Opportunities and Challenges in Biomass Conversion Technology (Bangkok, June 14, 2016)

Development of Biomass Conversion Technology for Transportation Fuels in Asian Countries

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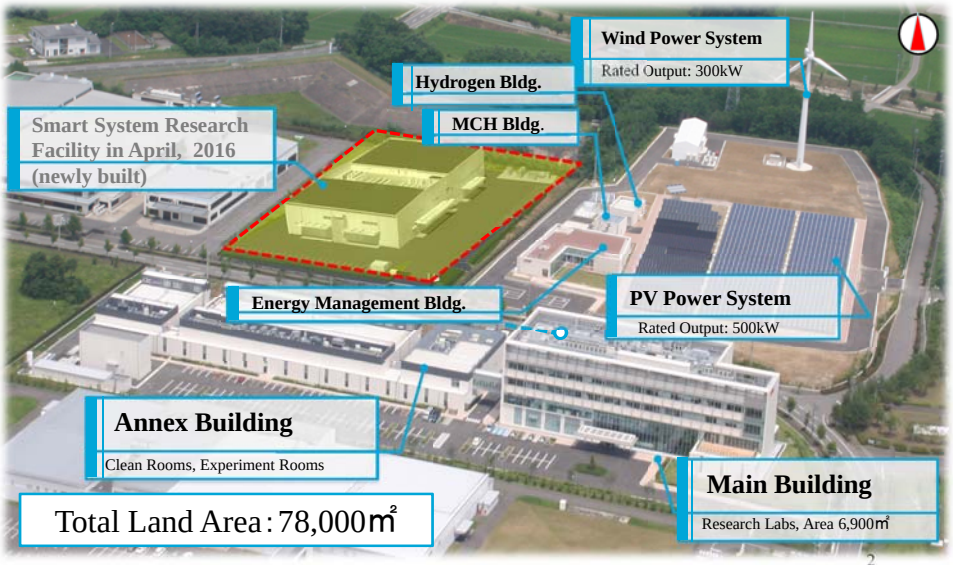
FREA(Fukushima Renwable Energy Institute, AIST)

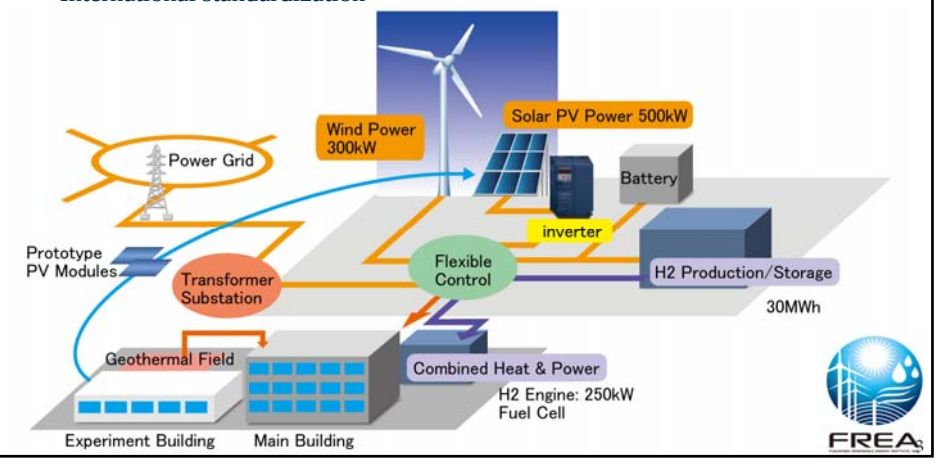
(Established in Koriyama , Fukushima Pref., Japan , in April, 2014)



