\$0.98 CDN/L  
(~3.28 US/gal)



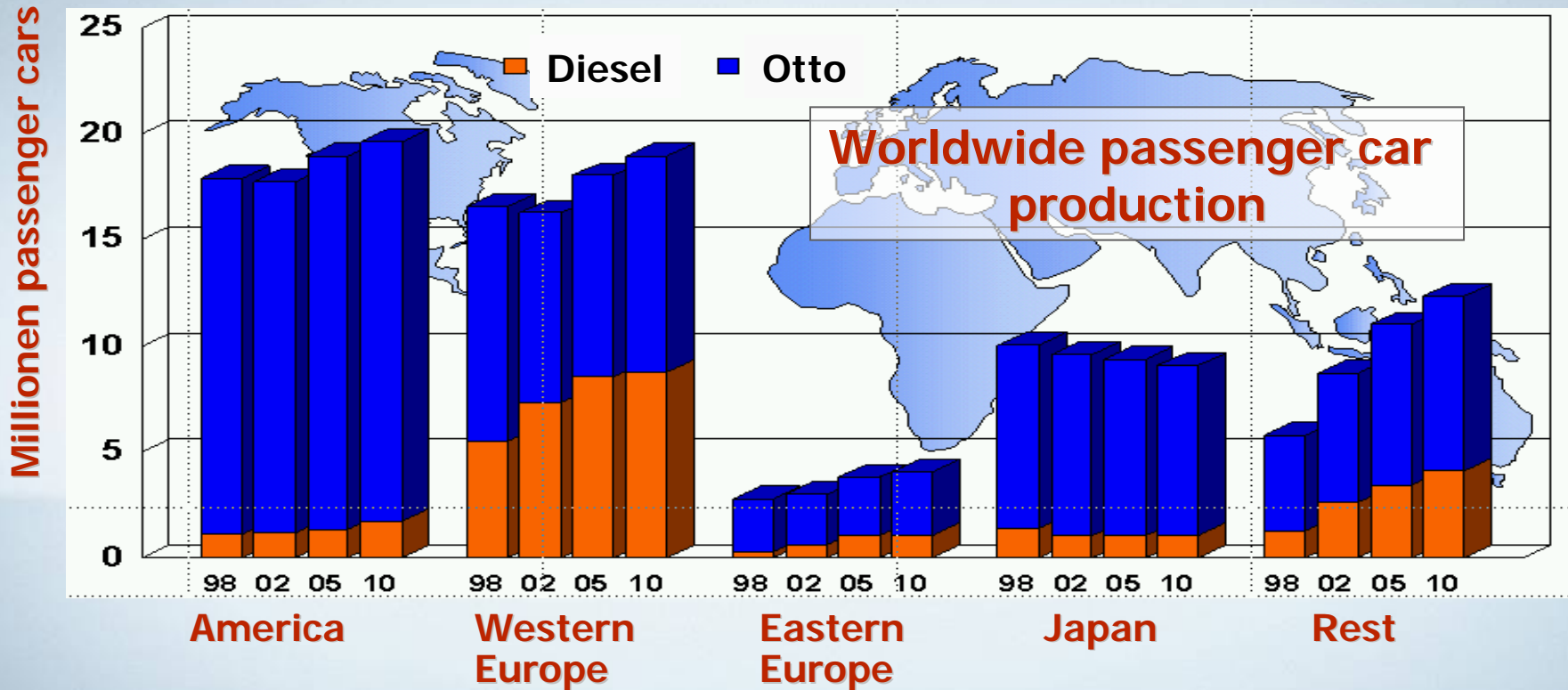
# Oil for Transportation



# The Gasoline engine dominates the world market



.... but Western Europe goes for Diesel engines

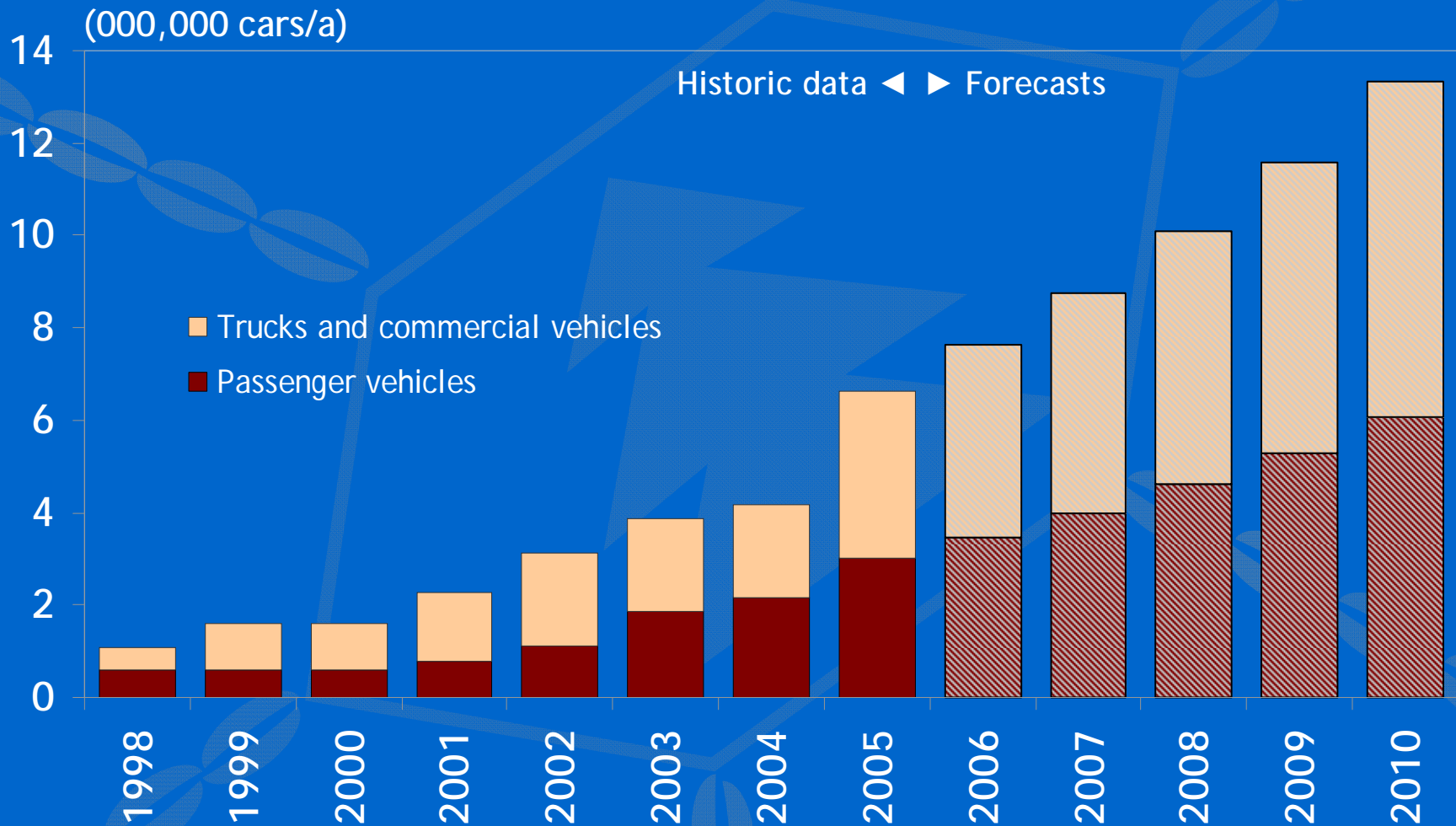


Quelle: AVL – TÜV HV 2004

Adding value to nature's gifts.

