Demonstration of Biofuels Production Technology from Non-Edible Biomass Resources at AIST for Sustainable Biomass-Asia Strategy

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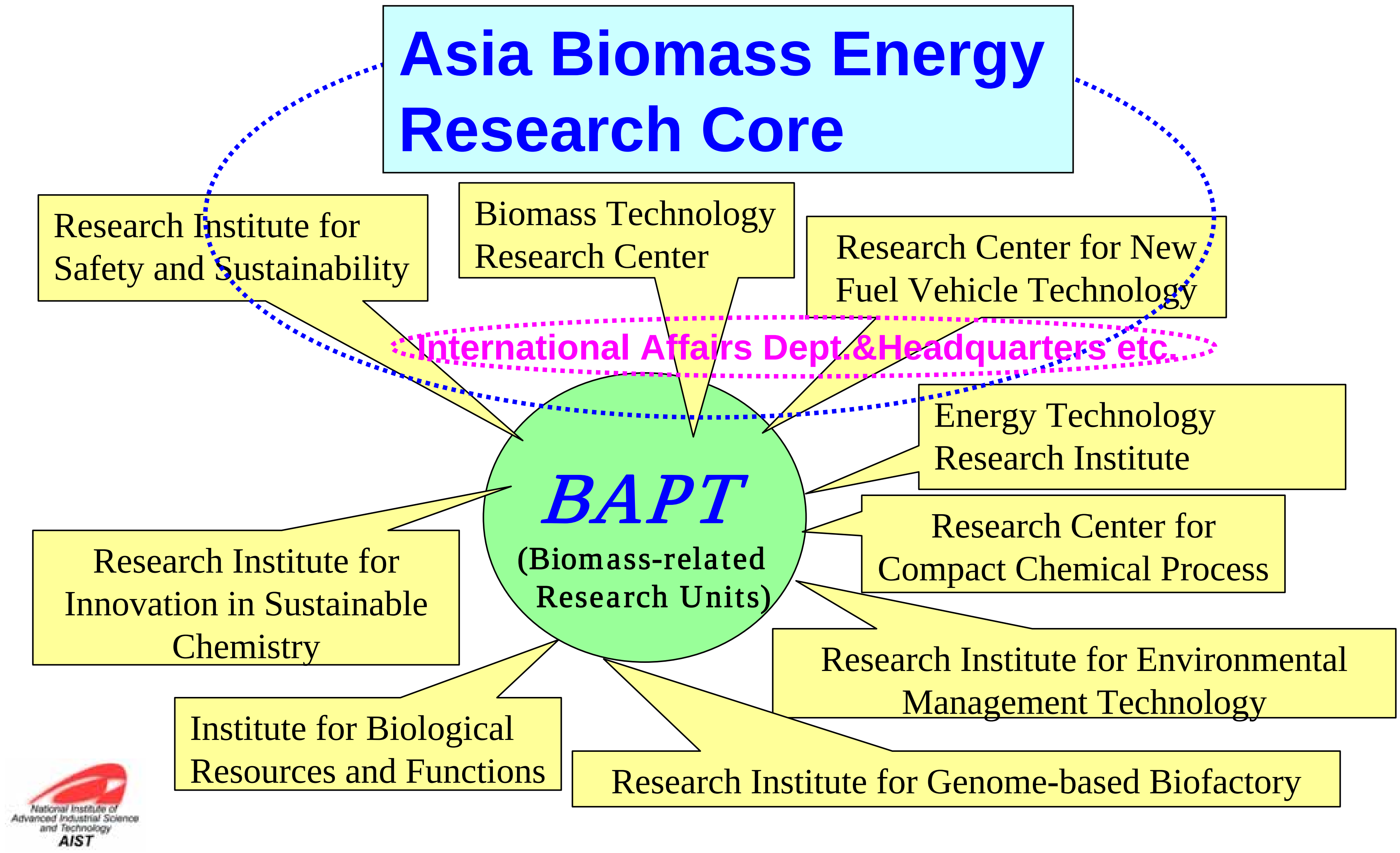
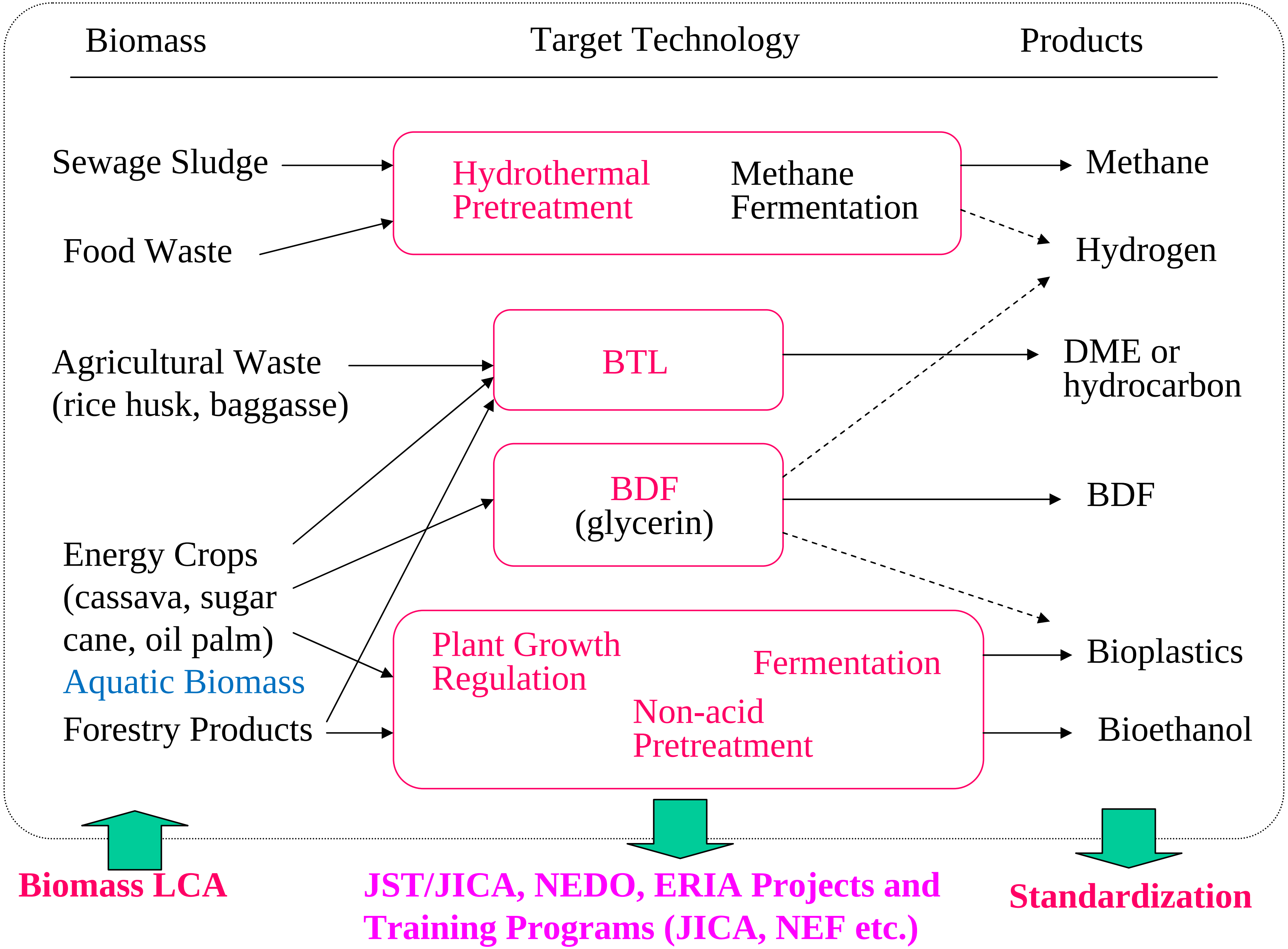
"Green Biomass for Blue Earth"