Renewable Energy Network at FREA

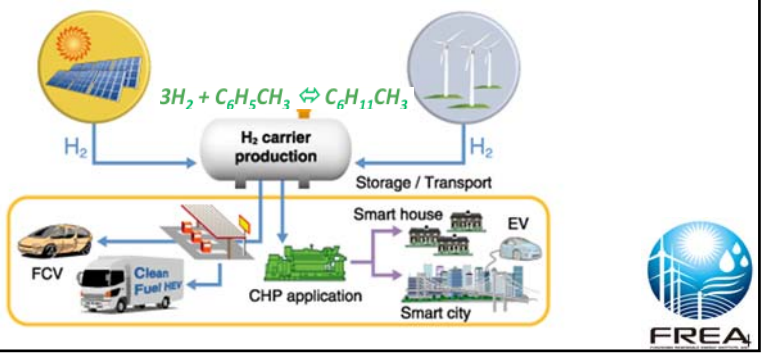
System R&D for renewable energies mass introduction

- MW PV, wind power integration with storage (batteries, hydrogen)
- ICT network for power generation forecast and system control
- Test bed for new technology (power electronics etc.), demonstration
- International standardization



Hydrogen Carrier Production / Application

- Hydrogen production from PV, wind turbine output
- Conversion to organic-hydrate (liquid at room temperature), large scale storage at high density for long term
- $3H_2 + C_6H_5CH_3 \leftrightarrow C_6H_{11}CH_3$ (methyl-cyclohexane)
  - Hydrogenation / dehydrogenation by catalytic reaction
- Combined heat and power application by engine / fuel cell



Major Developments of Biomass Policy in Japan

Ministry of Economy, Trade and Industry
Agency of Natural Resourcesand Energy

■After **the Great East Japan Earthquake and subsequent nuclear accident** happened, the biomass industrialization strategy was drawn as principle to create regional green industry and fortify an independent and distributed energy supply system.

Year	Policies
2002	Biomass Nippon Strategy
2005	Kyoto Protocol – Target Achievement Plan
2009	Basic Act for the Promotion of Biomass Utilization
2010	Basic Energy Plan（Revised)
2010	National Plan for the Promotion of Biomass Utilization

2011.3.11 Great East Japan Earthquake and Accident of Fukushima 1st Nuclear Power Plant

2012	Biomass Industrialization Strategy
2014	Basic Energy Plan (Revised）

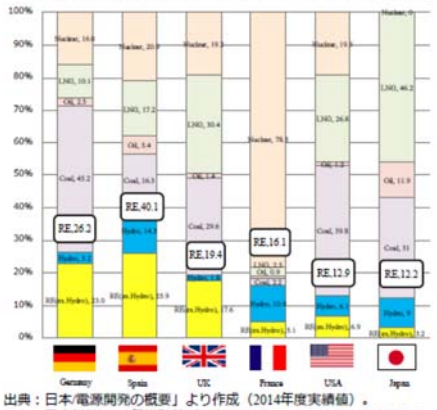
Source: Ministry of Agriculture,Forestry and Fisheries

Current State of Renewable Energy in Japan

Ministry of Economy, Trade and Industry
Agency of Natural Resources and Energy

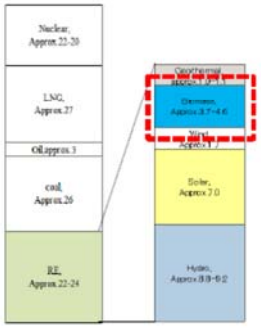
Renewable energy（RE）accounted for approximately 12.2% of power generation in 2014.
More specifically, hydroelectric power generated by large-scale dams, etc., accounted for 9.0%, with solar PV, wind, geothermal and **biomass** power accounting for 3.2%.

