



IEA Bioenergy Workshop – Biofuels and Bioenergy: Challenges and Opportunities



www.nrcan.gc.ca



Natural Resources
Canada

Ressources naturelles
Canada

Canada



Graham Campbell

**Chair – IEA Committee on Energy Research and
Technology**

**Director General - Office of Energy R&D
Natural Resources Canada**

**August 30th, 2006
Vancouver, B.C.**

OUTLINE



- **IEA's Technology Activities**
- **BioEnergy Challenges and Opportunities:
A Canadian Perspective**
- **BioEnergy R&D in Canada**
- **CBIN / IEA Relationship in BioEnergy**
- **Closing Remarks**



IEA's Technology Activities



□ The only structure in the world that ...

- Covers wide range of energy technologies**
- Facilitates exchange of technical and related policy expertise and information**
- Links researchers and research managers with policy makers**
- Has a time-tested structure for formalizing agreements**

IEA's Energy Technology Program

A Model of Collaboration



□ Structure

- **Technology scope - energy research and technology development, demonstration and deployment**
 - **Four Working Parties**
 - Fossil Fuels, Renewable Energy, Efficient End-Use, Fusion Power
 - **Information Centres – Coal research, CADDET, etc.**
 - **Implementing Agreements are key – 40+/-**
- **Programs, networks and analysis brings together:**
 - **Scientists and engineers – government, industry, academics**
 - **Policy makers**
 - **Industry experts and decision-makers**
- **Participants from IEA member and non-member countries**

The IEA Energy Technology Network

IEA GOVERNING BOARD

CERT - Committee on Energy Research and Technology

Fusion Power Co-ordinating Committee

IMPLEMENTING AGREEMENTS

Env. Safety, Econ. Aspects
Fusion Materials
Large Tokamaks
Nuclear Tech. of Fusion
Textor
Reversed Field Pinches
Stellarator
ASDEX Upgrade
Spherical Tori (forthcoming)

Working Party on Fossil Fuels

IMPLEMENTING AGREEMENTS

Clean Coal Centre
Clean Coal Science
Enhanced Oil Recovery
Fluidised Bed Conversion
Greenhouse Gas R&D
Multiphase Flow Science

Advisory Group on Oil & Gas Technology

Working Party on Renewable Energy Technologies

IMPLEMENTING AGREEMENTS

Hydrogen
Bioenergy ←
Geothermal
Hydropower
Ocean Energy
Photovoltaic Power
Solar Heating/Cooling
SolarPACES
Wind Turbines

Working Party on Energy End-Use Technologies

IMPLEMENTING AGREEMENTS

Advanced Fuel Cells
Advanced Materials Transp. ←
Advanced Motor Fuels
Hybrid/Electric Vehicles
Demand Side Management
Buildings/Communities
District Heating/Cooling
Energy Storage
Heat Pumps
Energy Cons./Emissions Red.
Industry Efficiency
Energy Technology
Superconductivity

Hydrogen Co-ordination Group

Experts Group on R&D Priority- Setting and Evaluation

Ad Hoc Group on Science and Energy Technologies

INTER-SECTORAL IMPLEMENTING AGREEMENTS

- Climate Technology Initiative (CTI)
- Energy and Environmental Technologies Information Centre (EETIC)
- Energy Technology Systems Analysis Programme (ETSAP)
- Energy Technology Data Exchange (ETDE)



CERT's mission is to support the goals of the IEA by

“ ... promoting the development and deployment of clean and advanced energy technologies through international networking, co-operation, collaboration, analysis and policy advice.”

CERT's Strategic Objectives



☐ CERT's four-part strategy

1. Identify and promote effective and innovative technology policies to stimulate energy technology RDD&D
2. Clearly define and analyze energy technology issues and opportunities, to enhance analytical tools
3. Vigorously foster international networking and collaboration in energy technology RDD&D
4. Effectively communicate the key lessons learned through the CERT's activities

☐ Excellent support, analysis and advice provided by the IEA's Energy Technology Office (ETO)

CERT and BioEnergy



- **CERT recognizes the importance of biomass as a transformative energy system for transportation fuels, electricity, heat, chemicals, materials and industrial bioprocesses**
- **CERT unanimously endorsed the continuation of the BioEnergy IA – Strategic Plan, Five-Year Plan**
- **Given the world wide interest in bio, it is now appropriate to review all the IEA bio activities to see what, if anything, is missing including long term fundamental research**
- **In addition, it is necessary to link with other major international activities in bio including G8 GBeP and APEC**

Other Major International BioEnergy Activities



- ❑ Two examples which can pursue cooperative technology development and deployment are:

1) Global BioEnergy Partnership (GBEP)