BTRC

Asia Biomass Energy Research Core(2007.4-)& Biomass Asia Project Team (BAPT;2005.12-)



Biomass Research & Technology Relationship



Political and Social Needs

Political Need;

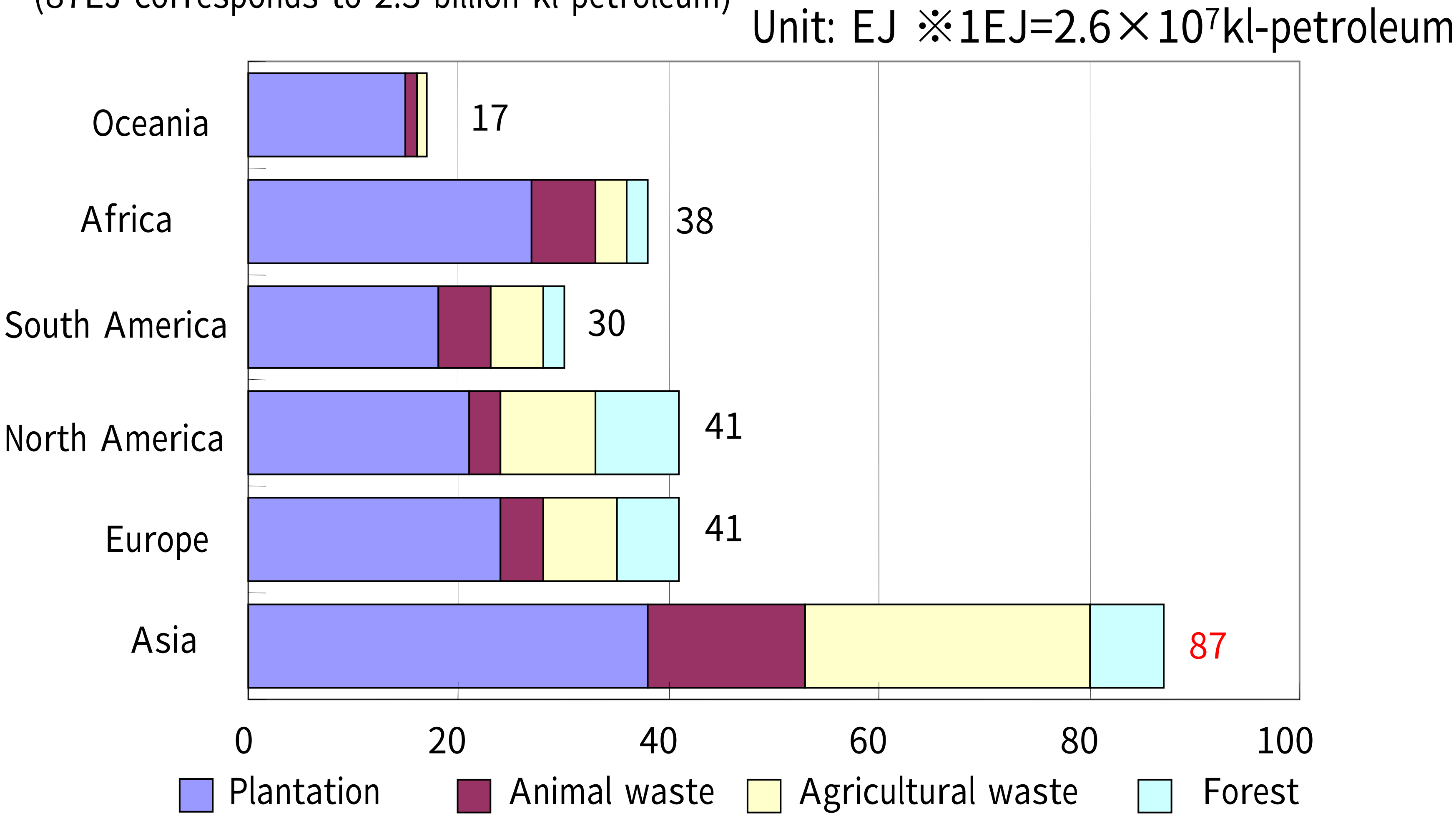
- Biomass Nippon Strategy（2002 & 2006 renewed）
- EPA：Japan-Malaysia(2006), Japan-Thailand(2007)
- Japan-China-Korea Science&Technology Collaboration Ministry Meeting(2007)
- East Asia(ASEAN+E3) Summit：Cebu Island Declaration(2007)
- **Toya Lake Summit (2008) , COP15 (2009) =>=> 2020, 2050**

