

Commercialization of 2nd generation biofuels

The Biorefinery concept for Biomass-to-Biofuels

J.N. Saddler

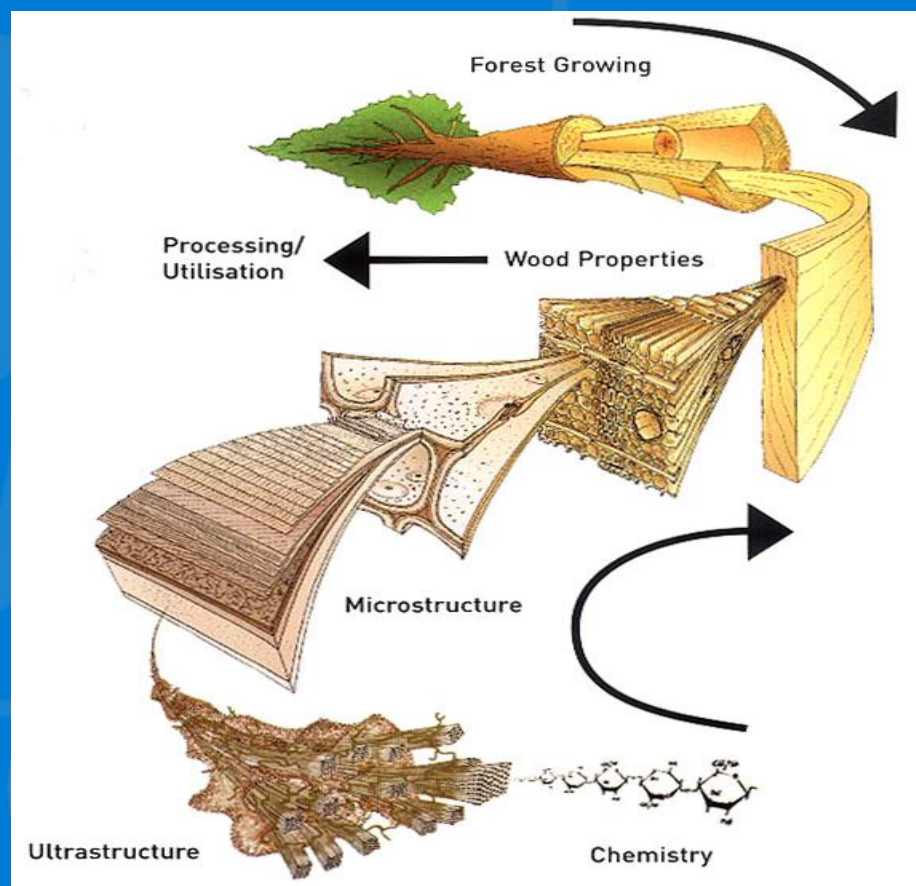
Forest Products Biotechnology/Bioenergy Group

University of British Columbia

Jack.Saddler@ubc.ca

www.Bioenergy.UBC.ca

Washington State Bioenergy Research Symposium
Seattle, Washington State , 8 November 2010



THE VANCOUVER SUN

FINAL EDITION

www.vancouverpub.com

SERIOUSLY WEST COAST SINCE 1912

SATURDAY, JUNE 2, 2007

B.C. 2050 What climate change will do to our province



Photo: David Hamilton/BCV2.com

How trees can fuel cars

BY GORDON HAMILTON
AND SCOTT SIMPSON
VANCOUVER

At a pilot plant located on an isolated corner of the University of B.C. campus, researchers are converting trees killed by the mountain pine beetle into high-grade ethanol, a green alternative to gasoline.

Four hundred kilometres away, north of Kamloops, waste bark fed into a high-tech burner comes out as synthetic natural gas for heating water and drying wood in a plywood mill.

And in B.C. Hydro's Vancouver office, staff are poring through more data for expressions of interest from energy and forest companies. They want to produce power from the residue of wood going to waste alongside British Columbia's logging roads.

Calling timber-rich B.C. the new green land, Astoria workers are polishing forest fuels and getting all well-oiled for the future.

All over the world, scientists, businesses and governments are looking for ways to produce energy without increasing greenhouse gas emissions that are contributing to global warming.

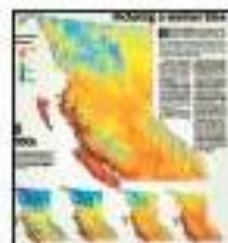
Over the past few weeks, a Vancouver Sun team of reporters, editors and graphic artists has been sifting through interviews, scientific journals, government reports and private sector studies, asking how our province will be transformed in the coming decades by climate change.

"We've chosen 2050 as our target date because scientists say it's a pivotal moment in the history of humanity — if we haven't curtailed our fossil fuel addiction by then, warming will be an irreversible trend.

"Whether or not you believe in global warming, we cannot afford to take that risk," deputy forest minister Doug Woodin told a recent Vancouver audience. "We have to start preparing for this. The fact is, in the short term, be it long term, our climate has changed right now."

WEEKEND EXTRA
CONTINUES ON A6

WEEKEND EXTRA



Forecasting a hotter future

What the province may be like at mid-century

WEEKEND REVIEW | C6-7



Picture of hope

Artist Robert Bateman refuses to give in to global-warming gloom

WEEKEND REVIEW | C1

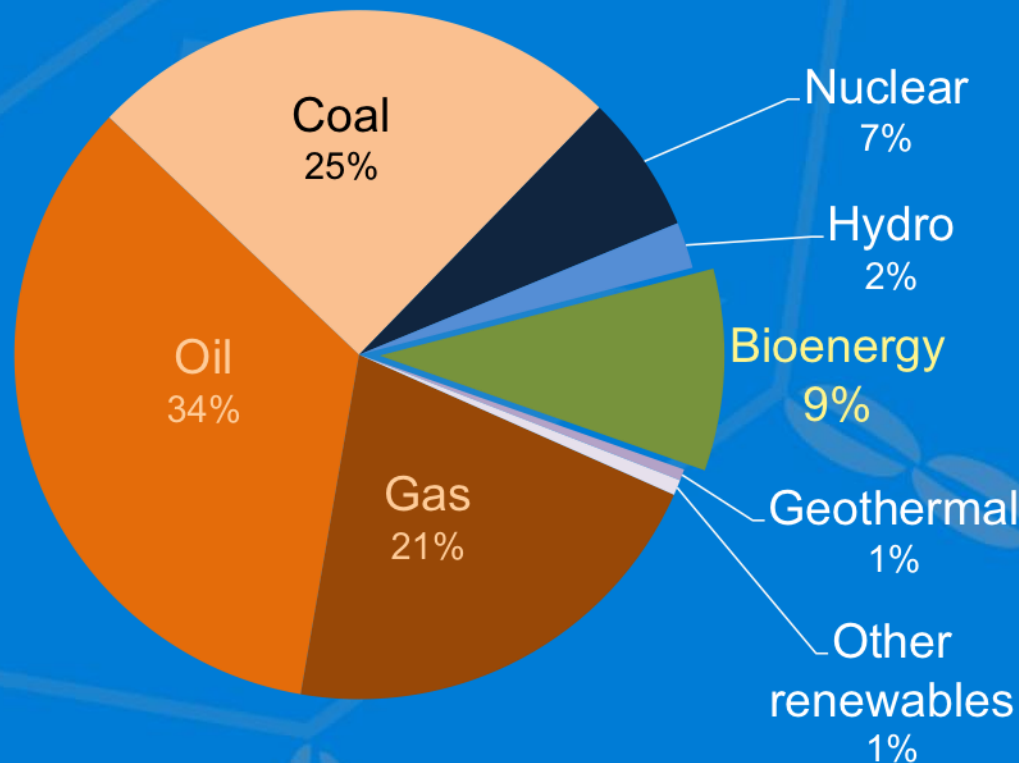
Overview

1. **Historical perspective**
2. Evolution of biorefining
3. Biorefining platforms
4. Progress with the bioconversion platform
5. Development of pilot facilities
6. Take-home messages