- Recently created, it includes all G8 countries plus Mexico and the FAO
- Led by Italy, it focuses on technology modification and deployment in developing countries

2) Asia-Pacific Economic Cooperation (APEC)

- Cooperation among 18 Pacific Rim countries intended to reduce trade barriers
- Composed of working groups, one of which is energy (expert group on new and renewable energy technologies which include bioenergy)
- A major study on biofuels has been approved by APEC ministers



BioEnergy Challenges and Opportunities: A Canadian Perspective

Why Focus on a Bio-based Economy



- **There is a need to complement highly efficient fossil fuels economy with renewable and sustainable alternatives**
- **Canada has a unique opportunity to take advantage of expected national and international bio markets**
- **There is a need to:**
 - 1) **improve the availability, accessibility, reliability, affordability and sustainability of biomass feedstock; and**
 - 2) **develop technologies, processes and systems to convert biomass into bioenergy, biofuels, biomaterials, biochemicals and bioprocesses**

Why Focus on a Bio-based Economy (Continued)



- Among the 6 Canadian Energy S&T priorities, biomass related systems and technologies have the biggest chance to bring about major changes towards a sustainable energy future/mix
- Biomass systems and technologies have potential applications not only in the energy sector but also in buildings, transportation (automotive industry), construction, etc.
- It has the potential to create sustainable jobs in rural, urban, and aboriginal communities

The Opportunity: An Integrated Industry



Biomass Feedstocks

Trees
Grasses
Agricultural Crops
Agricultural Residues
Animal Wastes
Municipal Solid Waste



Bioconversion Biorefinings

Enzymatic Fermentation
Gas/liquid Fermentation
Acid Hydrolysis/Fermentation
Gasification
Combustion
Co-firing
Extraction-purification

Fuels:
Ethanol
Renewable Diesel
Electricity
Heat
Chemicals
Plastics
Solvents
Pharmaceuticals
Chemical Intermediates
Phenolics
Adhesives
Furfural
Fatty acids
Acetic Acid
Carbon black
Paints
Dyes, Pigments, and Ink
Detergents
Materials
Food and Feed

Mark Stumborg, P.Eng., Agriculture and Agri-Food Canada, Swift Current, Saskatchewan

The Future



- **Cellulosic ethanol from a variety of feedstock biorefinery (value-added co-products, technology demonstration)**
- **Industrial bioprocesses (bio-catalysis, enzymes optimization)**
- **Sustainable biomass supply**
- **New crops (crops/trees developed specifically for the production feedstock with features sought by industry)**
- **Conversion Technologies (heat and power and energy carrier)**
- **Long term possibilities – bio PV, bio storage, nano biomaterials, hybrid bio/electric industrial processes**

Leveraging Photosynthesis for Efficient Energy Production



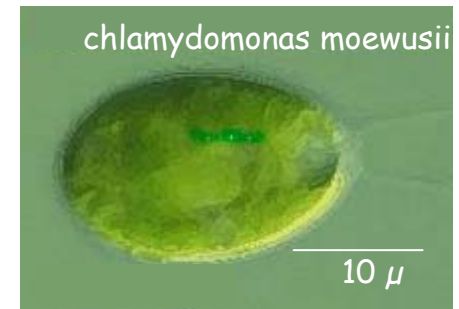
- photosynthesis converts ~ 100 TW of sunlight to sugars: nature's fuel
- low efficiency (< 1%) requires too much land area



switchgrass

Modify the biochemistry of plants and bacteria

- improve efficiency by a factor of 5-10
- produce a convenient fuel
methanol, ethanol, H₂, CH₄



hydrogenase
 $2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2$

Scientific Challenges

- understand and modify genetically controlled biochemistry that limits growth
- elucidate plant cell wall structure and its efficient conversion to ethanol or other fuels
- capture high efficiency early steps of photosynthesis to produce fuels like ethanol and H₂
- modify bacteria to more efficiently produce fuels
- improved catalysts for biofuels production

(Source Nathan Lewis)

Cellulosic Ethanol: Microbes as Processing Plants



Source
David Thomassen
US DOE

Today we utilize food starch to make alcohol and complex and costly processing of cellulose