# Mainland China Auto Use

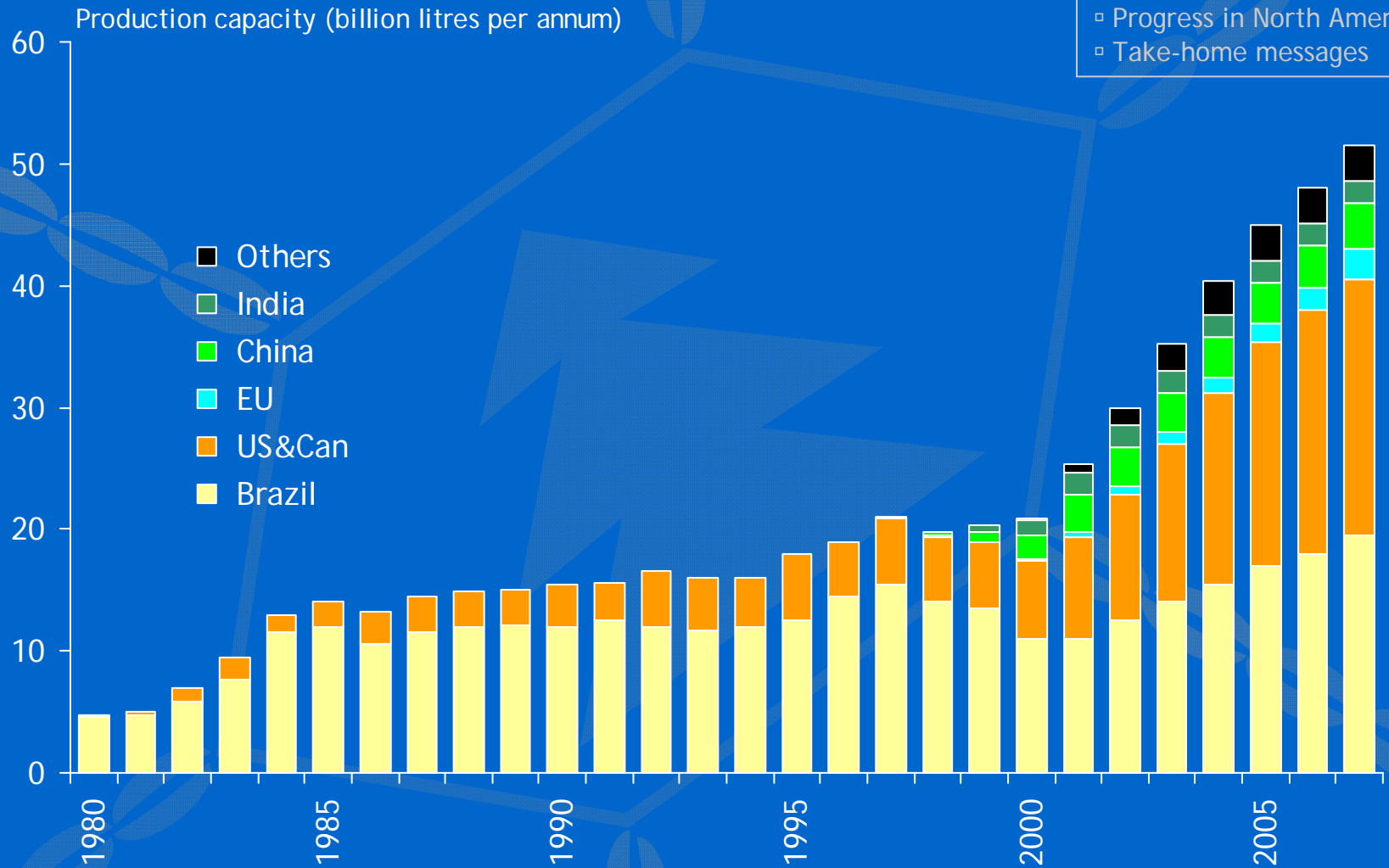
Vehicle Sales, 1998-2010





# Bioethanol worldwide

- Historical perspective
- Evolution of biorefining
- Biorefining platforms
- Bioenergy policy
- Progress in North America
- Take-home messages



# Overview

1. Historical perspective
2. **Biorefining platforms**
3. Demonstration facilities (primarily USA)
4. Take-home messages



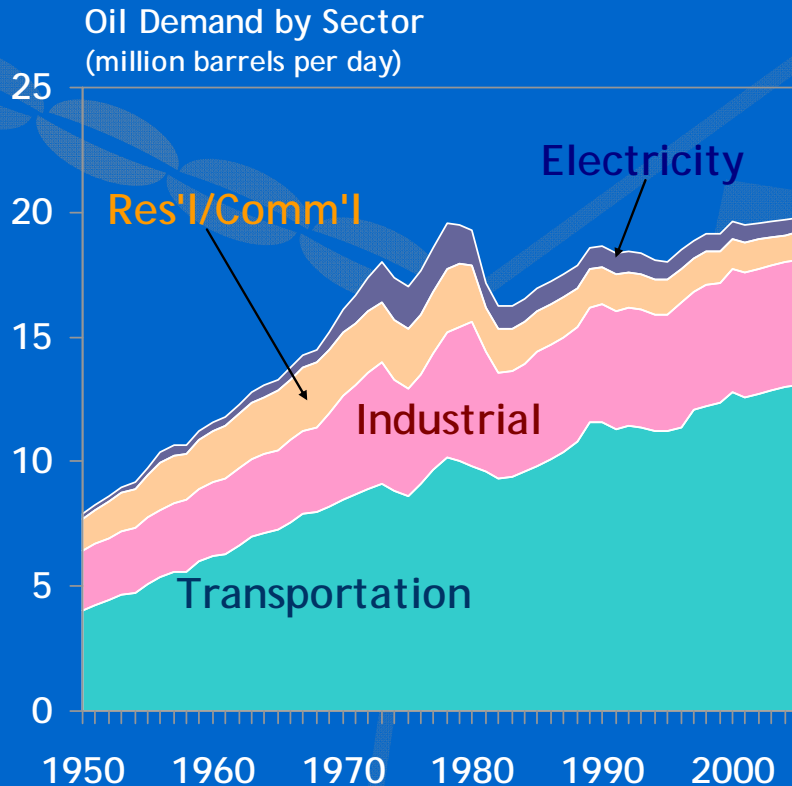
# Take-home messages

- ▶ Biorefining is the co-generation of a combination of bioenergy, biofuels, and/or bioproducts (which may be chemical or material)
- ▶ Biorefining platforms utilize chemical, thermal or biological mechanisms to process biomass from agricultural, forestry, marine, or municipal sources
- ▶ Essentially, analogous to a petroleum refinery