Social Need and Impact;

- Mitigation of Global Warming
- Substitution of Fossil Fuels
- Activation of Agriculture
- Suppression of Desertification
- Demonstration of Sustainable Development Scenario

Potential of Biomass Energy in the World

Asian region has abundant biomass resources.
(87EJ corresponds to 2.3 billion kl-petroleum)



Ref. “Study on energy conversion technology for Biomass” (RITE、1998～2000)

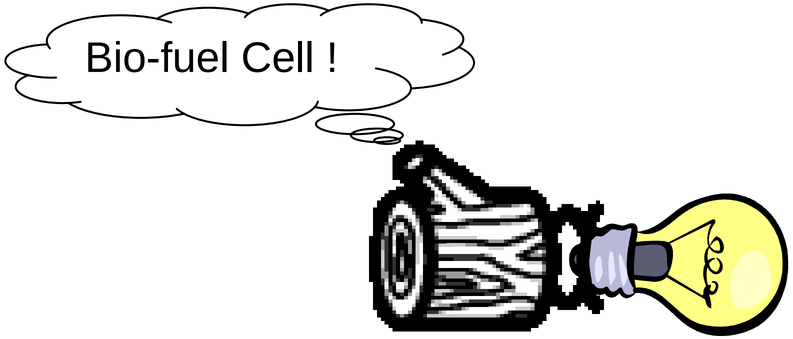
Estimated Biomass Yields as Main Product and Residues

(million tons)

Crops	Biomass		Thai-Land	Vietnam	Indonesia	Malaysia	Philippines
Oil Palm (Coconut Palm)	Main Product	33	1		13 (1)	16	(2)
	Factory Residue	38	1 (1)		10 (8)	11	(7)
	Field Residue	71	2 (1)		26 (6)	31	(5)
Sugar-cane	Main Product	15	7	2	3		3
	Factory Residue	44	21	6	8		9
	Field Residue	32	19	5	8		8
Cassava	Main Product	11	5	1	5		
	Factory Residue	14	6	2	6		
	Field Residue	20	9	2	9		
Rice	Main Product	74	15	20	31		8
	Factory Residue	34	7	9	14		4
	Field Residue	84	17	23	35		9
Timber (Wasted Trunk)	Main Product	18	2	1	8	6	1
	Factory Residue	18	2	1	8	6	1
	Field Residue	32	1 (1)	1	6 (9)	4 (7)	(3)

for 2003 or 2004

Two Opposite Directions of Biomass Utilization



High efficiency and convenience

⇧

Local Energy Supply

As small as possible

As large as possible

Industrial Utilization

⇩

High economical viability

Stable law material supply, High demand in product

Purpose of the Present Proposal

Best Practice Scenario and System for Sustainable Biomass Utilization Models in 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 ⇒ Sustainable Development

JST, Ministry of Education, Culture, Sports, Science & Technology,(MEXT)

Biomass-Asia Project-2nd Stage:
Research and Technological Development for Sustainable Biomass Utilization in Asian Countries

Members;

National Institute of Advanced Industrial Science and Technology (AIST)

Japan International Research Center for Agricultural Sciences (JIRCAS)

National Agriculture and Food Research Organization (NARO)

Forestry and Forest Products Research Institute (FFPRI)

The University of Tokyo

Hiroshima University

Chinese Academy of Sciences (CAS)

National Science and Technology Development Agency (NSTDA)

Standards and Industrial Research Institute of Malaysia (SIRIM)

Vietnamese Academy of Science and Technology（VAST)

The Agency for Assessment and Application of Technology (BPPT)

Proposal Content (draft)

Resources ⟷ **Technology**

1. Hybrid Agricultural Refinery Model (ex. China)
Corn, Rice, Wheat, Sugarcane, Cassava etc.

2. ASEAN Continental Model;
Rice & Sugar Energy Complex Model
(ex. Thailand, Viet Nam etc.)

3. ASEAN Islands Model;
Palm Oil Energy Complex
(Malaysia, Indonesia etc.)

1. Sustainable Biomass-Refinery
(1) Bio-Fuels
  1-1. Bio-ethanol
  1-2. Bio-diesel fuel(BDF)
(2) Bio-chemicals

2. Evaluation & Design of Biomass Utilization System
(1) Life cycle assessment(LCA)
(2) Demonstration plant projects
(3) Design of optimized local models

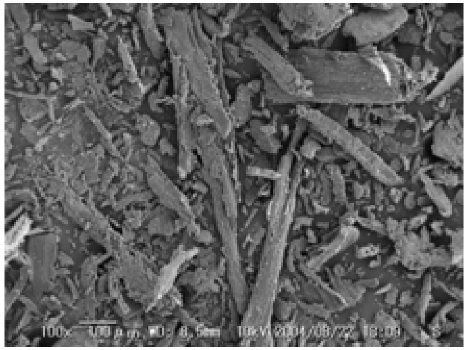
3. Research and Development for Sustainable Biomass Production

Proposal of Efficient Recovery and Utilization Model of Agricultural Wastes

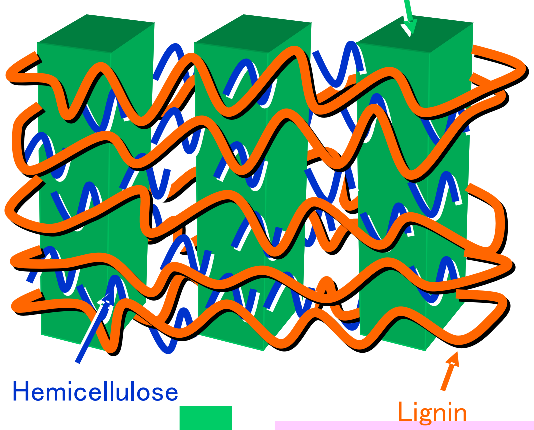
Promotion of enzymatic saccharification by mechanochemical milling