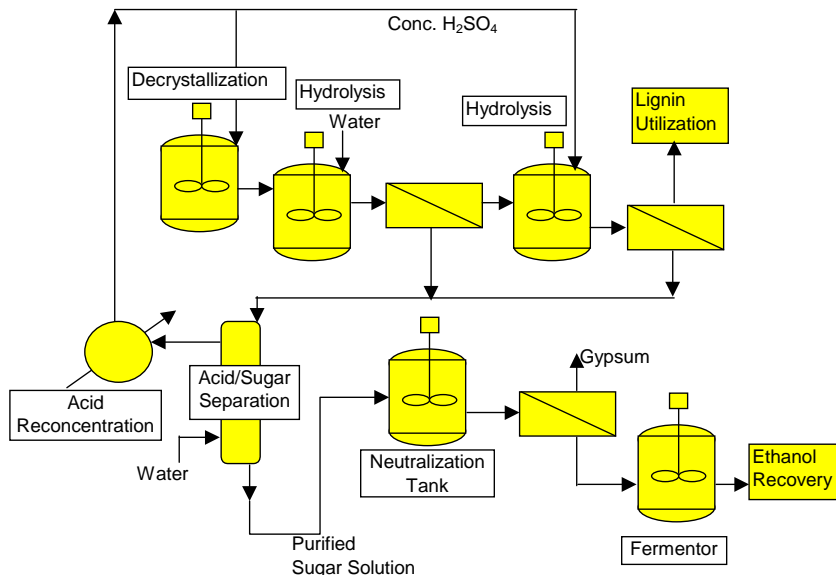
Tomorrow we want to utilize high yield cellulose crops with integrated processes in microbes to convert to alcohols and other fuels



Cellulose Today

Decrystallization
Hydrolysis of Cellulose,
Hemicellulose, and Lignin
Multiple Sugar Metabolism
Alcohol Synthesis

Tomorrow?





BioEnergy R&D in Canada

Canadian Biomass Innovation Network (CBIN)



- Canada recognizes the importance of biomass
- The country had a number of small programs spread across the government
- They were combined in CBIN to better coordinate, plan and manage federal bioenergy S&T and network with other sectors
- CBIN is network of researchers, program managers, policymakers
- The goal is to continually provide the knowledge base to support the development of a sustainable bio-based economy in Canada

CBIN – Strategy, Priorities



- **Funds applied R&D in bioenergy, biofuels, bioproducts & industrial bioprocesses**
- **Activity areas include: 1) Existing and New Biomass Supply; 2) Conversion and Utilization technologies; 3) Integrated Biomass Applications; and 4) Cross-cutting Issues**
- **Outputs feed demonstration and pre-commercialization programs and policymakers and technology developers**

CBIN's Reach



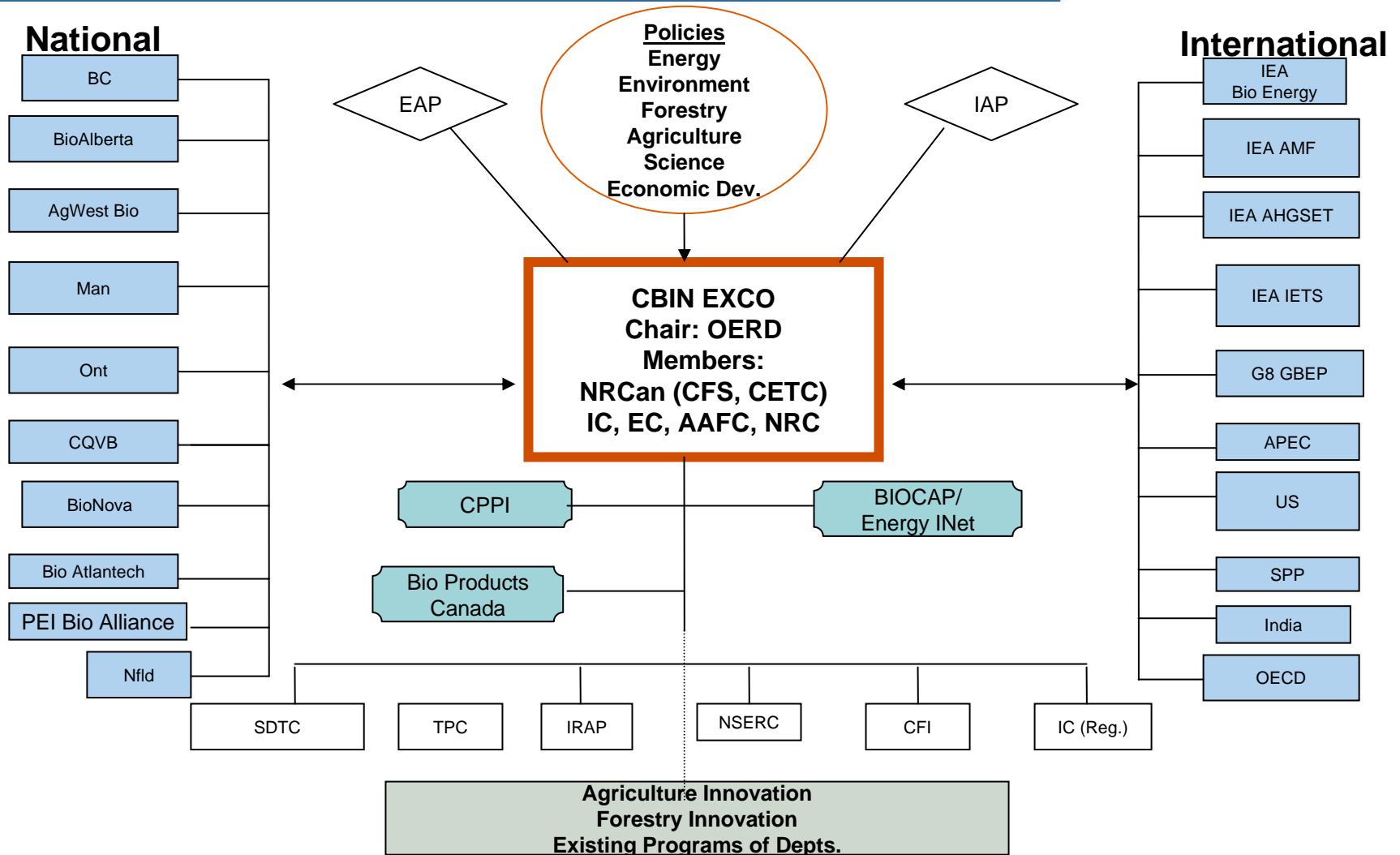
- An external to government advisory panel provides independent advice on strategy and project portfolio. It has representatives from industry, university, provincial organizations and the US DOE Office of the Biomass Program
- Over 20 federal departments, agencies, and institutes participate in and deliver energy R&D
- Partnerships with 10 provinces, 13 universities, 44 industries, and 16 NGOs
- Cooperates with other countries through IEA, APEC, GBeP, bilaterals