# Oil refinery

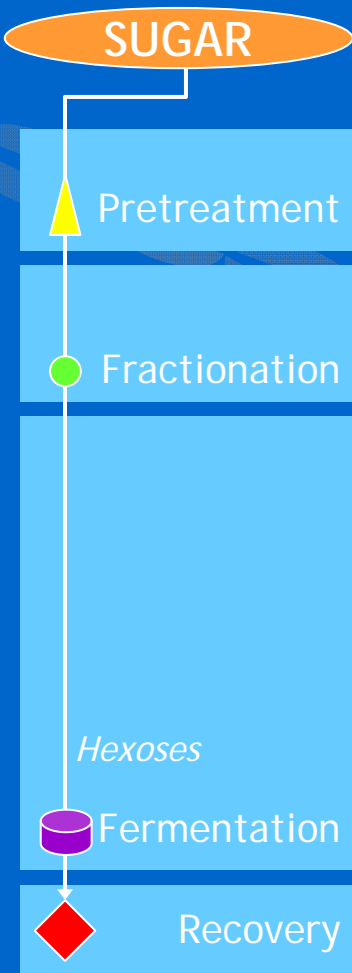
## Traditional oil refining:



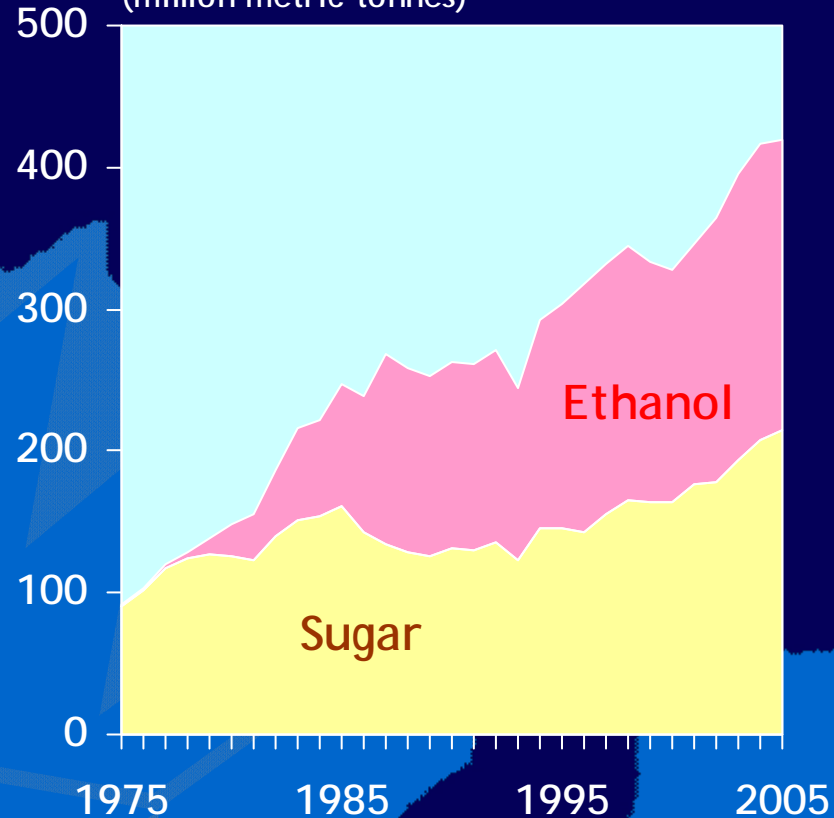
- ▶ ~68-70% transportation sector (i.e. gasoline, diesel)
- ▶ ~21% industrial processing, ~5% ind. plastics, chemicals (over 2,000 refinery products)
- ▶ ~4% residential/ commercial heating
- ▶ <3% electricity generation



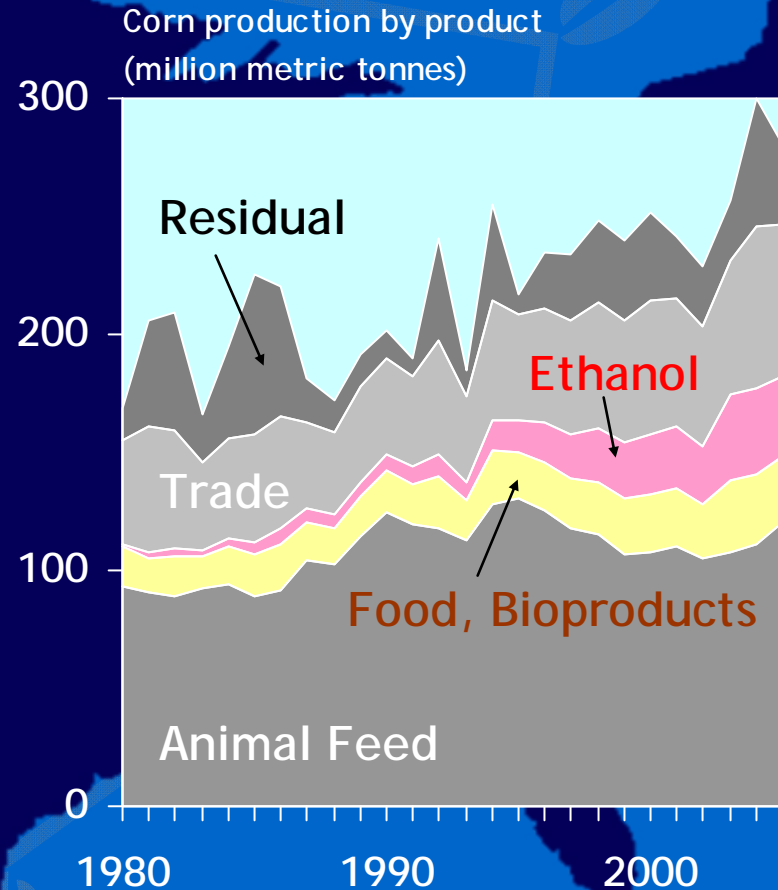
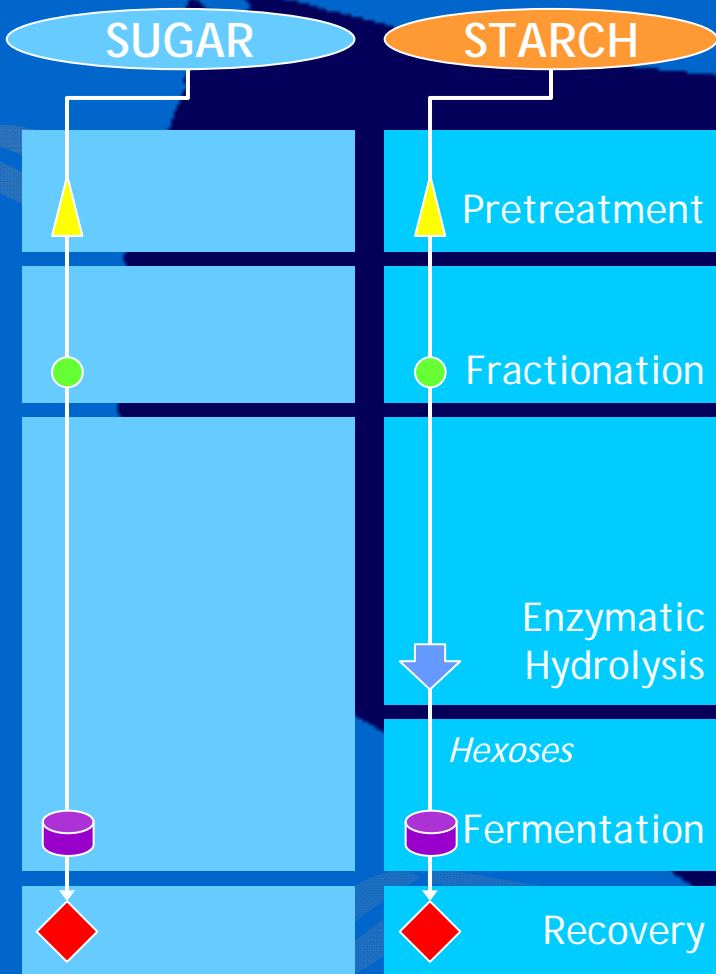
# Sugar-based biorefineries