Pretreatment

Beech



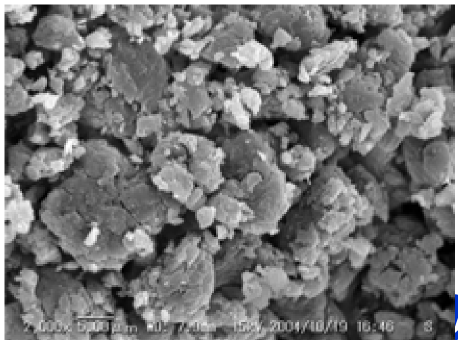
Model of wood structure

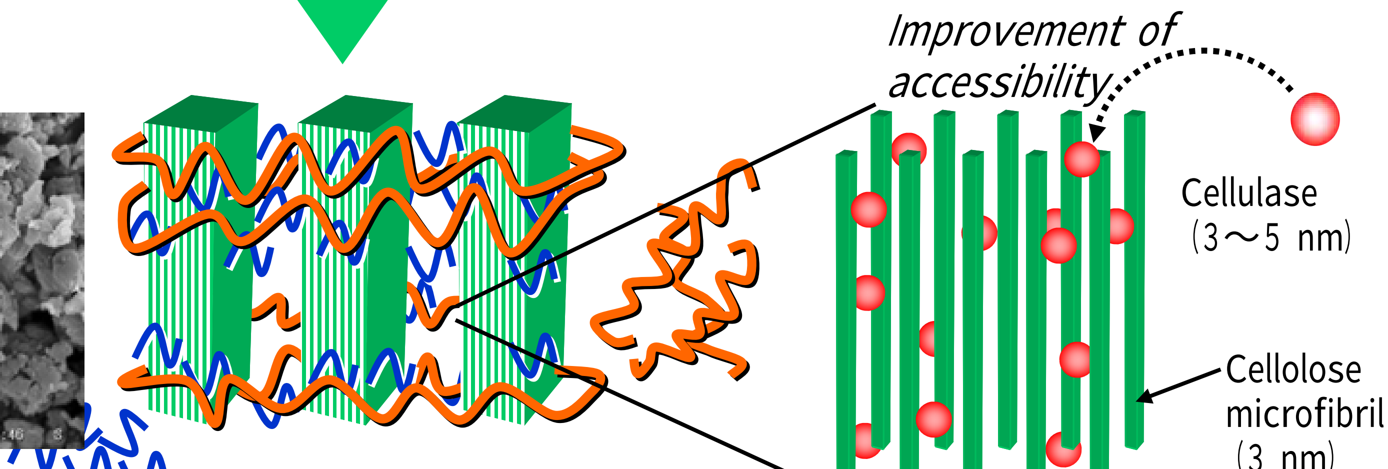


Planetary ball mill

Conversion of wood structure

Mechanochemical milling





Diameter: 20 μm,

molecular movement: 5nm

Mini plant
(pretreatment process)

① **Coarse pulverizing processes**:
Raw materials (wood chips or straw) are crushed and milled to under several mm.

Coarse grinder
(<3 mm)

Wet cutter-milling

Milled sample(<0.8 mm)

Mini plant
(pretreatment 2)

② Hydrothermal process:
The milled materials are softened by hot-compressed water.

Pressure cooker
(Max temp. 180°C,
Max press. 1.0 Mpa)

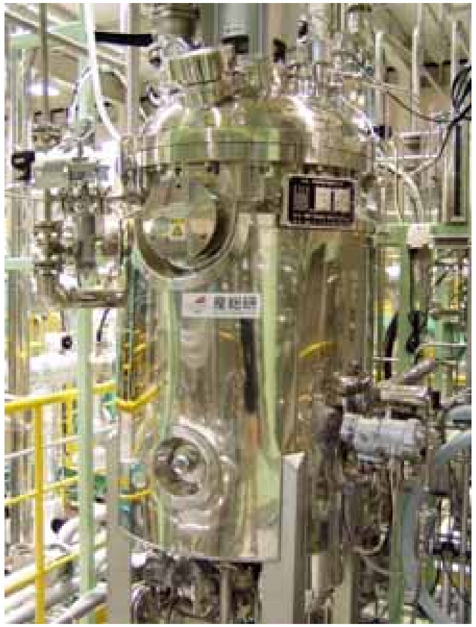
Wet disc-milling

Disc-milled sample
(5-7%w/v)

③ Fine pulverizing processes:
The softened materials are finely fibrillated to several microns by wet disc-milling.
The milled sample (5-7%w/v) are centrifuged to make a dewatered cake (20% w/v) .

Mini plant
(Saccharification & Fermentation)

④ Saccharification and fermentation processes:
The pretreated materials are hydrolyzed (48-72 h) and then fermented (24 h) by fungal enzymes and yeast cells, respectively. The enzymes and yeast cells are produced on-site.


Enzyme production
(400 L)


Saccharification&
fermentation (2,000 L)


Yeast production
(200 L)

Mini plant
(Distillation)