CBIN Funding (2005-06)



Program of Energy Research & Development	\$2863 k	
Climate Change Technology & Innovation	\$4918 k	
		Leverage In-kind Leverage
Other Government Departments	\$450 k	\$1013 k
Provinces	\$120 k	\$678.4 k
Academia	\$364 k	\$358 k
Industries	\$2189.5 k	\$2552 k
Other	\$662.5 k	\$467.5 k
Total Leverage	\$3786 k	\$5068.9 k

CBIN World





CBIN / IEA Relationship in BioEnergy

Partnerships



- **Canada's participation in biomass related IEA activities is approved by the CBIN ExCo and has to complement/enhance work of the overall program**
- **IEA's Implementing Agreements are embedded in our on-going R&D program**
- **Together, we can:**
 - 1) **Learn from each other in our respective areas of expertise**
 - 2) **Increase collaboration – no one country can do all the work that is needed**
 - 3) **Influence the development of the bio-based economy**
 - 4) **Position Canada as a leader and to develop a national and coherent approach in the emerging bio-based economy**



Closing Remarks

Working Together to Make it Happen



- **BioEnergy is a priority in all our countries**
- **The range of research needed is very broad, no one country can do it alone, we need to work together**
- **The IEA is the most important mechanism**
- **We need to build and strengthen it and link with others international activities to ensure a sustainable energy future**

Contact



Please visit the CBIN web site at:

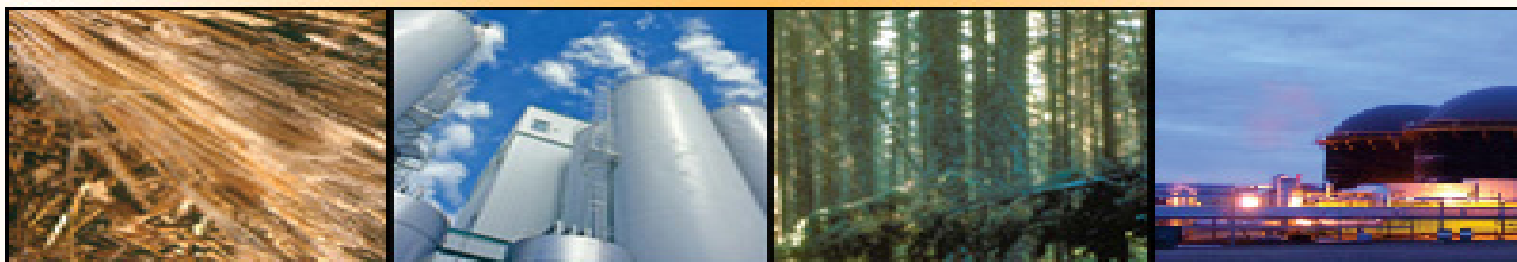
www.cbin-rcib.gc.ca

or

contact Nicole Richer at:

nricher@nrcan.gc.ca

THE CANADIAN BIOMASS INNOVATION NETWORK (CBIN)



RÉSEAU CANADIEN D'INNOVATION DANS LA BIOMASSE (RCIB)