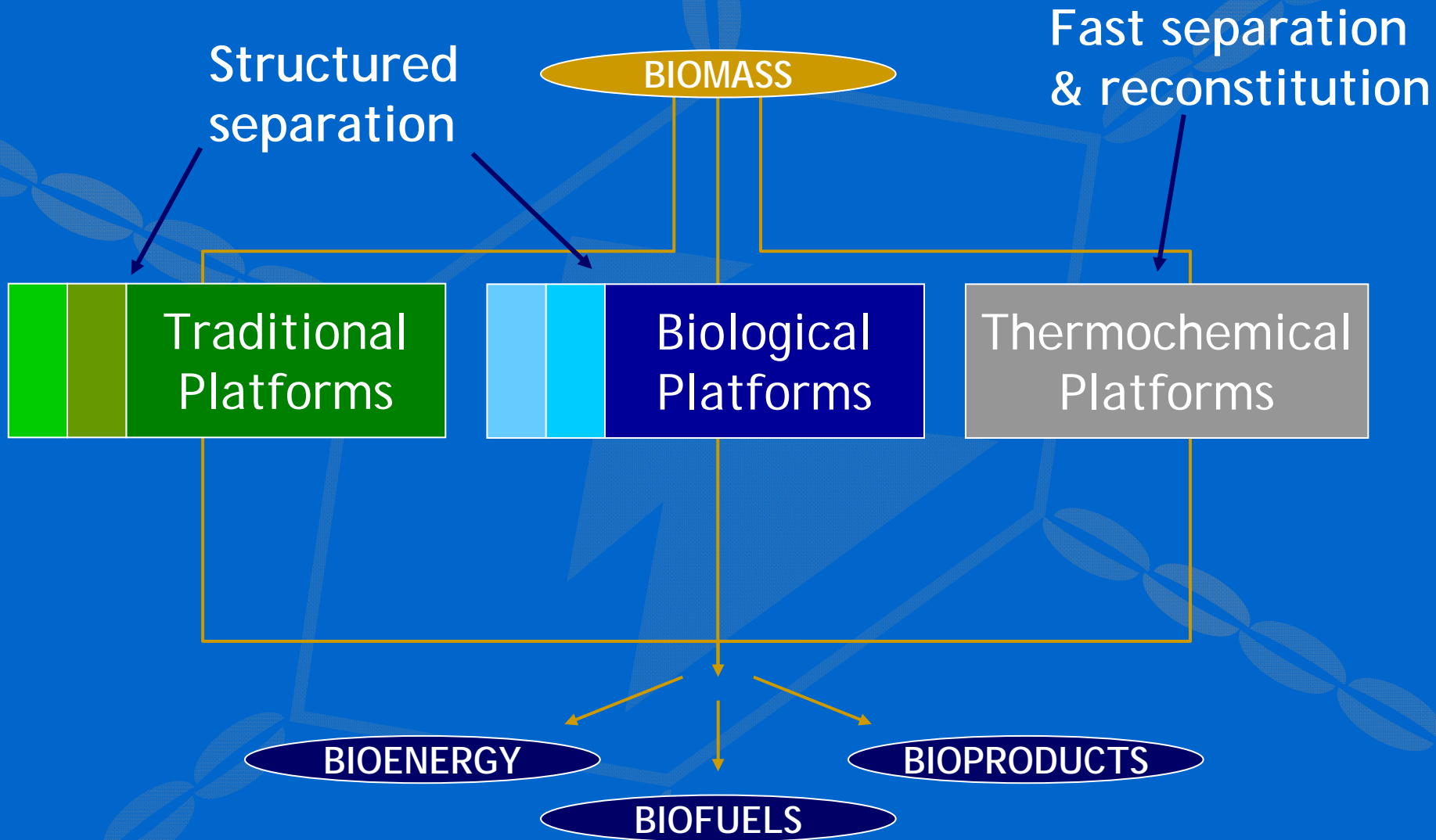
Sugarcane production by product  
(million metric tonnes)