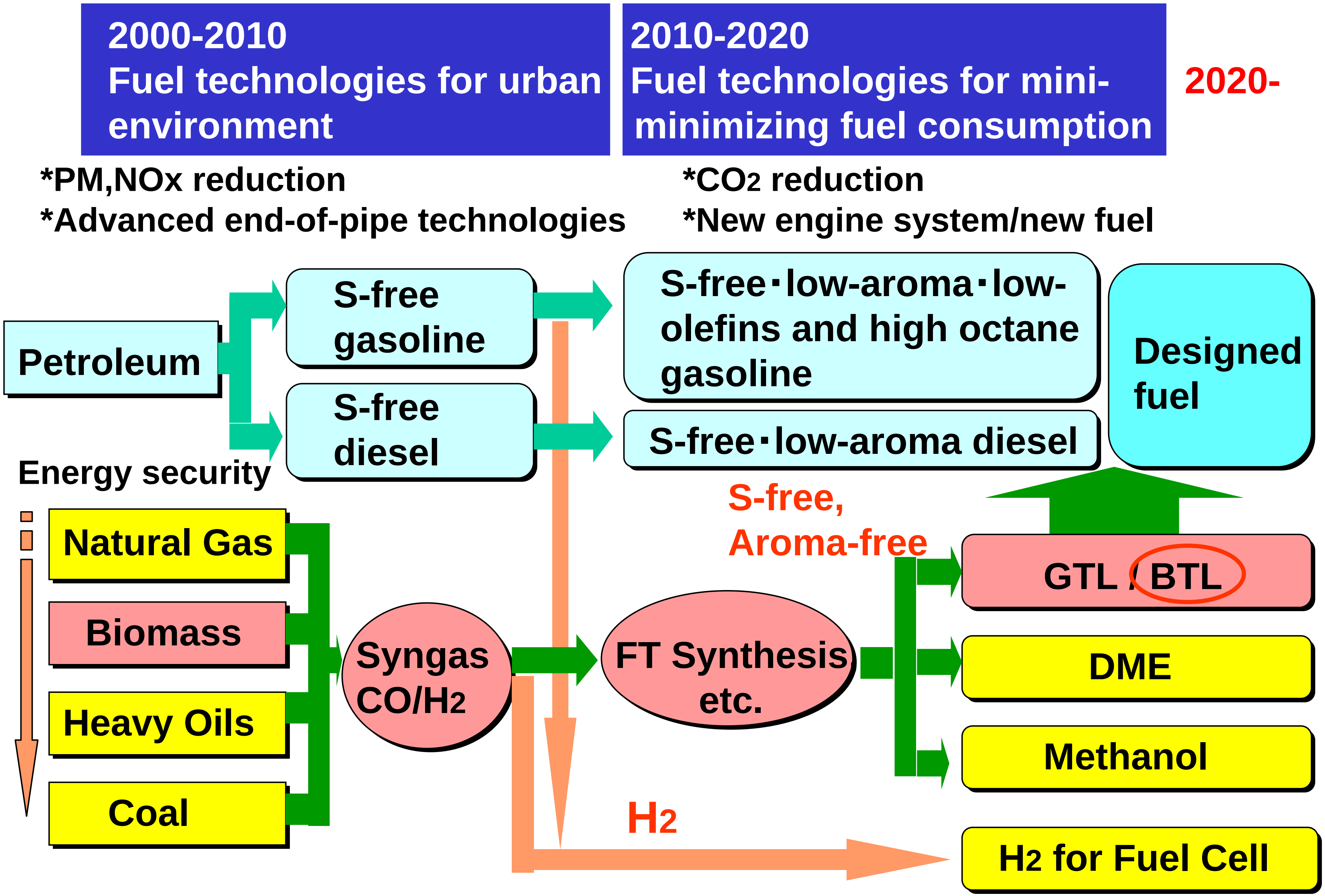
⑤ Distillation and dehydration processes:
The fermentation liquor is directly distillated without separation of the residue. Pure ethanol (99.5%v/v) is obtained by 2-nd distillation and dehydration processes.

First distillation
(20-30%v/v)

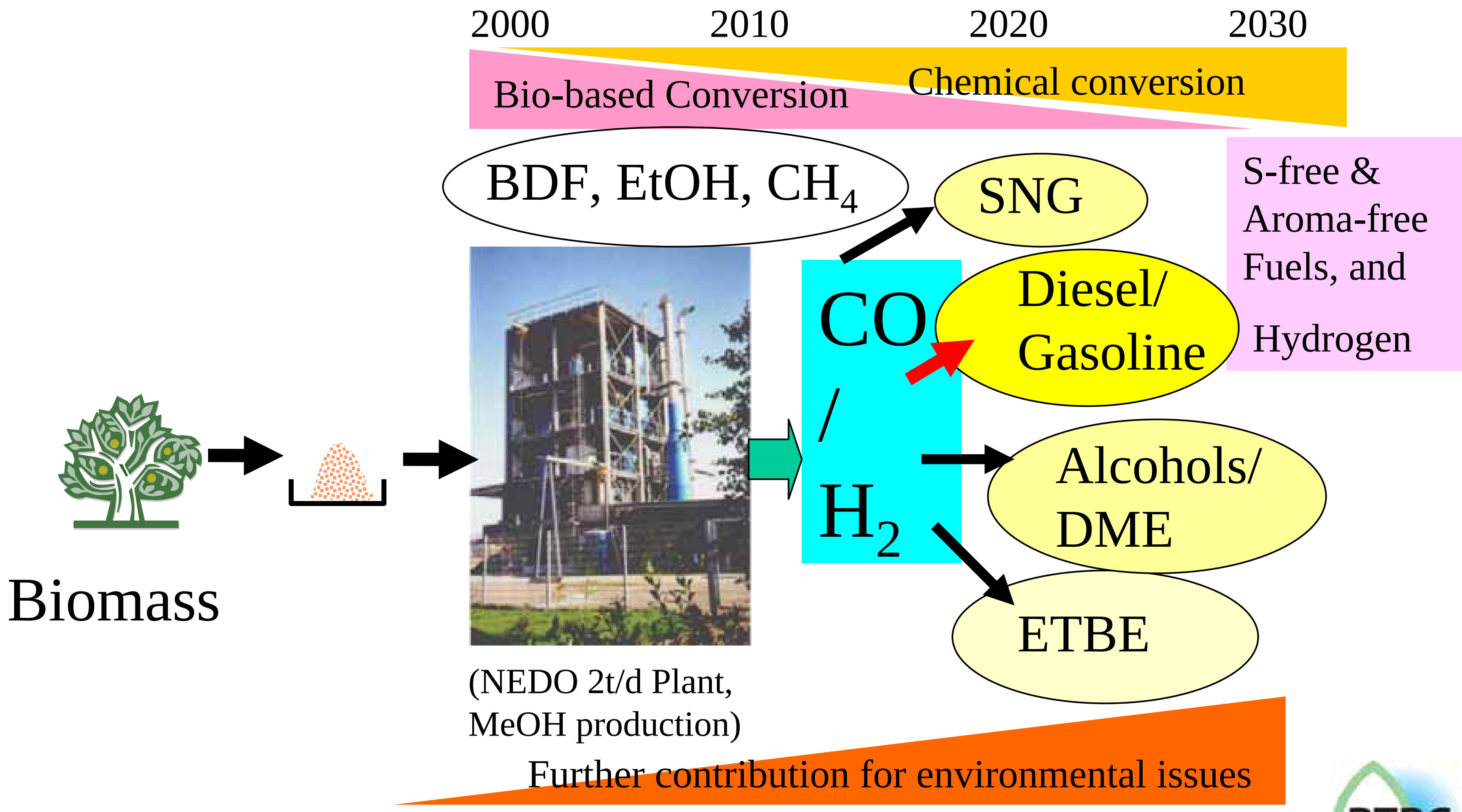
Second distillation (90%v/v)
& dehydration (99.5%v/v)