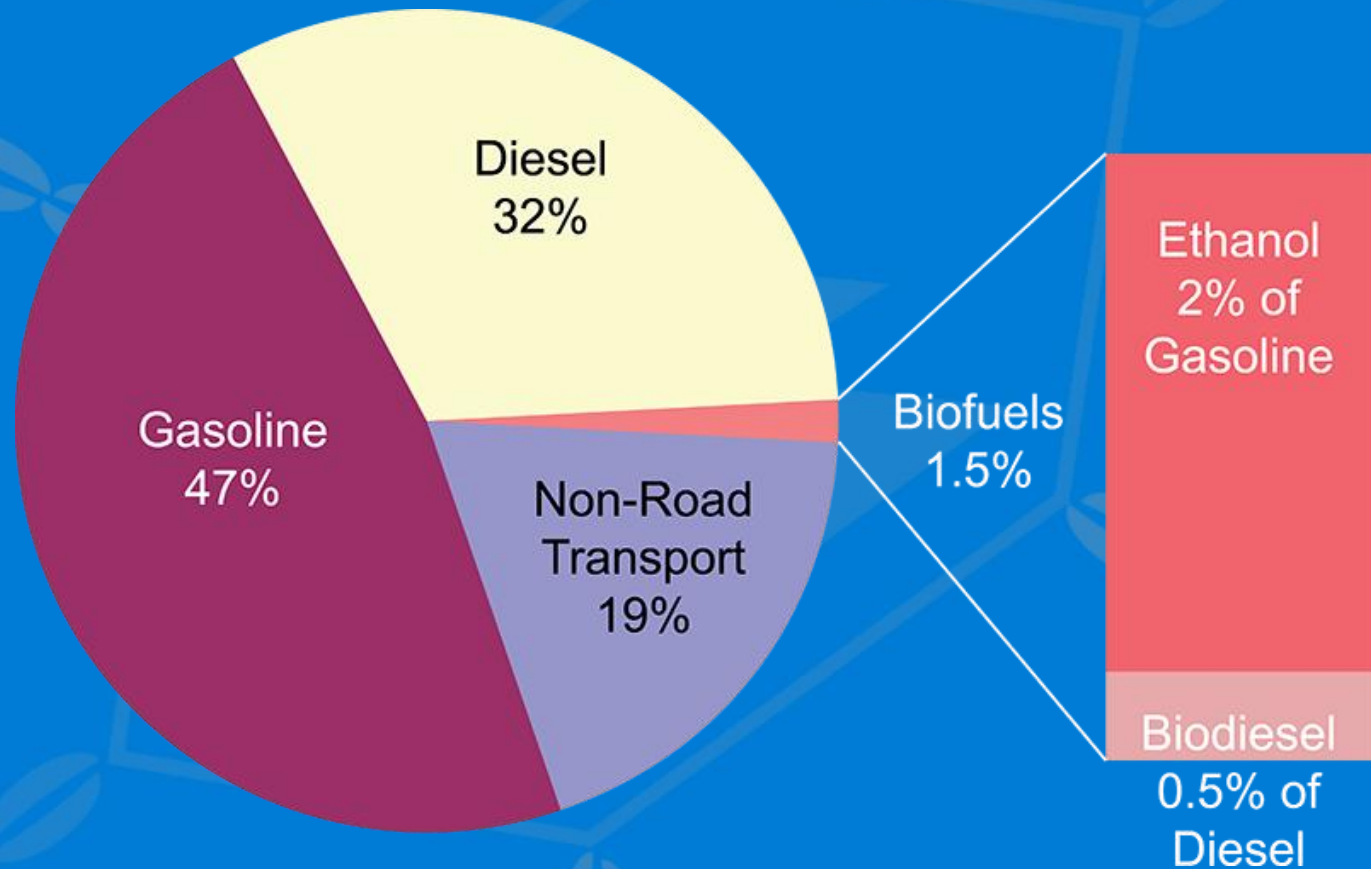


Total Primary Energy Supply (World)

Total Primary Energy
Supply (2005):
466 Exajoules
(or 466×10^{18} Joules)