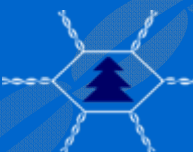
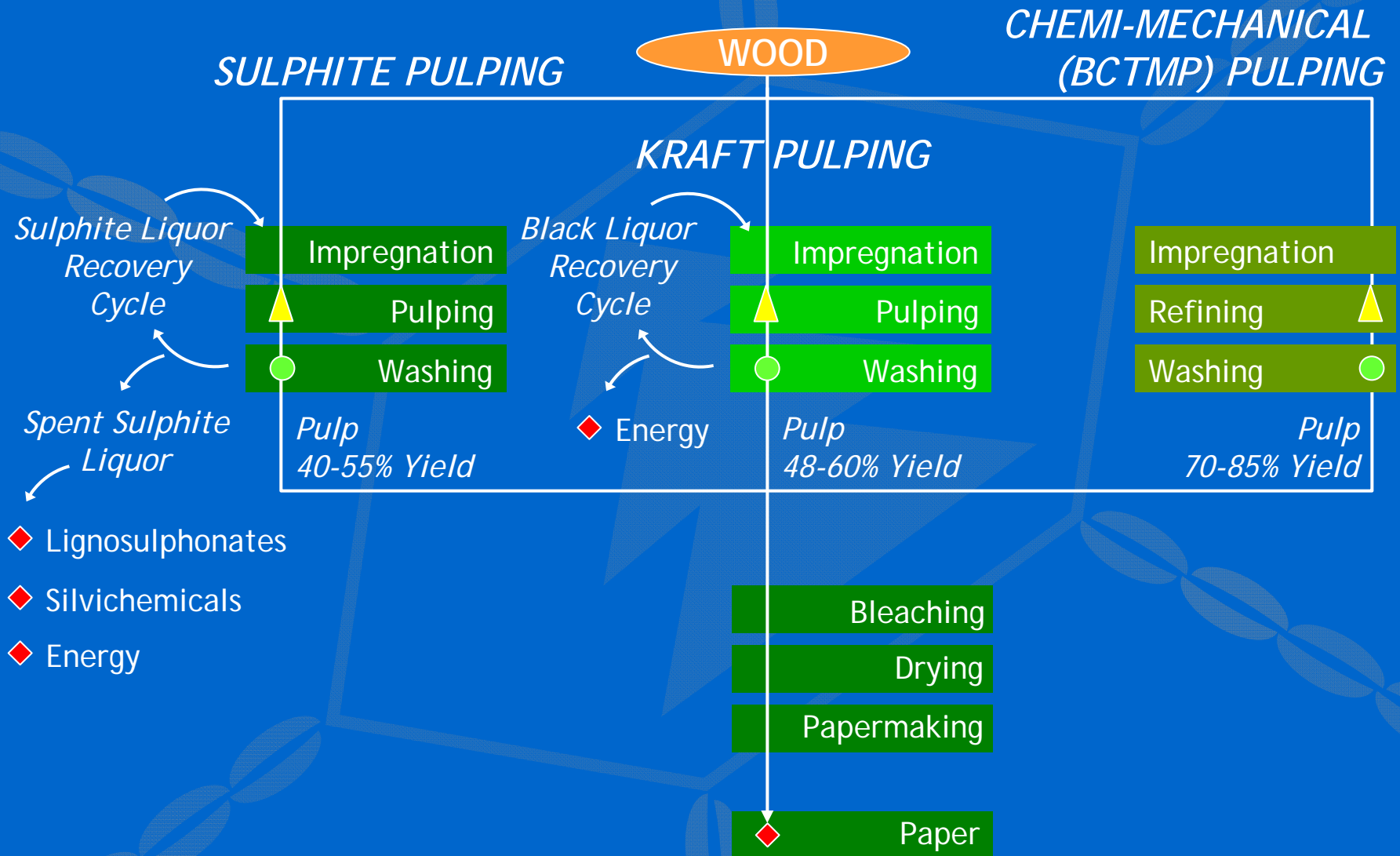
# Starch-based biorefineries



# Biorefining Platforms



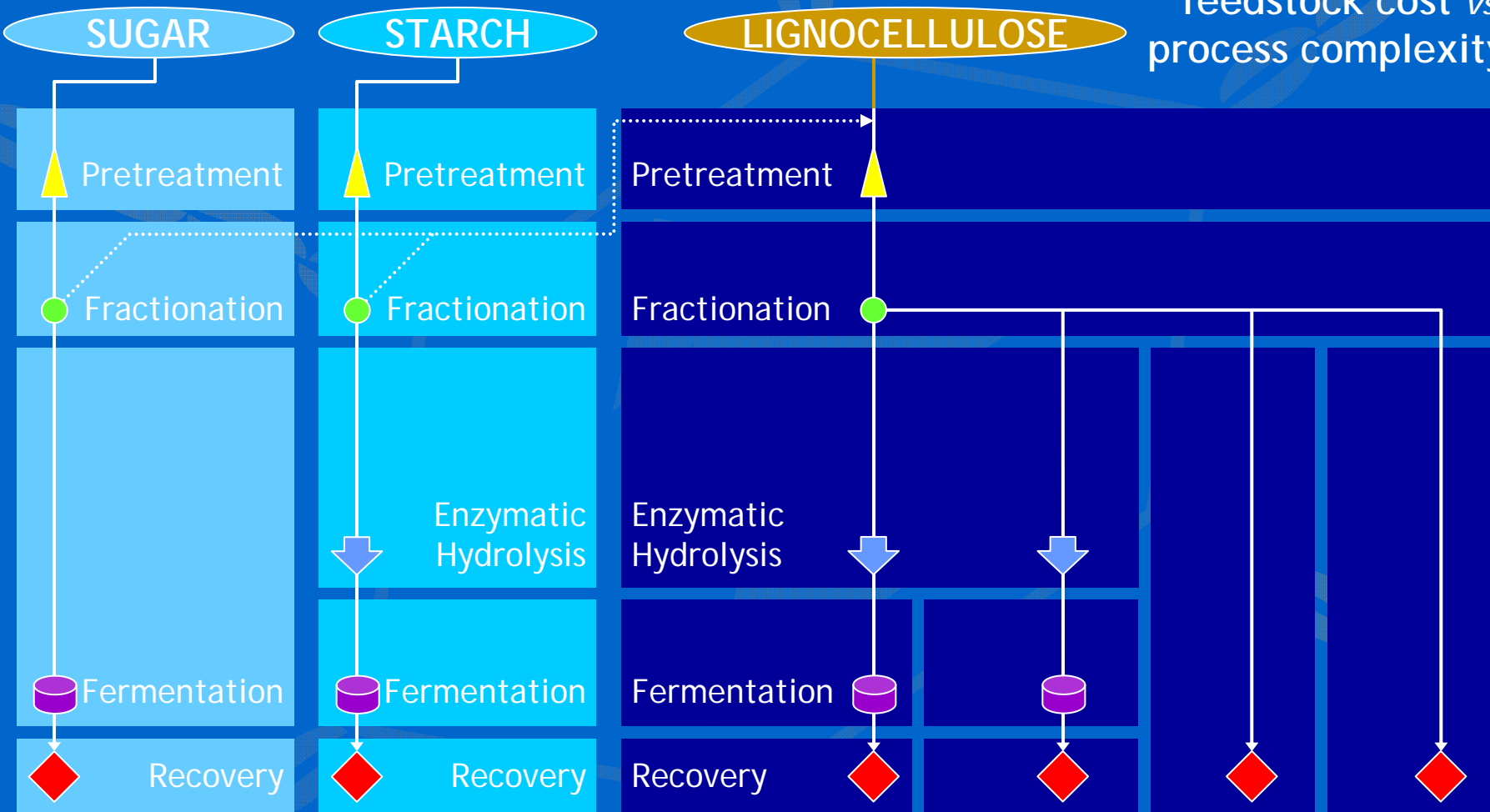
# Pulp and paper 'refinery'