Ethanol

Future Needs for Alternative Transportation Fuel



Road map of BTL development



Photograph of bench-scale BTL plant

Wood

Gasifier

Scrubber

Desulfurization tower
CO_2 removal tower

Compressor &
Gas holder

FT synthesis reactor

Liquid fuel

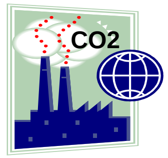
BTL(Biomass to Liquid) Process Scheme;

Biomass gasification with FT Synthesis via Hot Gas Cleaning => *Design of "Mobile BTL Plant"*

Pressurized Gasification of biomass (1～3MPa, ～900 ℃) → **H_2, CO** **Tar** **H_2S, COS** **NH_3, HCl etc.** → **FT Synthesis DME synthesis (1 ～3MPa, ～250 ℃**

Removal of Catalyst Poisons at 300 -400 ℃ for Direct Coupling

Biomass System Analysis and Simulation



Objectives;

1. To develop biomass system simulation technology, Ground database (DB) should be constructed.
2. To design economic feasible total system for biomass, the simulation have been conducted for optimization, economic & environmental analysis.

INPUT → Simulation → OUTPUT

INPUT

Wood DB

- Structures
- Molecules
- Elements
- .....

Cost DB

- Devices
- Processes
- Products
- .....

Thermo DB

- Calorie
- Moisture
- Enthalpy
- Entropy
- .....

Process DB

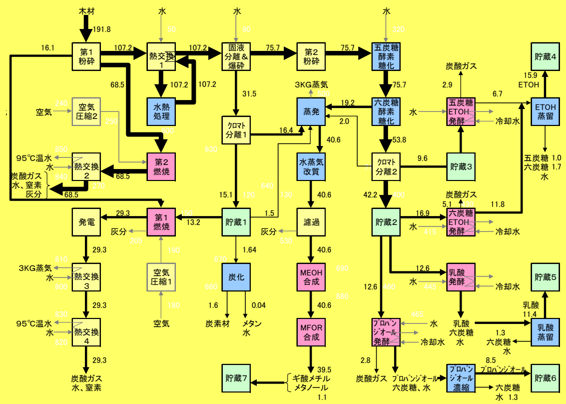
- Separation
- Fermentation
- Chemical
- Thermal
- .....

Simulation

Analysis

- Mass & energy analysis
- Cost analysis

Ex.: Process model for ETBE & BTL



OUTPUT

- Carbon balance
- Energy balance
- Efficient
- Impact (LCA)
- Economical Index (Payback Period)
- Cost recovery

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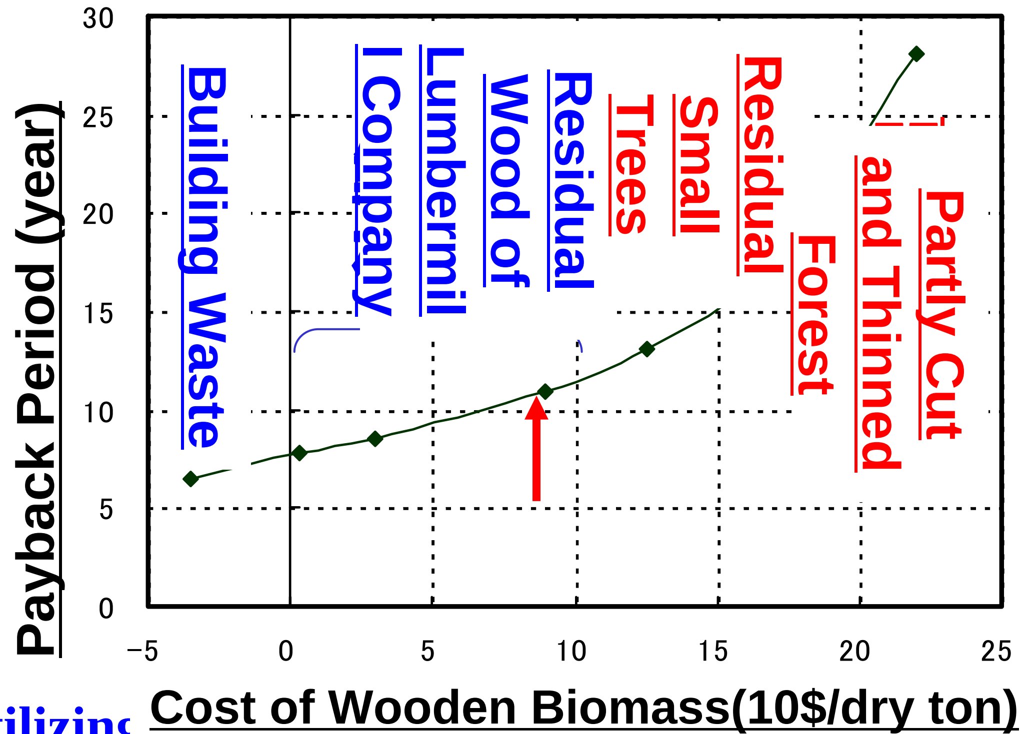
ETBE/BTL Simultaneous Production System from Wooden Biomass（Lumbermill Company Residual Wood, 400t/day scale）