Composition of power generation by energy source(2014)



出典：日本/電源開発の概要」より作成（2014年度実績値）。
日本以外/2014年推計値データ、IEA Energy Balance of OECD Countries (2015 edition)

Composition of power generation by energy source in Japan(2030)



Source:Ministry of Economy,Trade and Industry

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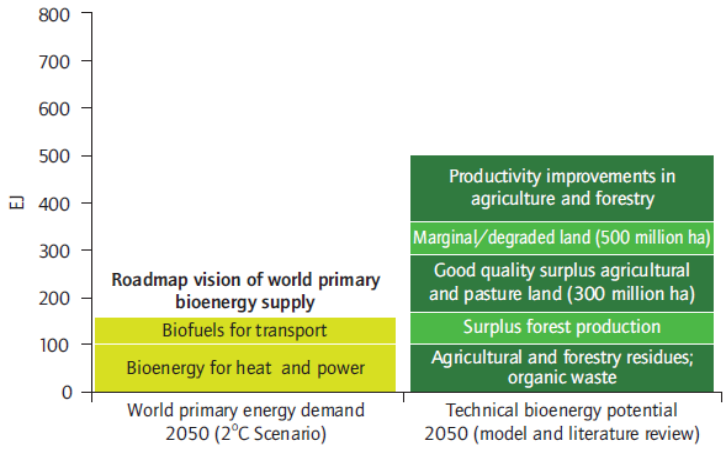
Biomass Supply Prospects – Uncertainties Remain



< Source: Based on IPCC SRREN, 2011 >

- Total biomass demand for heat, power and biofuels reaches 8-11 billion tons in 2050
- Intermediate targets should be adopted to enhance international biomass trade, and assess costs and impact on sustainability

Target of biomass utilization by type (2020)

Ministry of Economy, Trade and Industry
Agency of Natural Resources and Energy

National target of average utilization ratio is set for each type of biomass to promote high utilization biomass based on their types and to clarify the necessary measures to be taken on the national level.

Type of biomass	Amount generated annually (2009)	Present and target utilization ratio 2009→2020
1 Animal waste	Approx. 88 million tones	90% → 90%
2 Sewage sludge	Approx. 78 million tones	77% → 85%
3 Black liquor	Approx. 14 million tones	100% → 100%
4 Waste paper	Approx. 27 million tones	80% → 85%
5 Food waste	Approx. 19million tones	27% → 40%
6 Sawmill wood residue	Approx. 3.4 million tones	95% → 95%
7 Wood waste from construction	Approx. 4.1 million tones	90% → 95%
8 Non-edible parts of food crops	Approx. 14 million tones	85% → 90%
9 Forest off-cuts	Approx. 8 million tones	0% → 30%

Note: 1 Black liquor, saw mill wood residue, forest off-cuts are dry-weight, all others are wet weight.
2 Target for energy crops is 400,000 carbon tones produced by 2020.

Source: Ministry of Agriculture,Forestry and Fisheries

Scheme of Sustainable Asian Biomass Strategy

=> Asian-Pacific & Worldwide Collaborations

Best Practice Scenario and System for Sustainable Biomass Utilization Models in East Asian Countries

Total Promotion of Biomass Asia Strategy
Extensive Win-Win Collaboration in Asia
International R&D Joint Projects on Biomass,
Especially agriculture and engineering fields

Technology, IP, Human resources

Resources, Economical development, Technology transfer

Energy, Materials, CO_2 reduction:
CDM&JCM⇒Sustainable Development

Foresight of ASEAN Agricultural Residue in 2030

(Converted into Ethanol x1000 kL)

Type of Agriculture	Sugar cane	Cassava	Corn	Rice	Palm oil	Coconut	Total
Utilized part	Bagasse Filter cake	Lees Stems Leaves	Stems Leaves Cores Husks Fibers	Straw Husks	Shell Tuft	Shell Fiber	
Thailand	4,441	1,123	2,038	13,702	1,128	186	22,618
Malaysia	108	20	42	873	15,024	115	16,182
Indonesia	8,606	2,349	14,499	19,334	24,684	2,584	72,056
Philippines	2,555	187	5,572	6,265	32	5,186	19,797
Vietnam	1,319	388	3,906	12,696	0	137	18,446
Myanmar	1,392	20	1,421	7,161	0	132	10,126
Cambodia	16	40	400	2,436	0	16	2,908
Laos	72	12	327	1,511	0	0	1,922
Total	18,509	4,139	28,205	63,978	40,868	8,356	164,055