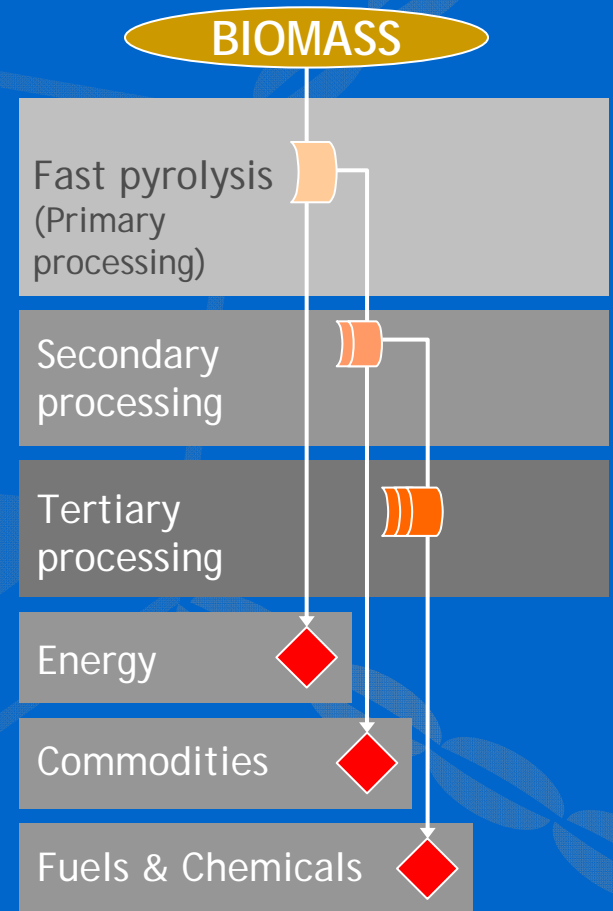
# Bioconversion platforms

Trade-off:  
feedstock cost vs  
process complexity

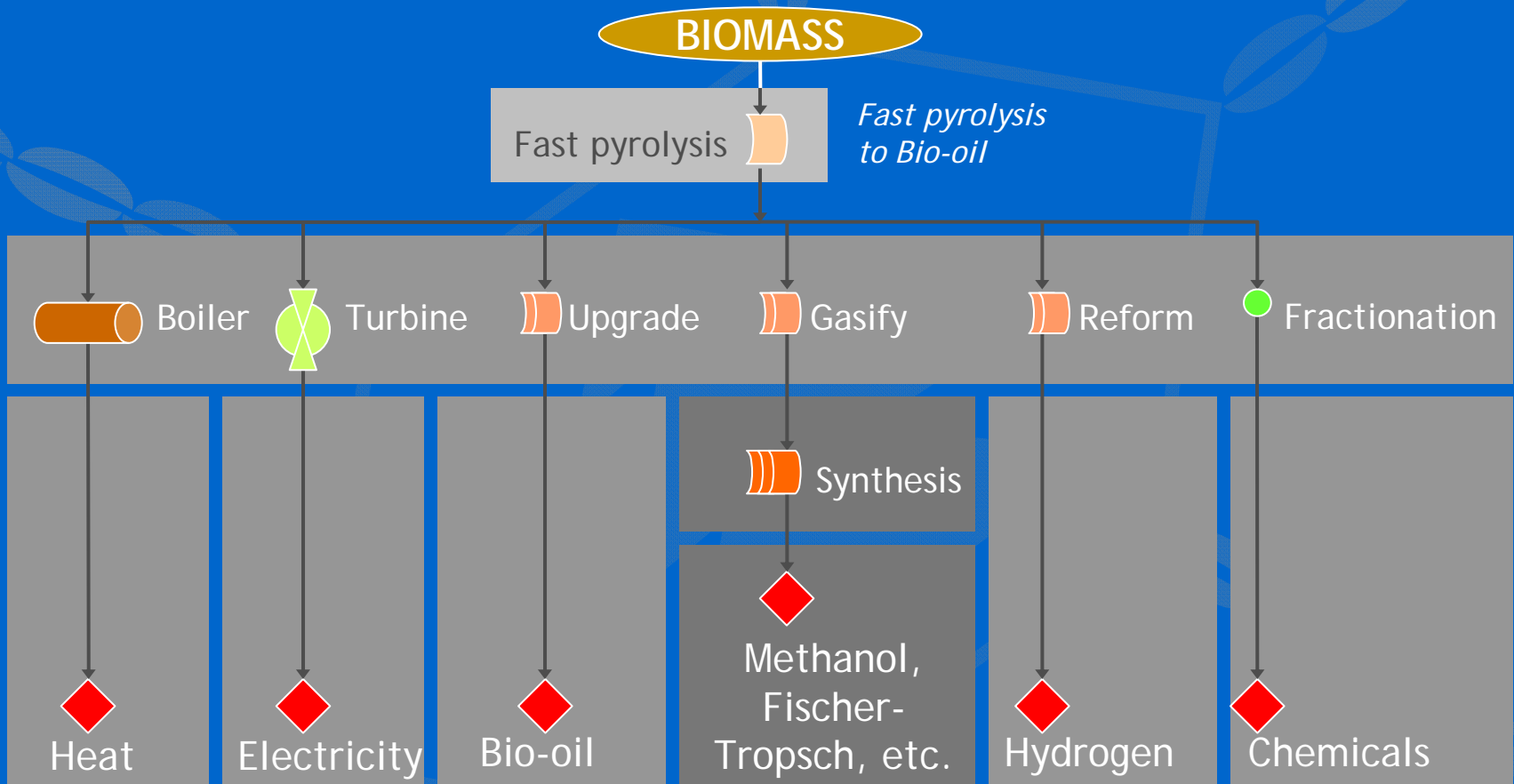


# Thermochemical biorefinery

- ▶ Integrate production of higher value chemicals and commodities, as well as fuels and energy
- ▶ Optimise use of resources, maximise profitability, maximise benefits, minimise wastes



# Thermochemical biorefinery





# Take-home messages

- ▶ Platform development is continuing, both thermochemical and biochemical
- ▶ Potential for co-products is highly dependent upon platform choice
- ▶ Various platforms are highly complementary and may be combined