Global transport fuel shares, 2007



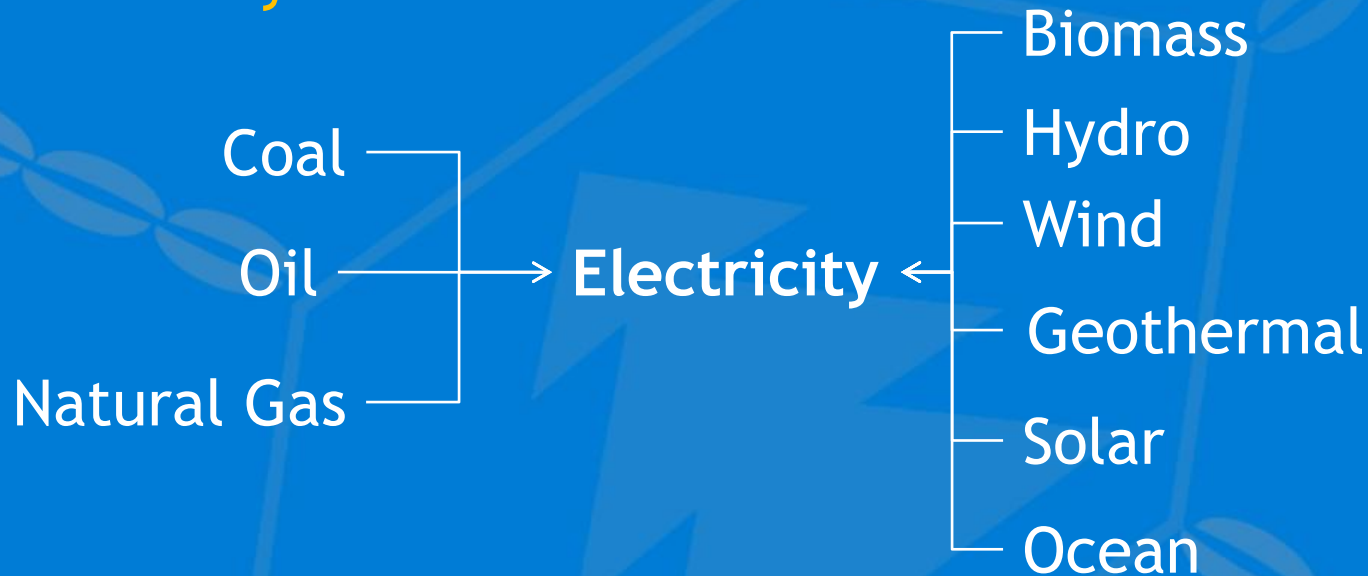
IEA/OECD 2008

Low Fulton – IEA HQ



Renewable Alternatives

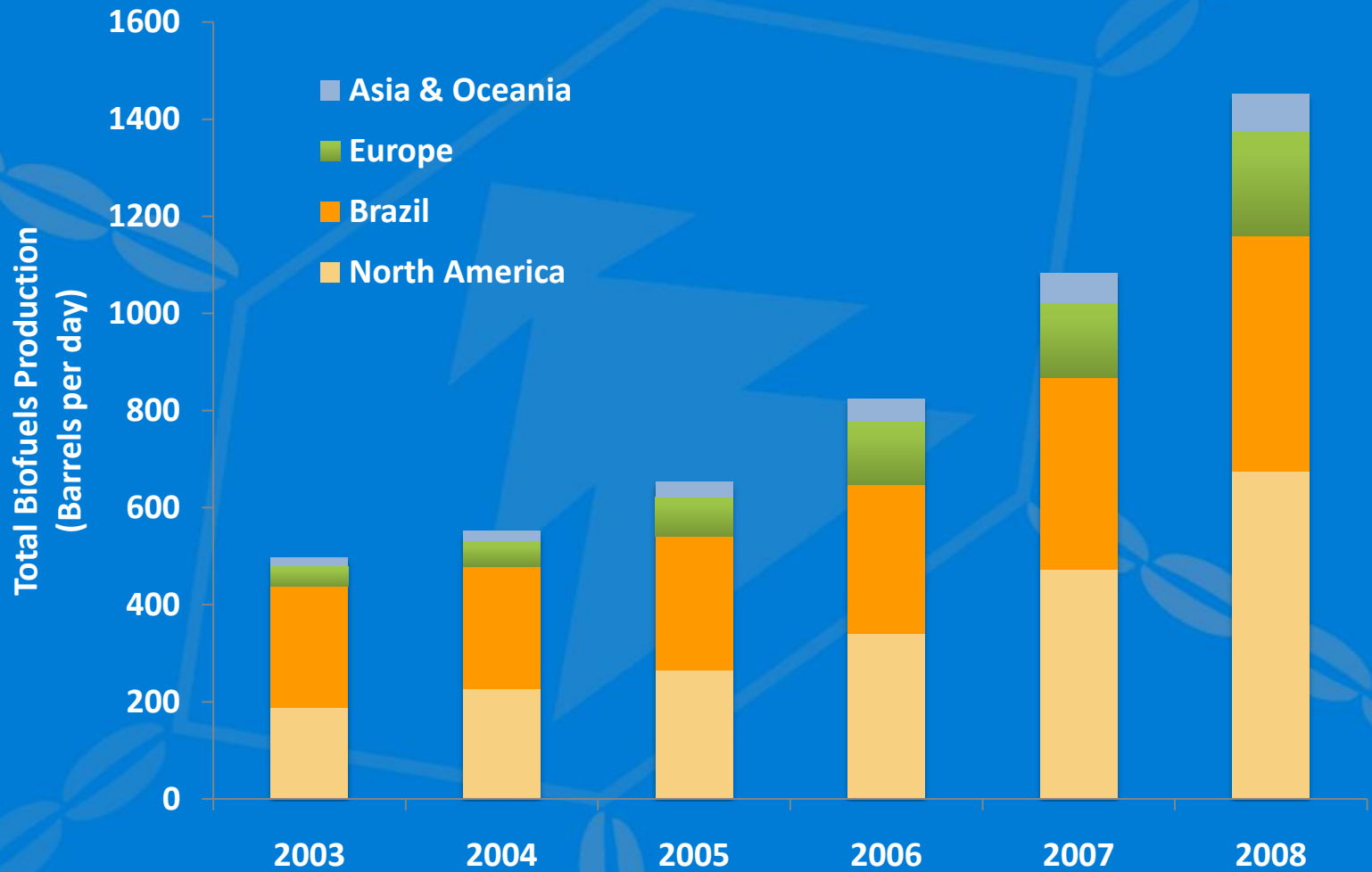
▶ 1. Electricity Generation



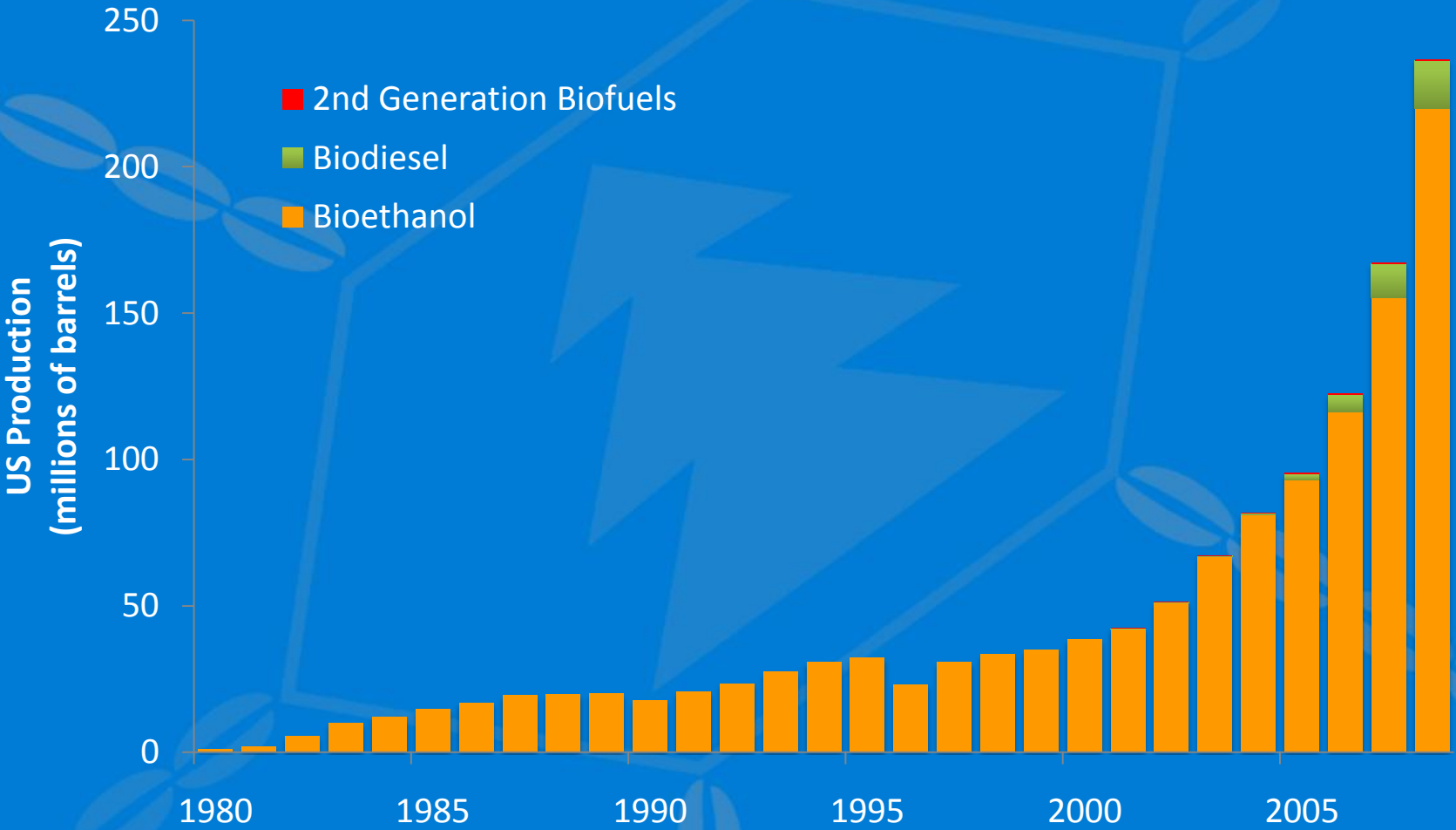
▶ 2. Transport Fuels



Biofuel Production Worldwide



Present share of 2nd-gen biofuels is only 0.1%

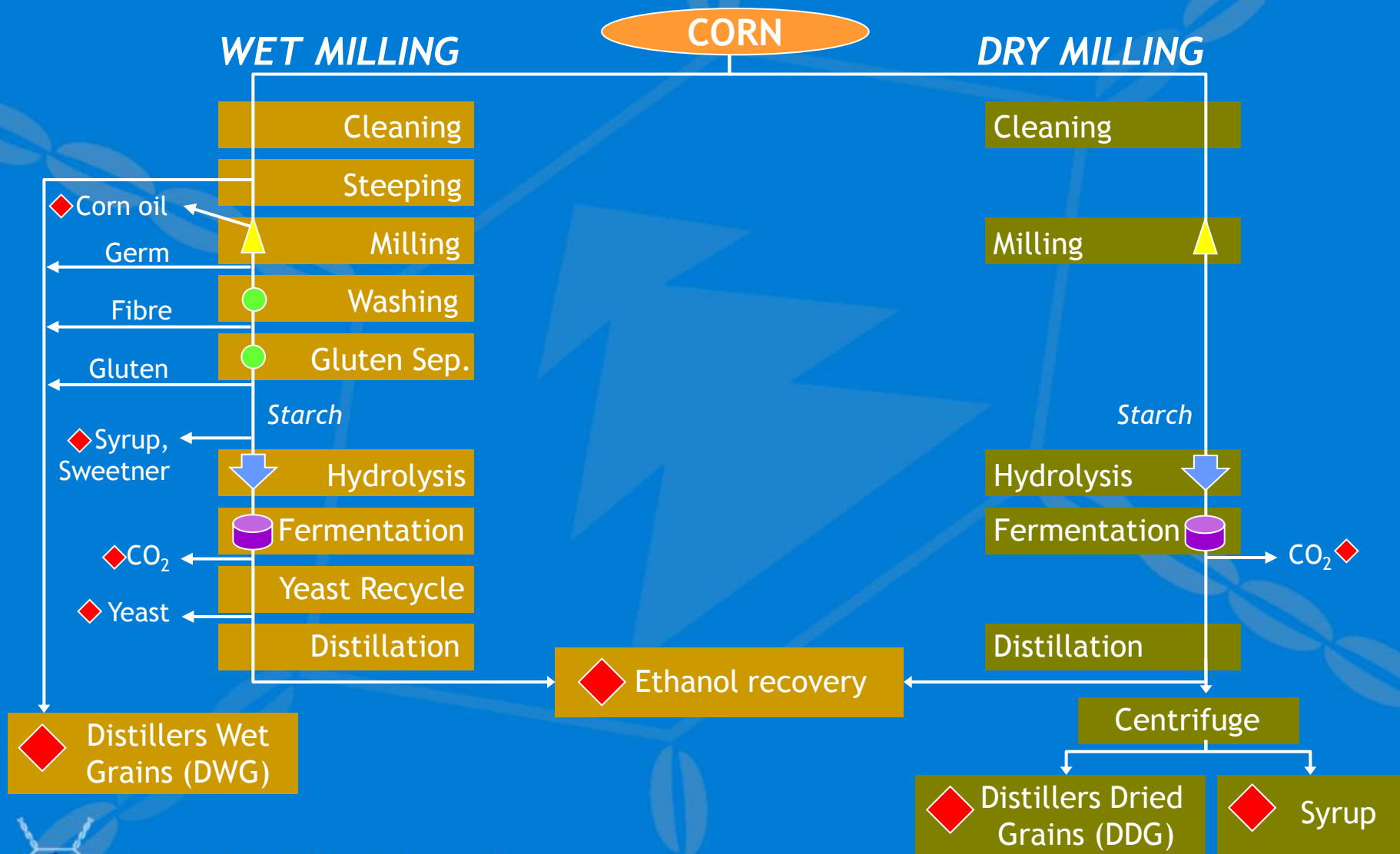


Overview

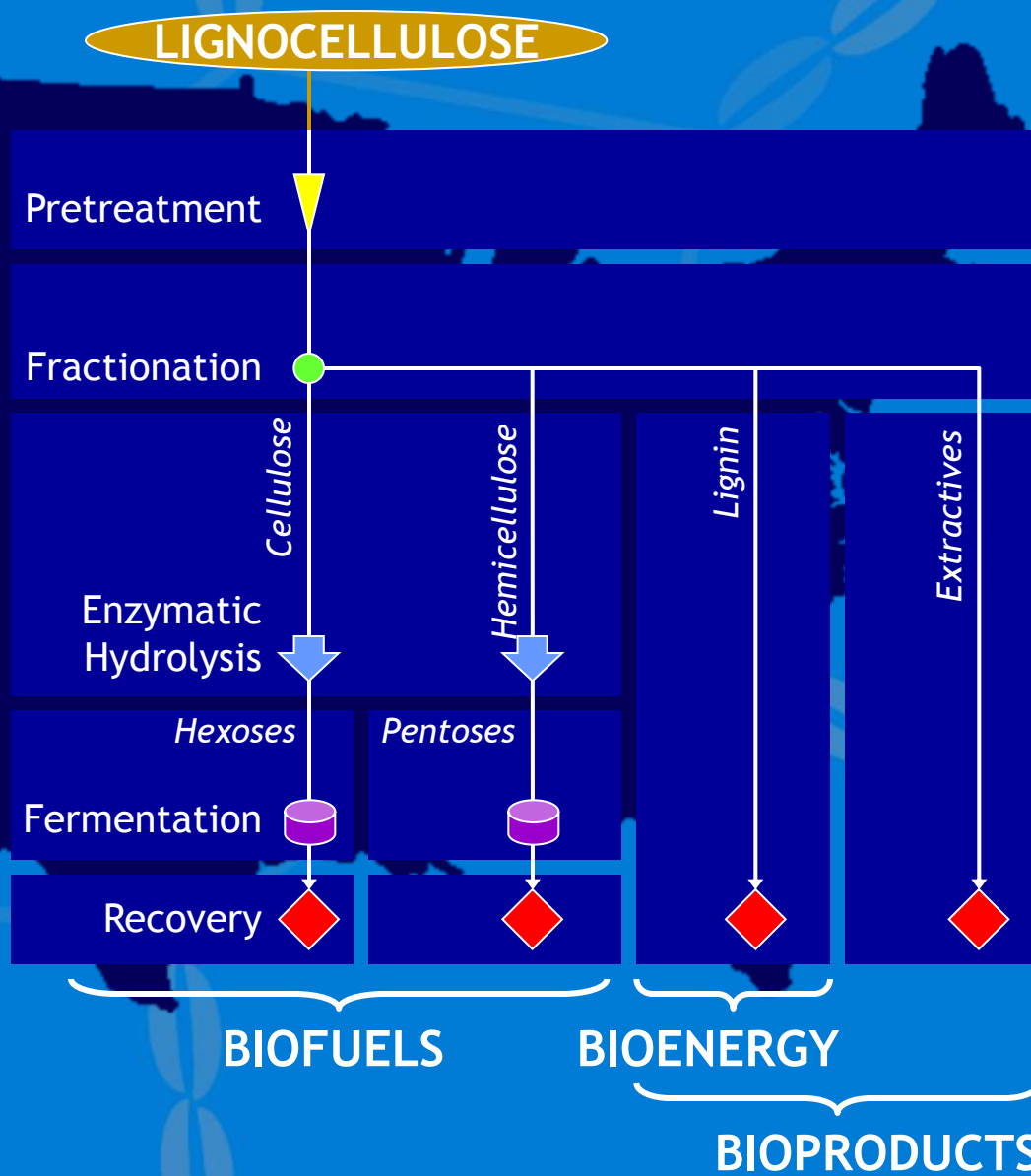
1. Historical perspective
2. **Evolution of biorefining**
3. Biorefining platforms
4. Progress with the bioconversion platform
5. Development of pilot facilities
6. Take-home messages