* The figures in yellow background are the promising quantities for producing ethanol

Source : NEDO Research Report in 2007

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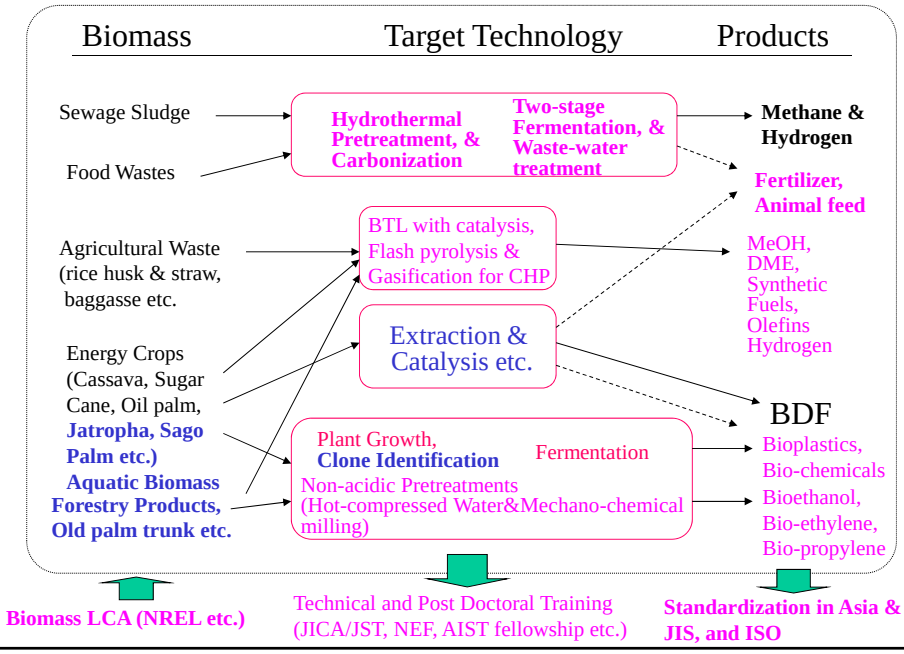
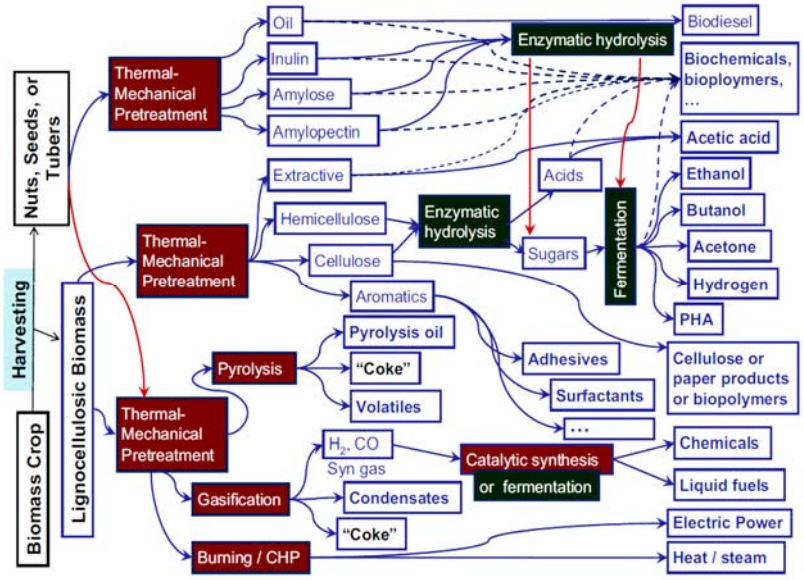
Target Technology & Products for Biomass Utilization