# Overview

1. Historical perspective
2. Biorefining platforms
3. **Demonstration facilities (primarily USA)**
4. Take-home messages



# US Biofuel RD&D

## Department of Energy Biomass Program:

- ▶ Large-scale ethanol demonstration (6): \$385 M
- ▶ Demonstration-scale biorefineries (10): \$200 M
- ▶ Research Centres (3): \$375 M

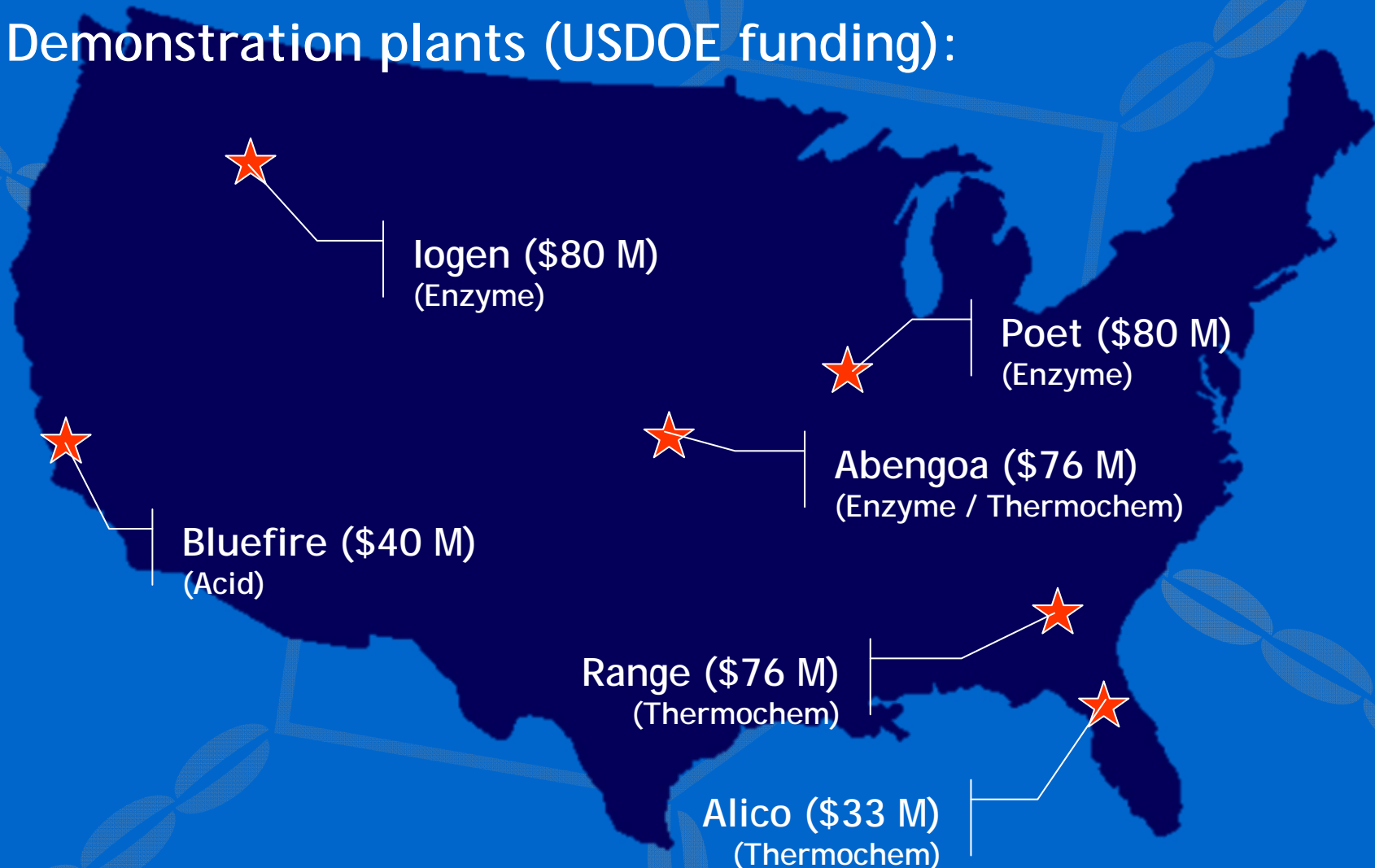
## BP Energy Biosciences Institute

- ▶ Headquartered at UC Berkeley (10 yr funds): \$500 M



# Cellulosic ethanol

Demonstration plants (USDOE funding):





# Abengoa Bioenergy

Strategic partners: Diadic International,  
SunOpta Bioprocess Group

Co-situated starch/cellulose mills:

- Castilla y Leon, Spain
  - 200 M litres EtOH (2.5% cellulosic)  
(wheat/wheat straw)
  - Co-products: DDGs, food-grade CO<sub>2</sub>
- York, Nebraska
  - 1 tpd biomass pilot plant (2007)  
(corn stover)
  - US\$36.1 million from USDOE
- Colwich, Kansas
  - 43.2 M litres EtOH + energy  
(corn stover/wheat straw)
  - Up to US\$76 million from USDOE



# logen Corporation

Pioneering company in biomass-to-ethanol  
and industrial enzyme development

Past investment:

- US\$29 million - Royal Dutch Shell (2003)
- US\$30 million - Goldman Sachs (2006)
  
- Ottawa, Ontario
  - Bioconversion commercial development facility
  - 40 tpd wheat straw & stover
- Shelley, Idaho
  - 70 million litres EtOH
  - Up to US\$76 million from USDOE



# Verenium

Formed in June 2007 (Formerly Celunol & Diversa)

Strategic partnerships with University of Florida,  
Marubeni Corp. (Japan) and Tsukishima  
Kikai Corp. (Japan)

- Jennings, Louisiana
  - 190,000 litres EtOH pilot facility
  - 5.3 million litre demonstration facility (started February 2007; sugarcane bagasse)
- Osaka, Japan
  - 1.3 million litre demonstration facility (completed January 2007; demolition wood waste)
  - Demonstration project built by Verenium partners



# Bluefire Ethanol

Based on Arkenol's concentrated acid hydrolysis technology

- Izumi, Japan
  - 300 lpd EtOH pilot facility (MSW as feedstock)
- Southern California
  - 71.9 M litres EtOH (green waste, wood waste)
  - Up to US\$40 million from USDOE



# Poet

Formerly Broin Companies

Largest dry-mill starch-to-ethanol in USA

Strategic partnerships with Novozymes,  
duPont as well as NREL

- Emmetsburg, Iowa
  - 470 M litre EtOH  
(corn-based dry mill)
  - 25% (117 M litre) cellulosic  
(corn fibre, corn cobs)
  - Addition to an existing corn-  
based dry mill
  - Up to US\$80 million from USDOE