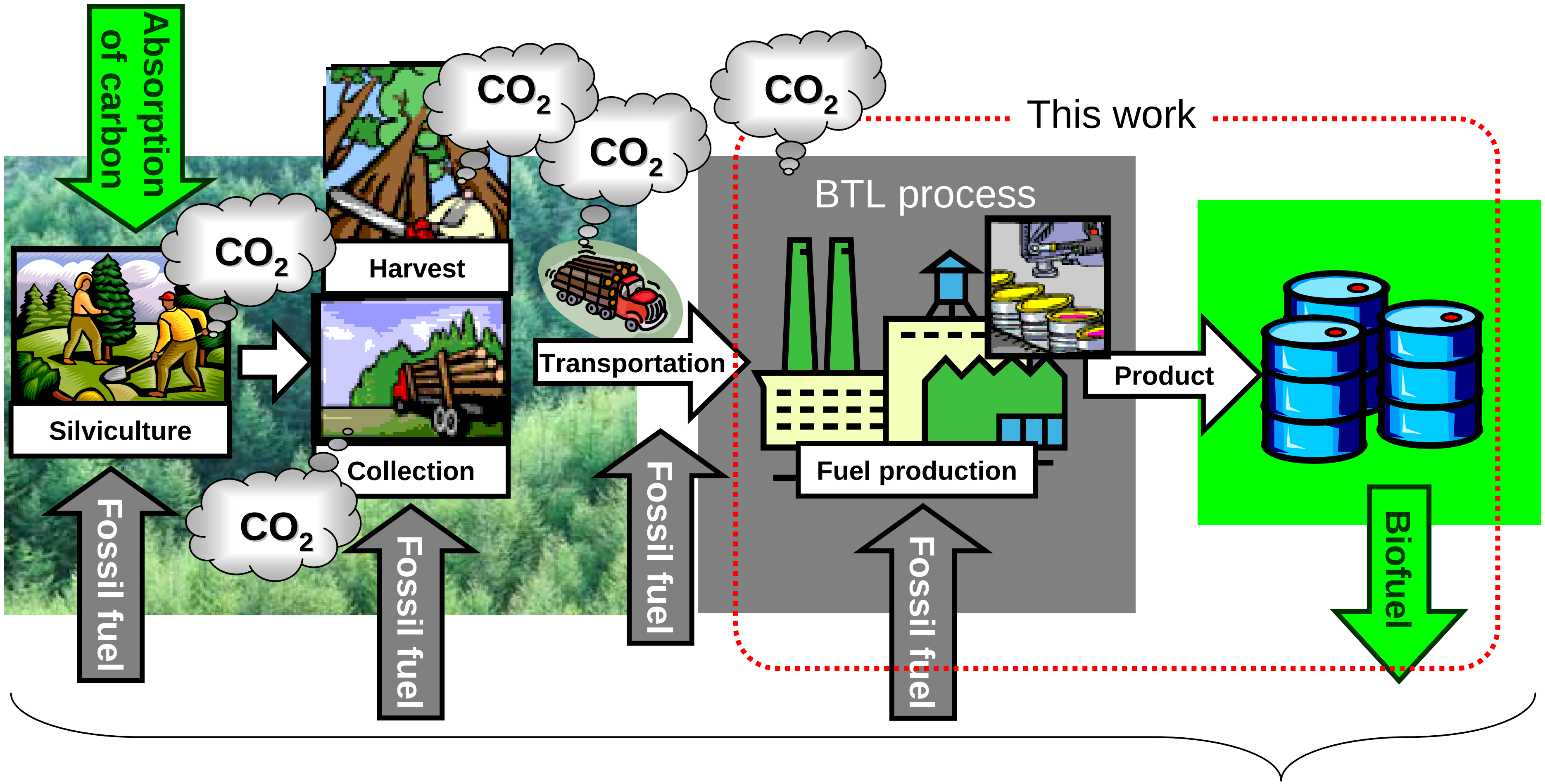
2 years longer than Material Co-production System

Feasible for utilizing Residual Wood of Lumbermill Company and Building Waste

Small ← Payback Periods of 11 years → **Large**

Reducing Cost of Gathering Wooden Biomass is essential

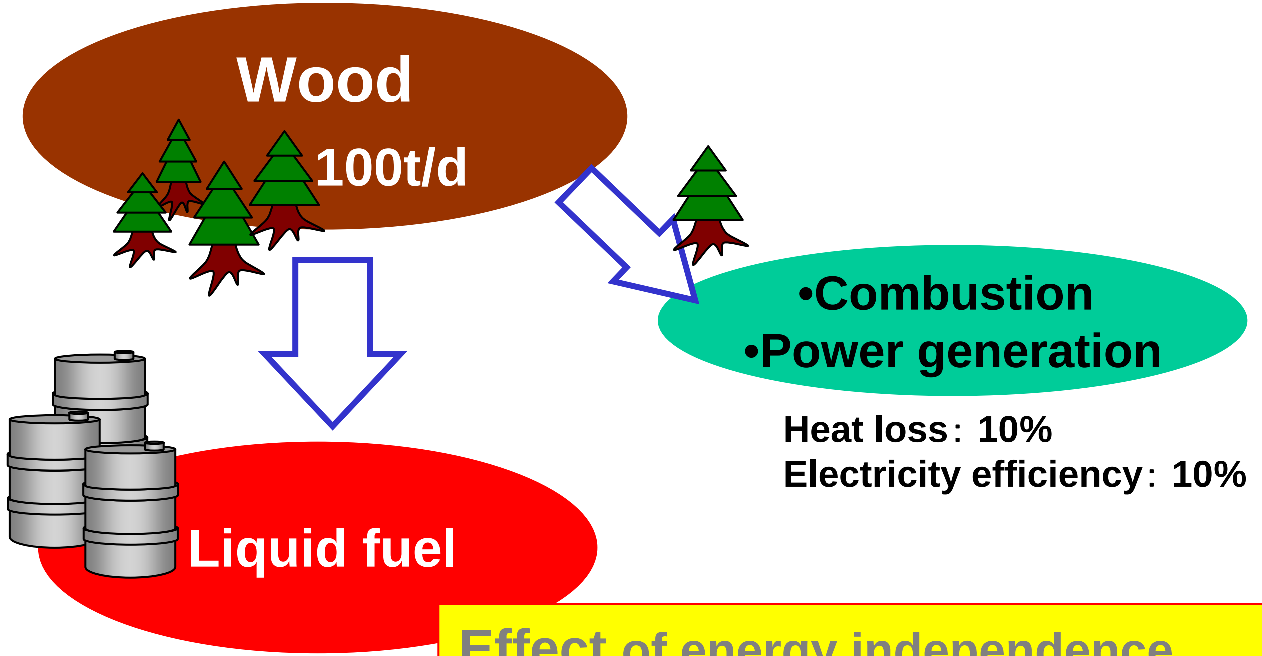
Simple Payback Period=Initial Cost/Payback money =267/24.4 =10.9 years