Agricultural biorefinery



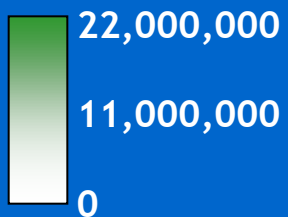
Cellulosic ethanol



Feedstock drivers

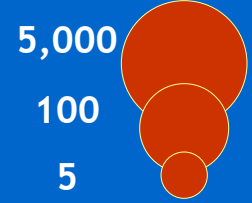
- ▶ Feedstock cost (as well as availability) will determine growth of 2nd-generation biofuel industry
- ▶ North American feedstock availability is being studied with several groups actively working on “bioenergy crops” (miscanthus, switchgrass, poplar, etc)
- ▶ However, biomass residues will be the initial feedstock and their long term availability and cost will be a key determining factor



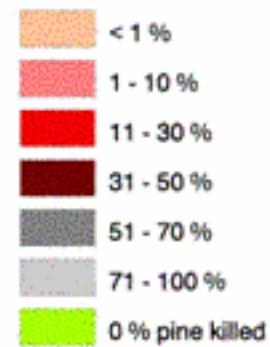


Wood Residue Generation
(Metric tonnes/year)

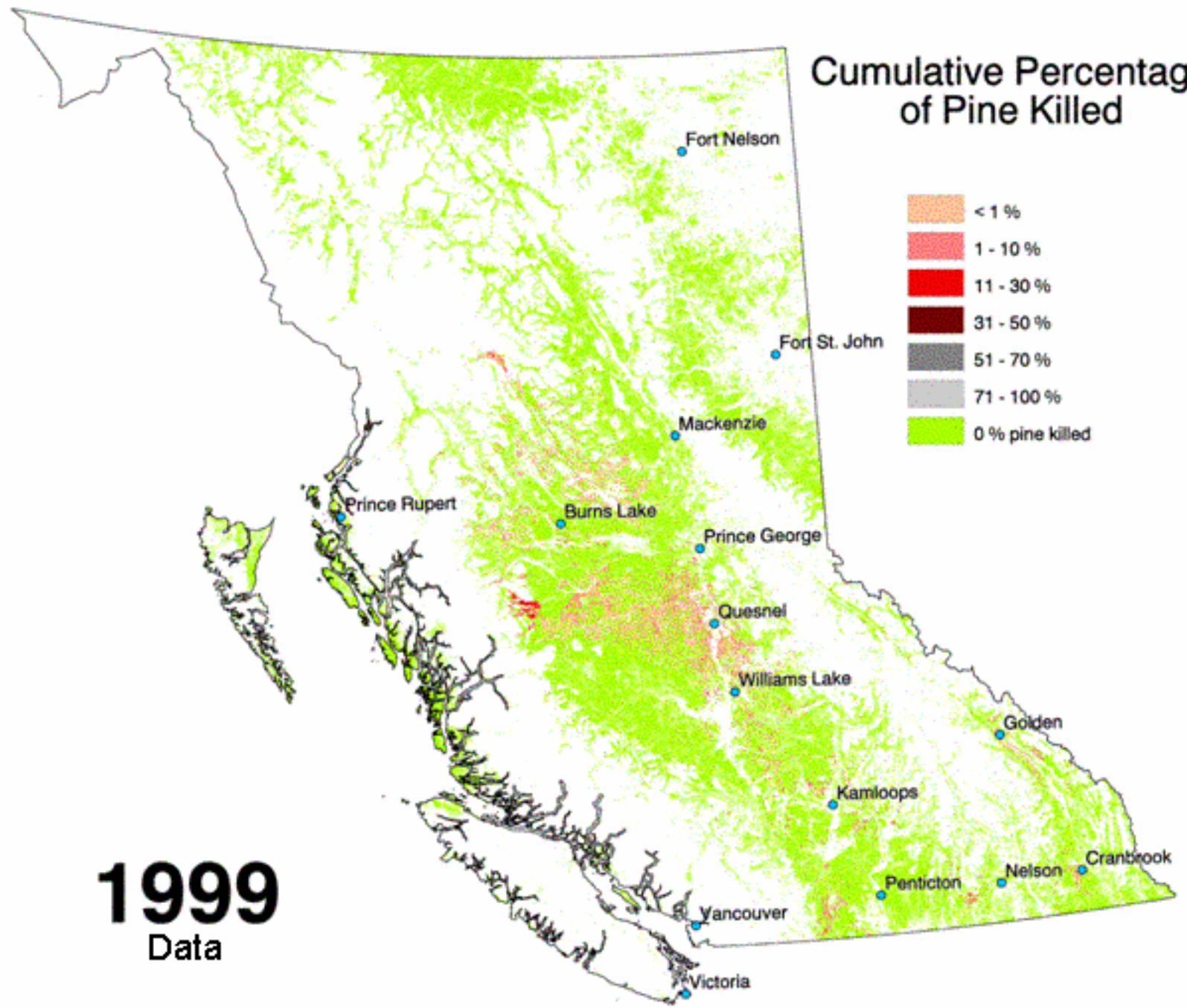
Ethanol Potential
(Million Litres/year)



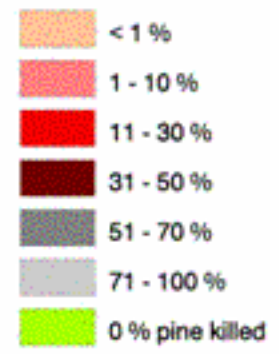
Cumulative Percentage of Pine Killed



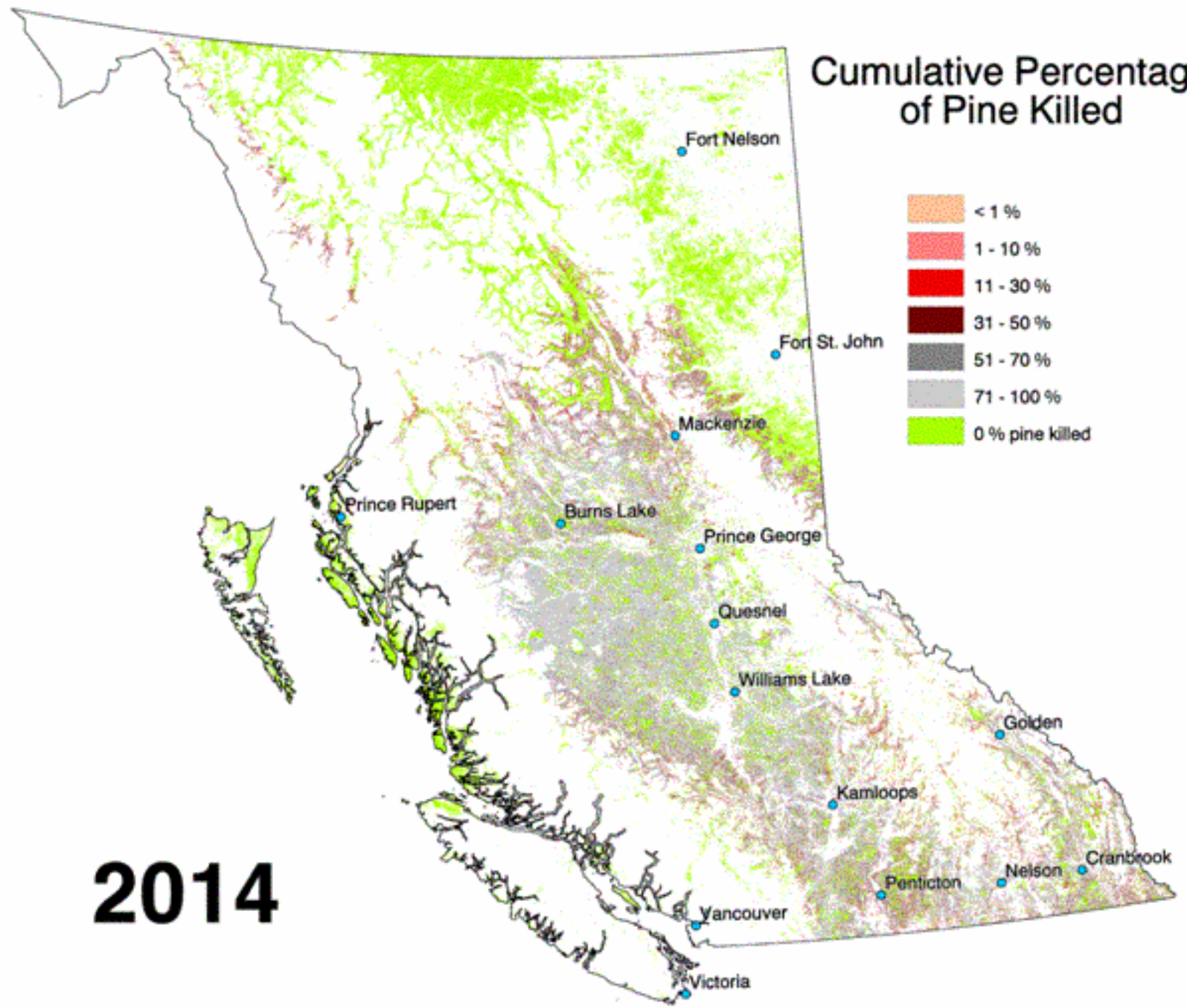
1999
Data



Cumulative Percentage of Pine Killed



2014



Biorefinery

		Company
Bulk polymers: Polylactide (PLA), 3-hydroxypropionic acid, 1,3-propanediol, etc.	BIOLOGICAL	NatureWorks, DuPont, Cargill
		Codexis
		DuPont
THERMOCHEMICAL		Iogen, Abengoa
		Choren
		Scandinavian/BC Cogen facilities
Nutraceuticals: xylitol, arabitol, etc.		
Platform chemicals: Glycerol, furfural, levulinic acid, succinic acid, etc.		
Biofuels: ethanol, bio-hydrogen, etc.		
Biofuels: bio-oil, methanol, ethanol, Fischer-Tropsch, BTL, etc.		
Bioenergy: electricity, steam, combined heat & power (cogen), district heating, wood pellets, etc.		