Overall Biomass Refinery Scheme



METI/NEDO's Current Projects of Biofuels

Ministry of Economy, Trade and Industry
Agency of Natural Resources and Energy

1. Element Technology Development for the 2nd Generation Biofuel

◆ Useful element technology development for biofuels

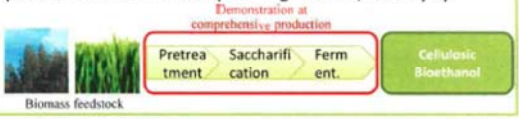
→ Aim to increase total productivity in integrated process of biofuel production from cellulosic biomass by developing and refining individual element technology such as improvement technology for plants growth and productivity in certain conditions, cutting-edge technology in saccharification and fermentation process, etc.

2. Development of Integrated Production System for the 2nd Generation Biofuel

◆ Development of an Innovative and Comprehensive Production System for Cellulosic Bioethanol

→ Aim to develop integrated production system to produce bioethanol in steady and large volume, not only by domestic production but by development import.

- ○improvement technology for feedstock cultivation, harvest, transport
- ○production technology demonstration at pilot plant
- ○study for sustainability of biofuels



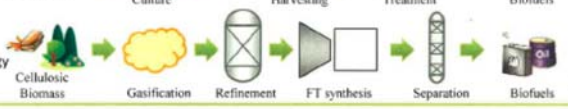
3. R&D for the 3rd Generation Biofuels

◆ Strategic Development of Next-Generation Bioenergy Utilization Technology

→ Aim to further broaden and diversify biofuel resources which do not compete with food supplies by conducting technology R&D on Microalgae-derived biofuel production, biomass gasification and liquefaction, etc.

- ○identify and develop high- oil producing strain
- ○high-efficiency culture, condensation, extraction technology

- ○low-cost gas refining technology
- ○high-efficiency synthesis/reforming technology in low pressure condition, etc.



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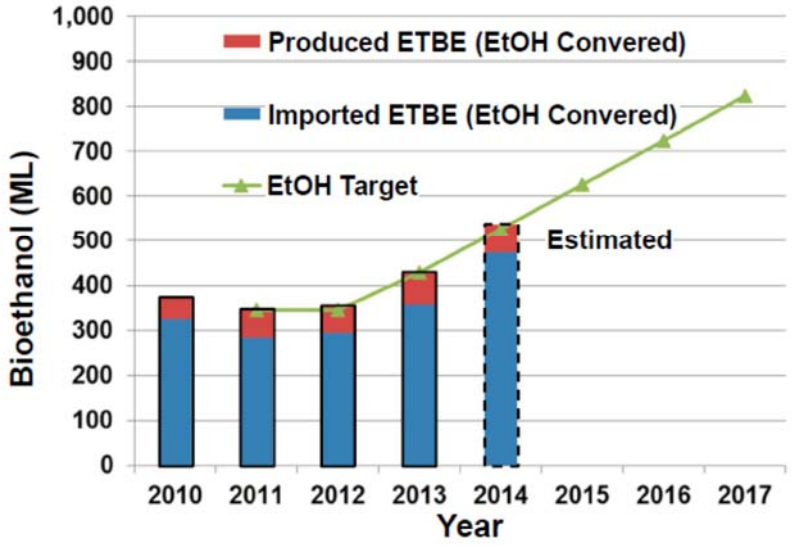
Production/Consumption of Bioethanol and its Future Prediction



Ref: Trade Statistics of Japan, Target by Petroleum Association of Japan

Overview of Development of Cellulosic Bioethanol

A : R&D for Fundamental Technologies

Project to Develop Base Technologies for Non-edible Plant-derived Bioethanol （FY2007-FY2012）

Project to Develop Efficient Elemental Technologies for Biofuel Production (FY2013-FY2016)