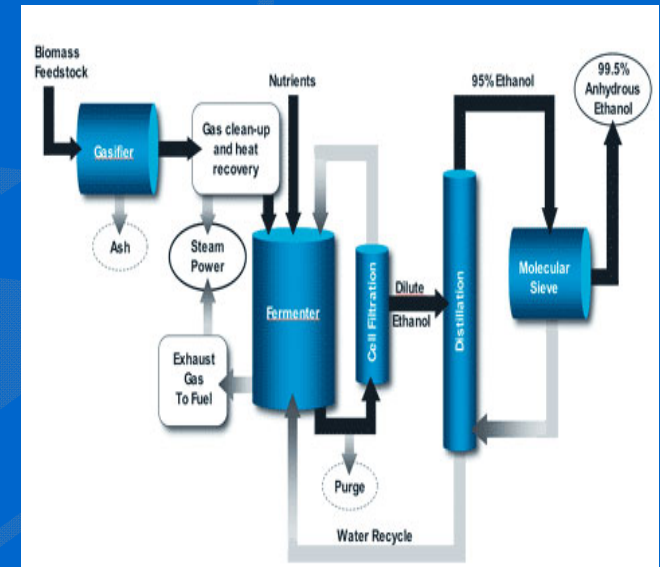


# ALICO, Inc.

Thermochemical-based process

Uses BRI's gasification/fermentation technology

- LaBelle, Florida
  - 52.6 M litre EtOH (yard waste, vegetable waste)
  - 6,255 kW electricity
  - Will use energy cane later
  - Up to US\$33 million from USDOE



# Range Fuels, Inc.

Thermochemical-based process  
(Formerly Kergy, Inc.)

Anaerobic thermal conversion

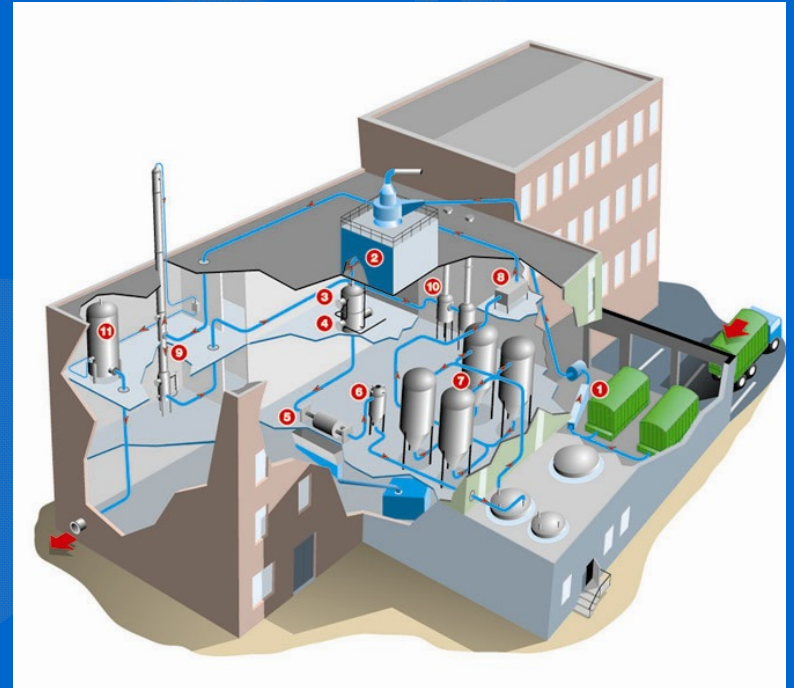
- Soperton, Georgia
  - 151 M litre EtOH  
(wood residues, energy crops)
  - 34 M litre MeOH
  - Up to US\$76 million from USDOE



# Etek Etanolteknik (Sweden)

Supported by government and industry

- One of three pilot plants to support national R&D efforts
  - Important training & testing facility
  - \$15 million investment by four shareholders
- 
- Örnsköldsvik, Sweden
    - 2 tpd capacity (~500 lpd)  
(wood residues, wood chips)
    - Research and development centre





# Lignol (Canada)

Organosolv pulping originally developed by GE and Repap for pulp and paper application

- US\$100 million investment in 80's-90's

- Vancouver, British Columbia

- 1 tpd pilot plant (hardwood & softwood residues)
- Products include
  - (1) lignin
  - (2) furfural
  - (3) ethanol
- 3 key products to minimize risk

- Further co-products will strengthen business later



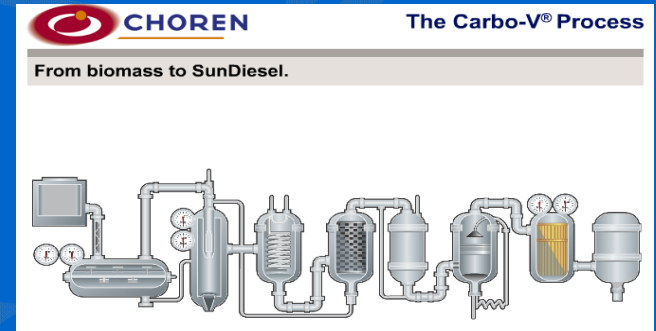
# Nexterra (Canada)

- Gasification technology designed for fuel displacement & cogeneration markets in North America
- Kamloops
  - Partner with Tolko
  - 11 MW thermal power
  - Used for veneer drying
- University of South Carolina
  - Partner with Johnson Controls
  - 60,000 lbs/hr of steam
  - 1.4 MW electricity
- Victoria
  - Dockside Green facility
  - 2-3 MW thermal power



# Choren (Germany)

- The Carbo-V® Process is a three-stage gasification process involving the following sub-processes:
  - low temperature gasification,
  - high temperature gasification and
  - endothermic entrained bed gasification
  
- Freiberg/Saxony
  - 16.5 M litres SunDiesel
  - 45 MW thermal power
  - > € 100 million investment
  - 68,000 t/a feedstock (50% residues, 50% chips)



# Overview

1. Historical perspective
2. Biorefining platforms
3. Demonstration facilities (primarily USA)
4. Take-home messages



# Overview

1. Historical perspective
2. Biorefining platforms
3. Demonstration facilities (primarily USA)
4. **Take-home messages**



# Take-home messages

- ▶ Greatest historical increases in energy demand are for transportation fuels
- ▶ The biorefinery concept can maximize returns and improve the economic performance of different biofuel technologies
- ▶ Tremendous progress has been made in creation of demonstration facilities, which will allow real assessment of economics and environmental performance
- ▶ Task 39 is working to combine policy and technology issues to commercialize 2<sup>nd</sup>-generation liquid biofuels
- ▶ Task 39 looks forward to working with Task 38 on the strategic project





# Picture from 1954 Popular Mechanics Magazine

Scientists from the RAND corporation have created this model to illustrate how a „home computer“ could look like in the year 2004.

However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the FORTRAN language, the computer will be easily to use.