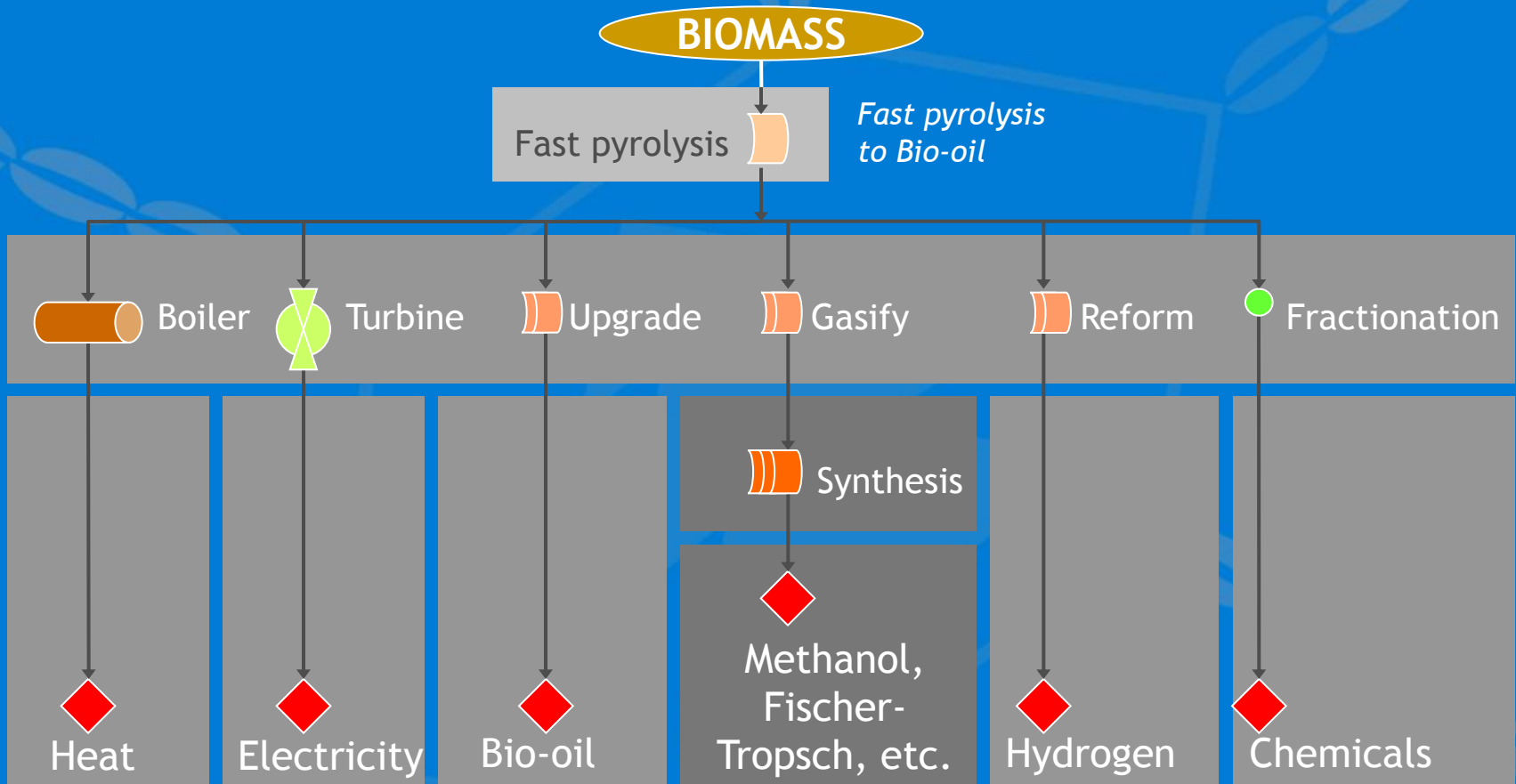


Overview

1. Historical perspective
2. Evolution of biorefining
3. Biorefining platforms
4. **Progress with the bioconversion platform**
5. Development of pilot facilities
6. Take-home messages



Thermochemical biorefinery



Applications

Bio-Oil

- ▶ Bunker fuels (Commercial)
- ▶ Preservatives
- ▶ Resin precursors

Fractionated oil

- ▶ Liquid smoke (Commercial)
- ▶ De-icers

Chemicals

- ▶ Acetic acid (Commercial)
- ▶ Hydroxyacetaldehyde
- ▶ Levoglucosan
- ▶ Levoglucosenone
- ▶ Maltol



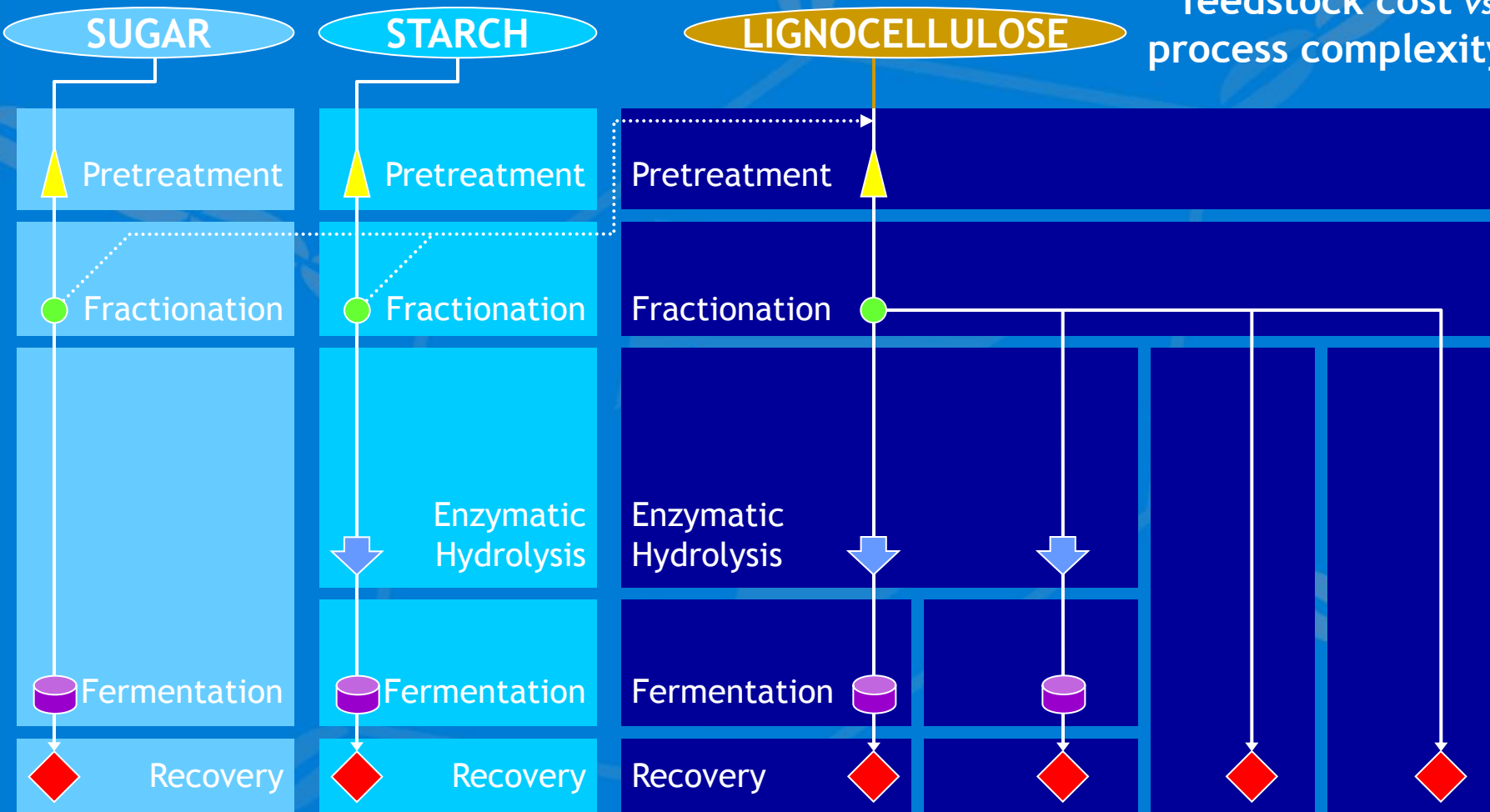
Polymers

- ▶ Furfural -> tetrahydrofuran and butanediol
- ▶ 5-hydroxymethylfurfural ->
 - furan-di-carboxylic acid
 - levulinic acid, PLA
- ▶ Phenol -> antioxidants for plastics