Theme	Biomass
(1)Cultivation Technology of Biomass Resource	
・Research and Development for Increased Woody Biomass Production through Genome Breeding and High Efficiency Forestry Operations	Eucalyptus
(2)Production Technology of Efficient Saccarifying Enzyme	
・Research and Development on Producing Woody –Biomass Pulp Degrading Enzymes by Microbial Cultivation on Soluble Sugars	Eucalyptus
・Construction of Innovative Saccharifying Enzyme-producing Microorganism and Development of Manufacturing Technology of the Enzyme for the Biofuel Commercialization	Eucalyptus Bagasse
(3)Fermentation Technology using Efficient Microorganism	
・Development of Fermentation Technologies using Efficient Ethanologenic Microorganisms	Eucalyptus Bagasse

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Overview of Development of Cellulosic Bioethanol

B : Bioethanol production System

Project to Develop Integrated Production System for Ethanol Derived from Non-edible Plant（FY2009-FY2013）

Theme	Biomass
Development of a Comprehensive Bio-ethanol Production System from Fast Growing Trees Using Mechanochemical Pulping	Woody biomass (Eucalyptus)
Development of an Integrated System for Low-cost Cellulosic Bio-ethanol Production from Energy Crop Cultivation to Conversion Process Based on Environmentally-friendly Pretreatment Technology	Herbaceous plants (Napier grass, Eriunthus, etc)

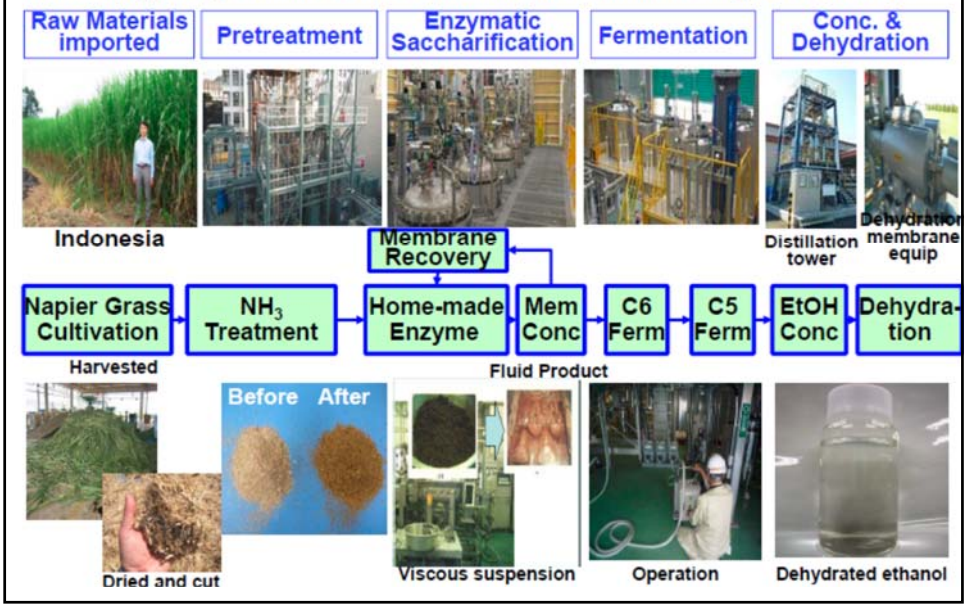
2nd Stage Projects of Dev. Integrated Pro. Sys from Cellulosic biomass (FY2014—)