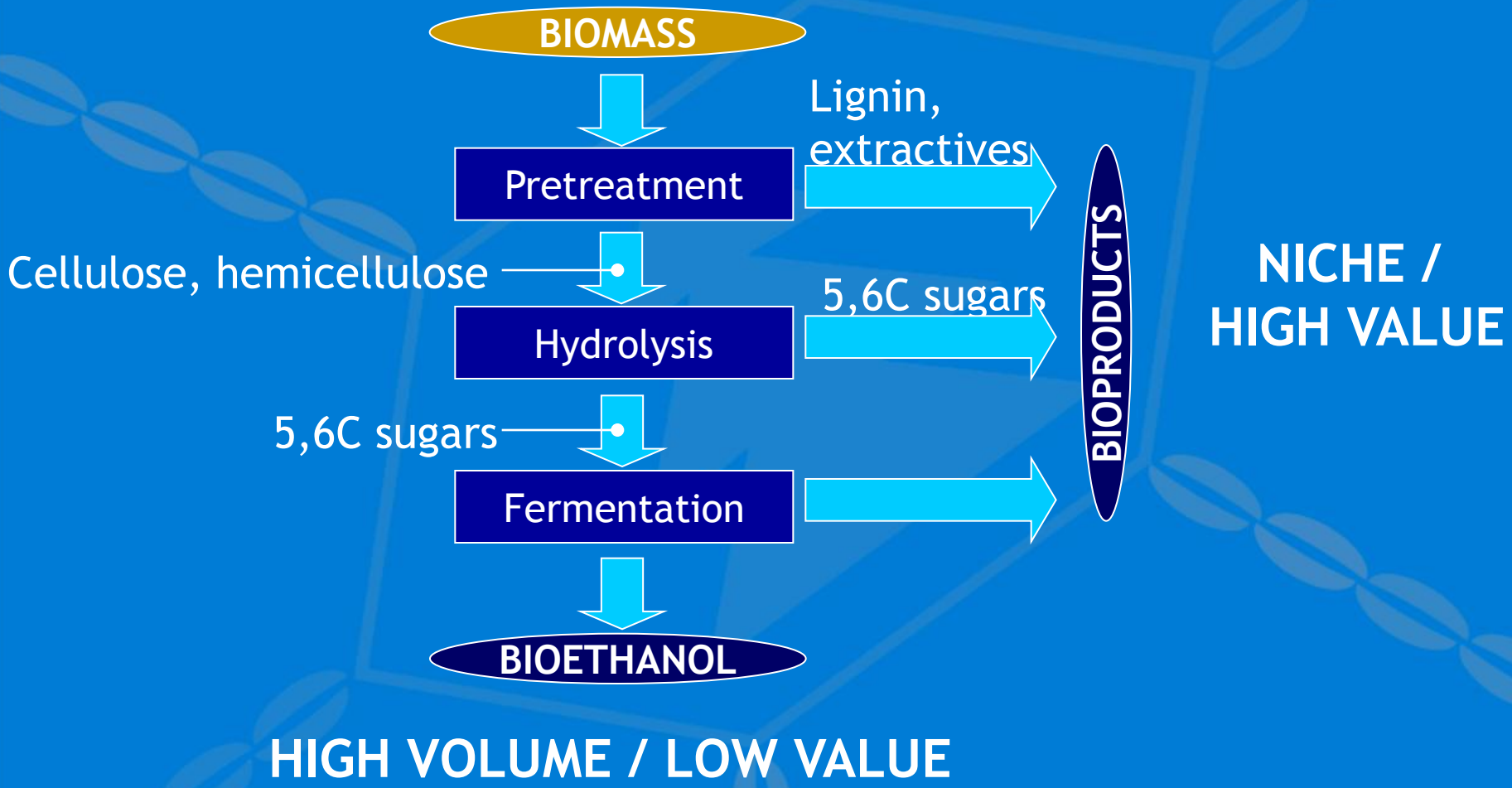


Comparing platforms

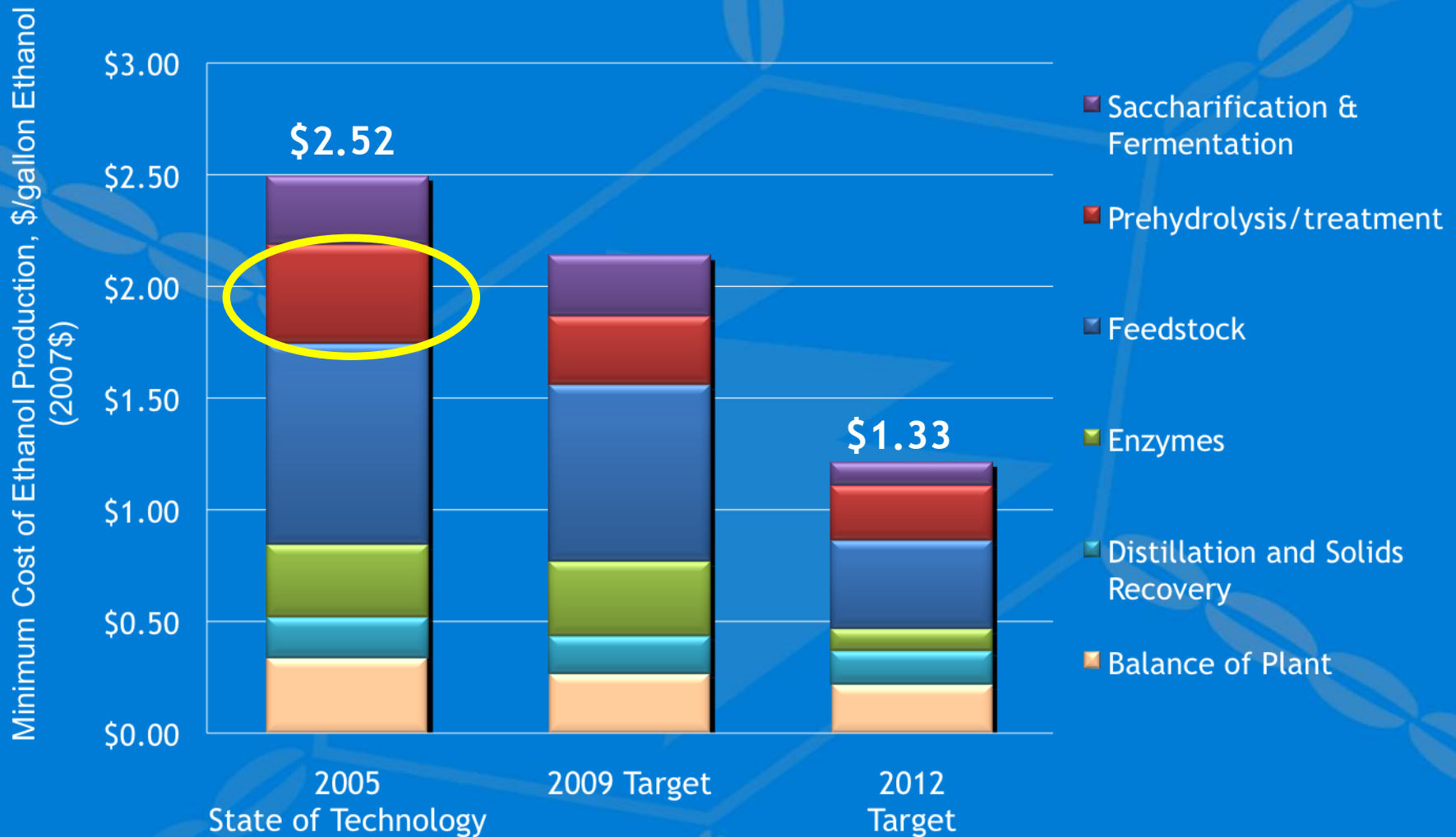
Trade-off:
feedstock cost vs
process complexity



Bioconversion refinery



Bioconversion Costs



Overview

1. Historical perspective
2. Evolution of biorefining
3. Biorefining platforms
4. Progress with the bioconversion platform
5. **Development of pilot facilities**
6. Take-home messages



“From 1st to 2nd Generation Biofuels” - Current Efforts

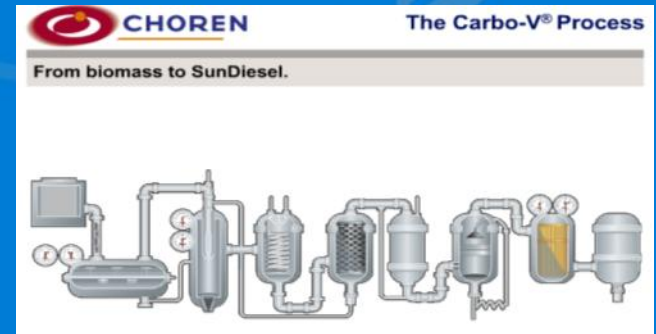
Project investments and locations of major biofuel plant USDOE investments in the US.