Eucalyptus

Eriunthus

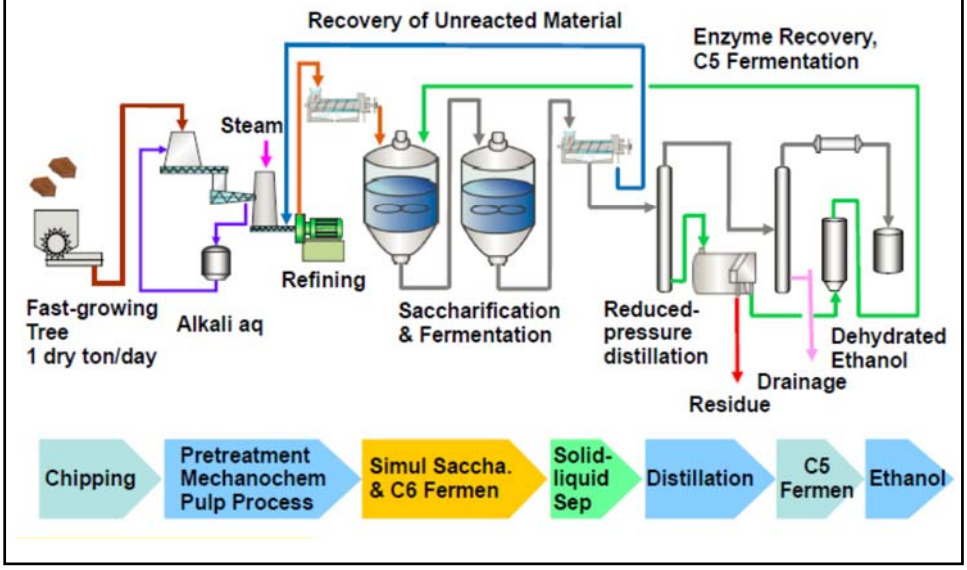
NEDO Project 1

Dev of an Integrated System for Low-Cost Cellulosic Bioethanol Prod from Energy Crop Culti to Conv Proc Based on Environ-friendly Pretreat Tech



NEDO Project 2

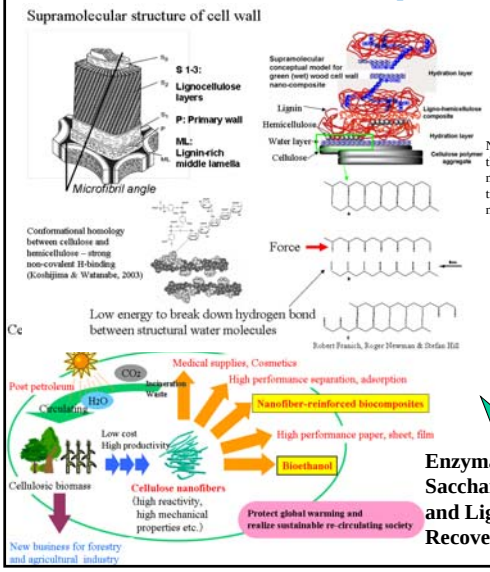
Dev of a Comprehensive Bioethanol Production System From Fast Growing Trees Using Mechanochemical Pulping



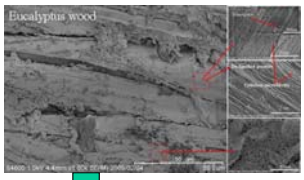
Principles of Biomass Refining Technology

To overcome "Biomass Recalcitrance": responsible for the high cost of lignocellulose conversion.

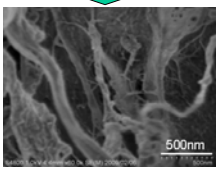
Cell wall structure: Natural nanocomposite



Nanospace formation between cellulose microfibrills by HCW treatment

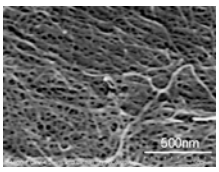


Nanofibrillation by the combined method of HCW treatment and wet-milling process



Morphology of the fibrillated products by wet-milling after the hot compressed water (HCW) treatment.

Enzymatic Saccharification and Lignin Recovery



De-lignification of wet-milled product

Achievements – Pilot Plant in Hiroshima, Japan –

Development of a Comprehensive Bioethanol Production System From Fast Growing Trees Using Mechanochemical Pulping

Project to Develop and Demonstrate Production System of Cellulosic Ethanol (FY2014-2019)

Project Outline

Objectives and Overview

- For realization of large-scale commercial production plant for cellulosic ethanol without competing with food, this project is designed to improve a comprehensive production process and establish scale-up technology.