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)



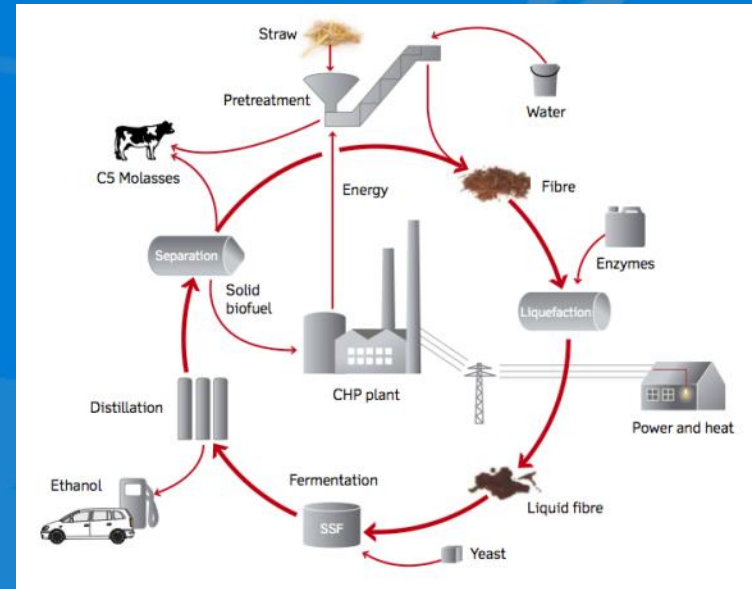
Dong, Inbicon (Denmark)

Symbiosis between bioethanol plant and a power station (CHP)

Kalundborg

Demonstration plant

- ▶ 30,000 tonnes of straw per year
- ▶ 4,300 tonnes / 5,400 m³ of ethanol per year
- ▶ 8,250 tonnes of powdered biofuel per year
- ▶ 11,100 tonnes of molasses (65%DM) per year (animal feed)
- ▶ Autumn 2009 scheduled start-up
- ▶ Located in a port along with an oil refinery and cooperative farm supplier



Nesté Oil - Stora Enso(Finland)

► Porvoo

- 14 million € demonstration
- 2008 start-up
- Integrated with Varkus paper mill energy structure (CHP)
- Fischer-Tropsch to generate crude biodiesel
- Stora Enso will supply biomass and utilize energy
- Nesté will refine and market biodiesel

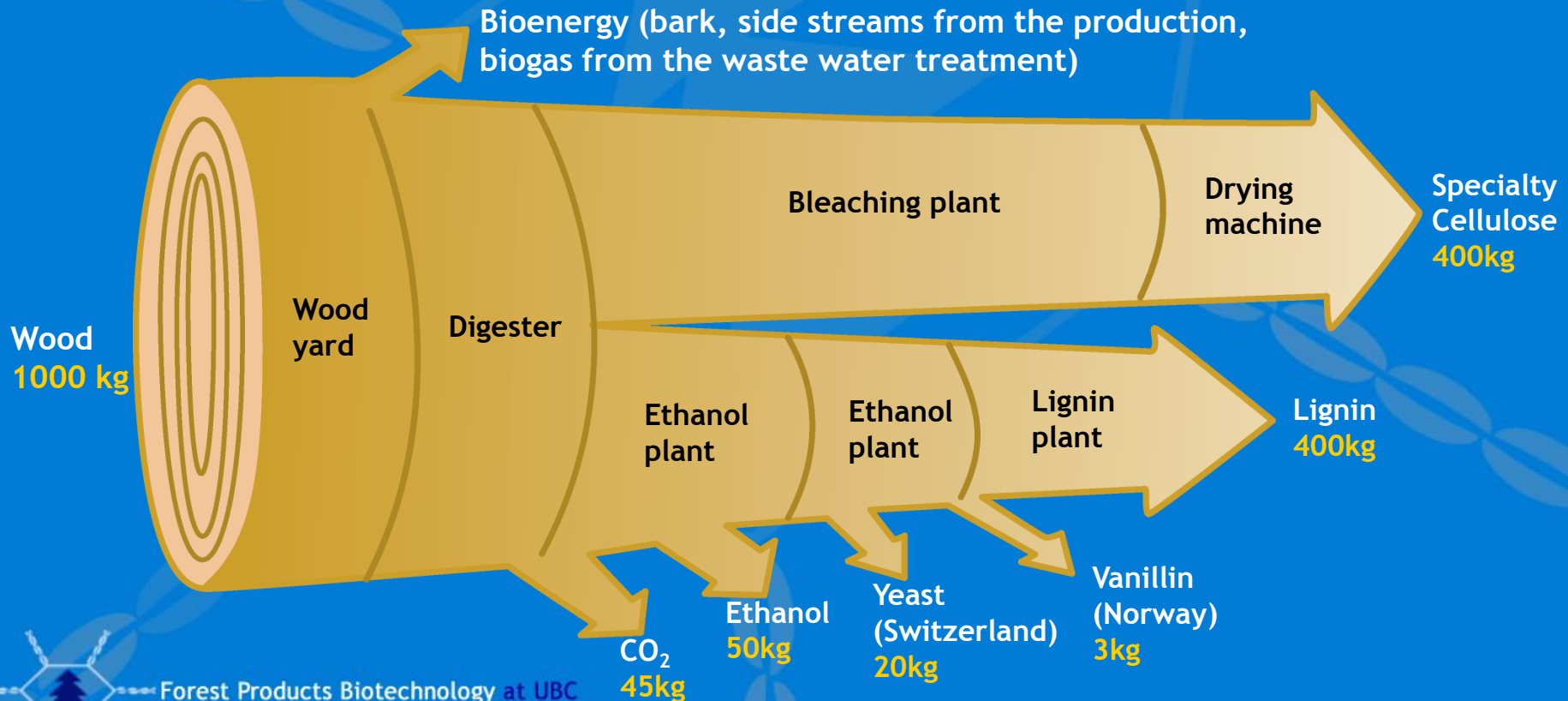
The first second-generation biodiesel

	1st generation 2000	2nd generation NExBTL 2007	3rd generation ≈ 2015
Raw material	Rapeseed oil	Vegeteable oil and animal fat	Biomass
Technology	Esterization	Hydrogenation	Bio-hydrocarbon
End-product	Esterized biodiesel	Bio-hydrocarbon	Bio-hydrocarbon



Borregaard (Norway)

- ▶ Core business is based on softwood biorefinery
- ▶ Specialty cellulose, lignin products, ethanol, yeast, yeast extracts, vanillin, diphenols, fine chemicals
- ▶ Two biorefineries: Sapsborg, Norway & Solothurn, Switzerland



IEA - International Energy Agency

www.iea.org

- ▶ IEA - Autonomous organization linked to OECD
- ▶ Created due to oil-shocks
- ▶ IEA Objectives:
 - Assist in integration of environmental and energy policies
 - “Improve the world’s energy supply and demand structure by developing alternative energy sources and increasing efficiency of energy use”

The screenshot shows the IEA website homepage. At the top left is the IEA logo and the text "International Energy Agency". To the right of the logo are three bullet points: "Energy security", "Environmental protection", and "Economic growth", with a fourth point "Engagement worldwide" below them. Below the logo is a navigation menu with links: HOME, ABOUT IEA, By TOPIC, By COUNTRY, PUBLICATIONS, EVENTS, PRESS, MULTIMEDIA. A search bar is on the right. The main content area is titled "Latest Information" and features four news items, each with a small photo and a title: "Energy Technology Focus in Latin America" (9 July 2010), "Breakfast debate in Paris on Energy Technology Perspectives 2010" (8 July 2010), "Oil and Gas Market Report Presented in Washington" (7 July 2010), and "Energy Technology Perspectives presentation in Germany" (6 July 2010). On the left side of the page, there is a "QUICK MENU" section with links to Statistics, Energy Technology Perspectives, Energy Technology Initiatives, QN/G20 Related Work, Environment, and Free Newsletters. Below that is a "WEBSITE" section with links to Oil Market Report, World Energy Outlook, Energy Business Council, IEA in Chinese, IEA in Russian, and Bookshop. At the bottom left of the page is a "CONTACT US" section with links for "What is the IEA?", "Member Countries", "Shared Goals", "FAQ", "Executive Office", and "Employment at IEA". On the right side of the page, there are several "RESOURCES" sections: "For Delegates", "JUST RELEASED" (with a link to "Energy Technology Perspectives 2010"), "FOCUS" (with a link to "Oil Embargo"), "DON'T MISS" (with links to "Global Analysis of Low-Carbon Technology R&D Spending Needs" and "European Gas Trade Flows Map"), and "IEA Training".



IEA Bioenergy Tasks 2010-2012

Social & Environmental Issues:

- ▶ Task 29 - Socio-economic drivers in implementing bioenergy projects
- ▶ Task 38 - GHG Balances of Biomass and Bioenergy Systems

Conversion Technologies:

- ▶ Task 32 - Biomass combustion and co-firing
- ▶ Task 33 - Thermal gasification of biomass
- ▶ Task 34 - Pyrolysis of biomass
- ▶ Task 36 - Energy recovery from municipal solid waste
- ▶ Task 37 - Energy from biogas and landfill gas
- ▶ **Task 39 - Commercializing liquid biofuels (Task Leader: Jack Saddler)**
- ▶ Task 42 - Biorefineries

Trade:

- ▶ Task 40 - Sustainable international bioenergy trade
- ▶ Task 41 - Joint project with the Advanced Motor Fuels IA
- ▶ Task 43 - Biomass Feedstocks and Energy Markets



IEA Bioenergy Task 39

- ▶ Commercializing of sustainable Liquid Biofuels
- ▶ Collaboration between 15 countries
 - Analysis on policy, markets and sustainable biofuel implementation
 - Catalyze cooperative research and development
 - Information dissemination & outreach with stakeholders
 - Focus on Technical and Policy issues

TECHNICAL ANALYSIS

POLICY AND IMPLEMENTATION

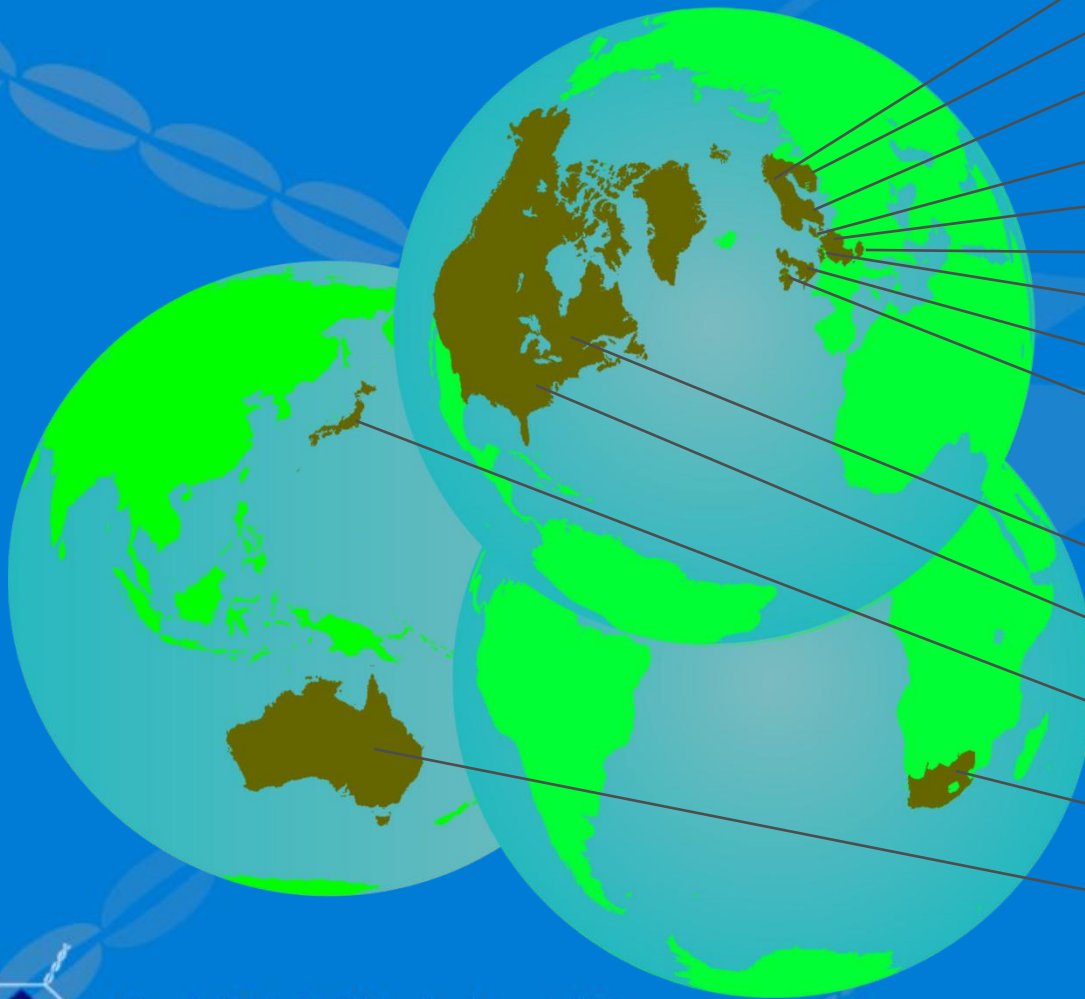
Catalyze
Cooperative
Research

State of
Technology &
Trends Analysis

Policy, Market
and
Deployment
Analysis

Biofuel
Deployment
and Information
Sharing

International Network



Norway

Lars Sorum, Karin Oyass, Roger Khalil

Finland

Tuula Makinen

Sweden

Guido Zacchi, Alice Kempe, Kenneth Weuring

Denmark

Henning Jorgensen

Germany

Axel Munack

Austria

Manfred Wörgetter

The Netherlands

John Neeft,

United Kingdom

Tony Sidwell

Ireland

Jerry Murphy

European Commission

Kyriakos Maniatis

Canada

Jack Saddler

United States

Jim McMillan

Japan

Shiro Saka,

South Africa

Bernard Prior, Emile van Zyle

Australia

Les Edye



Task Outputs

INTERNATIONAL ENERGY AGENCY
AGENCE INTERNATIONALE DE L'ENERGIE



FROM 1st- TO 2nd-GENERATION BIOFUEL TECHNOLOGIES

*An overview of current
industry and RD&D activities*

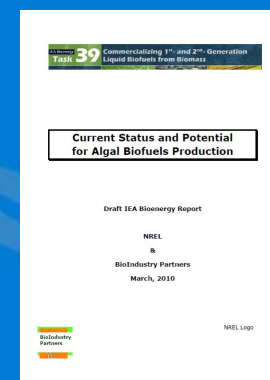
RALPH SIMS, MICHAEL TAYLOR
INTERNATIONAL ENERGY AGENCY
AND JACK SADDLER, WARREN MABEE
IEA Bioenergy

© OECD/IEA, November 2008

Technical and Policy Reports



Sustainability
of Biofuels

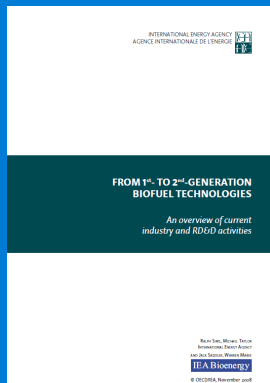


Algal Biofuels:
Current Status and
Potential

www.Task39.org

Task Outputs

www.Task39.org



From 1st to
2nd gen Biofuels

Sustainability
of Biofuels

Forest Products Biotechnology at UBC



Current Status and Potential for Algal Biofuels Production

Draft IEA Bioenergy Report

NREL

&

BioIndustry Partners

March, 2010



NREL Logo

Task 39 Outputs cont'd

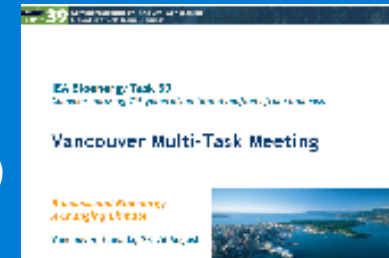
- ▶ Newsletters

- Featuring newest developments)



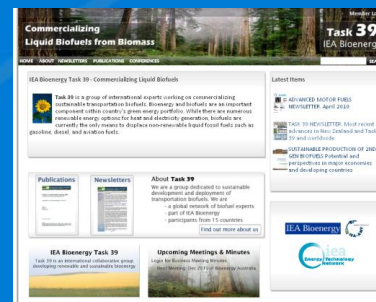
- ▶ Facilitating international collaboration

- Organized Multi-Task Conferences (i.e. Vancouver 06, 09)
- 2-3 Business Meetings / year

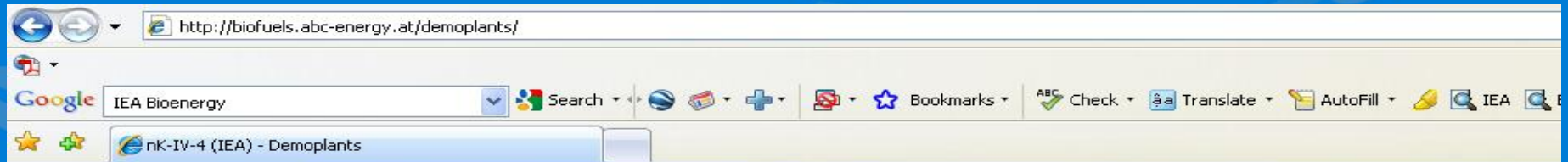


- ▶ Website / facility database

- Resource for biofuels stakeholders
- Worldwide biorefinery database



Demonstration Plants (cellulosic ethanol)



IEA Bioenergy

Task 39

Commercializing 1st- and 2nd- Generation Liquid Biofuels from Biomass

This overview has been elaborated by ABC (now Bioenergy2020+) and FJ-BLT.



Please click here for more information

Status of 2nd Generation Biofuels Demonstration Facilities

Currently, large efforts are dedicated to the production of biofuels from lignocellulosic raw materials. While only few production facilities are operational yet, many projects are under construction or planned. But which are the companies involved, where are production facilities under construction, and which technologies will be applied? In order to answer these questions, IEA Bioenergy Task 39 has collected data on pilot and demonstration projects and displays the results in a web-based, interactive map. (Click on map to obtain information)

For more information and for data upload please continue reading below the map or contact dina.bacovsky@abc-energy.at



Cellulosic Biofuel

Maximum Potentially Available Volume 2011

Company Name	Location	Feedstock	Fuel	Capacity (MGY)	Earliest Production	Max 2011 Potential (MG)	Ethanol equiv Gallons (MG)
AE Advanced Fuels Keyes	Keyes CA	Corn, then stover	Ethanol	20	Jun 11	0.5	0.5
Agresti Biofuels	Pike County KY	MSW	Ethanol	20	Oct 11	1	1
Bell Bio-Energy	Atlanta GA	MSW / other cellulosic biomass	Diesel Feedstock	14.4	Jun 11	7	11.9
Cello Energy	Bay Minette AL	Wood, hay	Diesel	20	Online	5	8.5
DuPont Danisco*	Vonore TN	Corn cobs, then switchgrass	Ethanol	0.25	Online	0.15	0.15
Firebright*	Blairstown IA	MSW	Ethanol	6	Apr 10	2.8	2.8
Iogen	Ottawa Ontario	Wheat, oat & barley straw	Ethanol	0.5	Online	0.25	0.25
KL Energy*	Upton WY	Wood	Ethanol	1.5	Online	0.4	0.4
					Total	17.1	25.5

Overview

1. Historical perspective
2. Evolution of biorefining
3. Biorefining platforms
4. Progress with the bioconversion platform
5. Development of pilot facilities
6. **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 both of these technologies
- ▶ Tremendous progress has been made in biological lignocellulose-to-ethanol pathways
- ▶ Policy and technology must work together to bring new forest products to market



IEA Recent Work on Biofuels

1. *From 1st to 2nd Generation Biofuels: An Overview of Current Industry and RD&D activities*

Report in collaboration with IA Bioenergy. 12/2008

Available as a free download at www.iea.org

2. More recent reports on sustainability, demonstration/commercial plants, Algal Biofuels, etc, at www.Task39.org
3. Updated Biofuels Roadmap from IEA due out in early 2011



Acknowledgements

- ▶ Jana Hanova/Warren Mabee
- ▶ IEA Bioenergy Task 39
- ▶ IEA HQ Colleagues (Ralph Sims, Lew Fulton, Michael Taylor)
- ▶ Forest Products
Biotechnology/Bioenergy Group
UBC
- ▶ Many colleagues and
collaborators

www.Bioenergy.UBC.ca



Forest Products Biotechnology at UBC

Thank You!



Questions



Forest Products Biotechnology at UBC