1) Studies of most suitable combination of elemental technologies

(i) Verification of most suitable combination
Combination of key elemental technologies such as pretreatment, saccharification, fermentation will be investigated. After selecting most promising combination, pilot-scale verification will be conducted to establish large-scale production technology.

(ii) Research of domestic and foreign excellence technologies
Besides the latest technical trend research, technologies and cost of each elemental process will be estimated.

(iii) Feasibility study (FS)
After determination of commercial plant process, feasibility study (FS) from materials collecting to ethanol supply will be conducted.

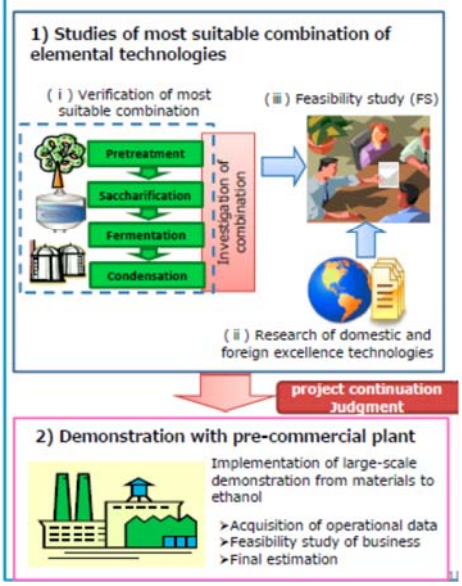
2) Demonstration with pre-commercial plant

When judged to deserve continuation by FS, large-scale demonstration with pre-commercial plant from materials to ethanol will be implemented.

Goals

- Through this project, which lasts 6 years from FY2014 to 2019, we will establish large-scale production system for cellulosic ethanol and implement its demonstration toward commercialization around FY2020.

Project Image



C. Next Generation Biofuel – Biomass to Liquid -

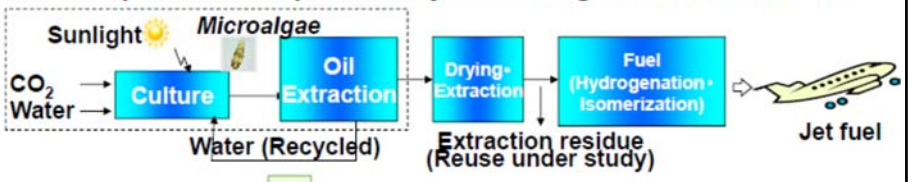
Theme	Biomass
Synthesis of LPG from Biomass-derived Syngas	Forest residue
Development of a High-performance and Clean Gasification System and Low Temperature and Low Pressurize FT Synthesis for Total BTL System Construction	Forest residue(Torrefaction)
Development of Bio-jet Fuel Production Systems with Innovative Entrained Flow Gasifier and Anti-ASF FT Synthesis ※It Shows the bench plant below in Fig-1.	Forest residue
Development of Biomass Conversion Process for Producing High-quality Biofuel Using Hydrothermal Pretreatment and Catalytic Reforming with Zeolite	Bagasse etc (Wet)
Development of Hybrid Steam/Hydrogenation Processes for High-grade Fuel Production from Biomass ※It Shows the bench plant below in Fig-2.	Woody biomass& animal manure

Fig-1
・Biomass feeding : 0.24t/d(10kg/h)

Fig-2
・Biomass feeding : 2t/d

R&D projects regarding Next Generation Biofuel

Improvement in productivity of Microalgae and its oil content



Scale Up Test for Culture Process

Large-scale Culture Test Equipment in 2015 (1,500 square meters)

Successful 100 square meters outdoor stability culture

FREA

Thank you !

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