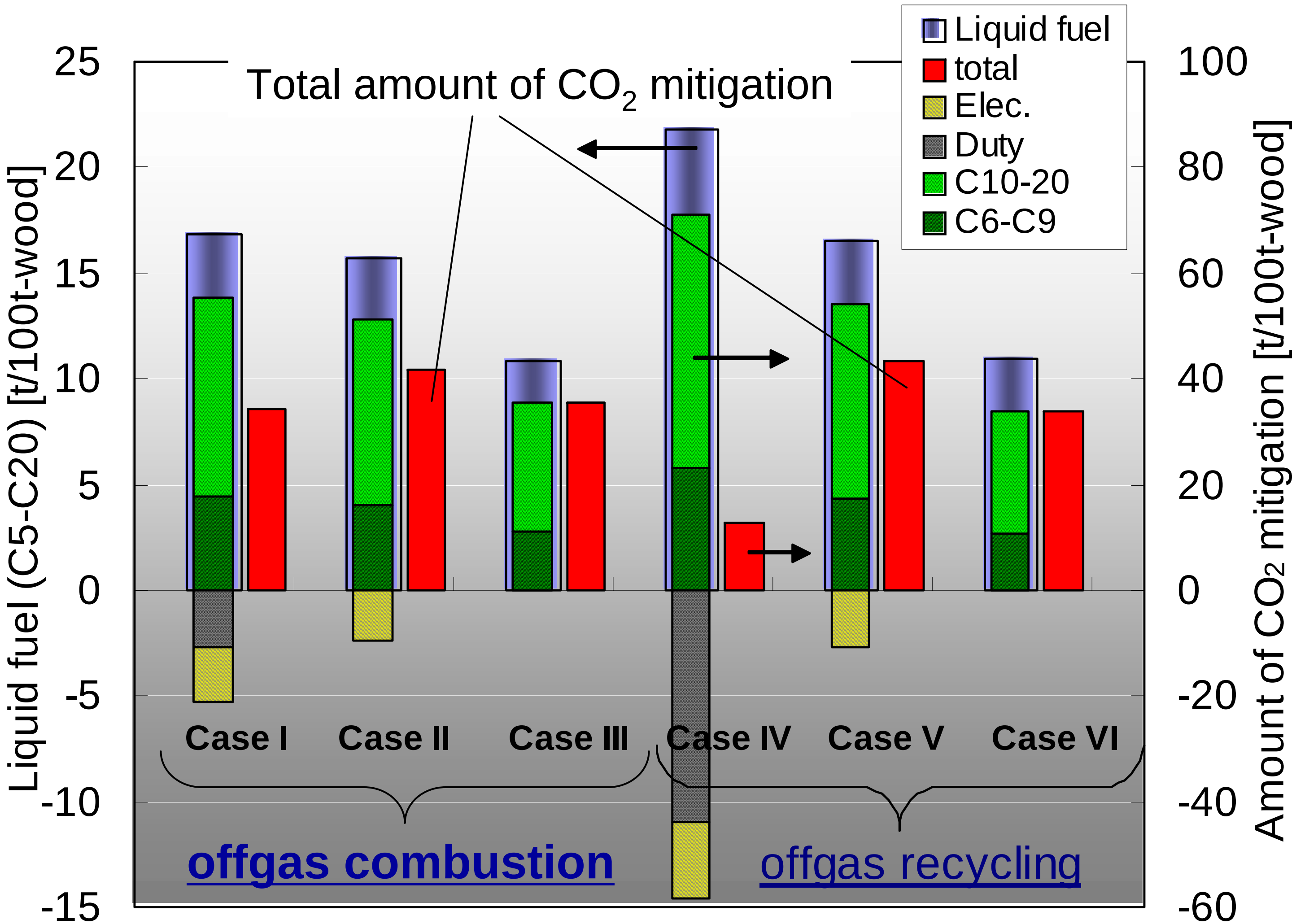
How much CO_2 can Biofuel mitigate?

Case study No.1: Effect of energy independence

	Case I	Case II	Case III
Duty (for gasifier and distillation column)	Heavy oil	Wood	Wood
Elec. (for compressor)	External	External	Wood



Effect of energy independence on yield of products and CO_2 emission



/ CO_2 mitigation t-CO_2 /kL-product	1.60	2.11	2.584	0.466	2.06	2.45

without fossil fuel

Characteristics of AIST Biomass Technologies

1.Wooden Biomass and Cellulose Containing Biomass have been the Main Target of Biomass Energy Utilization.

2.Environment Friendly Pretreatment System Utilizing Hot Compressed Water Process & Mechano-Chemical Treatment has been established.

3.Economical Analysis Based on Payback Period has been successfully conducted for Ethanol BTL Production Process.

4.Demonstration Plant of Biomass Utilization Process has been established by AIST Industrial Innovation Initiative.

5. Production, standardization, and LCA technologies for sustainable biomass utilization in Asia and other countries are proposed and to be demonstrated.

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Sustainable Biomass Utilization Scenario in Asia

1) Palm Oil and Energy Complex ;

- Combined production of BDF and other bio-fuels for sustainable availability and environmental protection

2) Sugar and Rice Energy Complex;

- Large-scale bio-ethanol production from agricultural wastes for simultaneous supply of food and bio-fuels

3) Wood Refinery Complex;

- Total multi-production system of timber, paper pulp, ethanol, and chemicals for new business model

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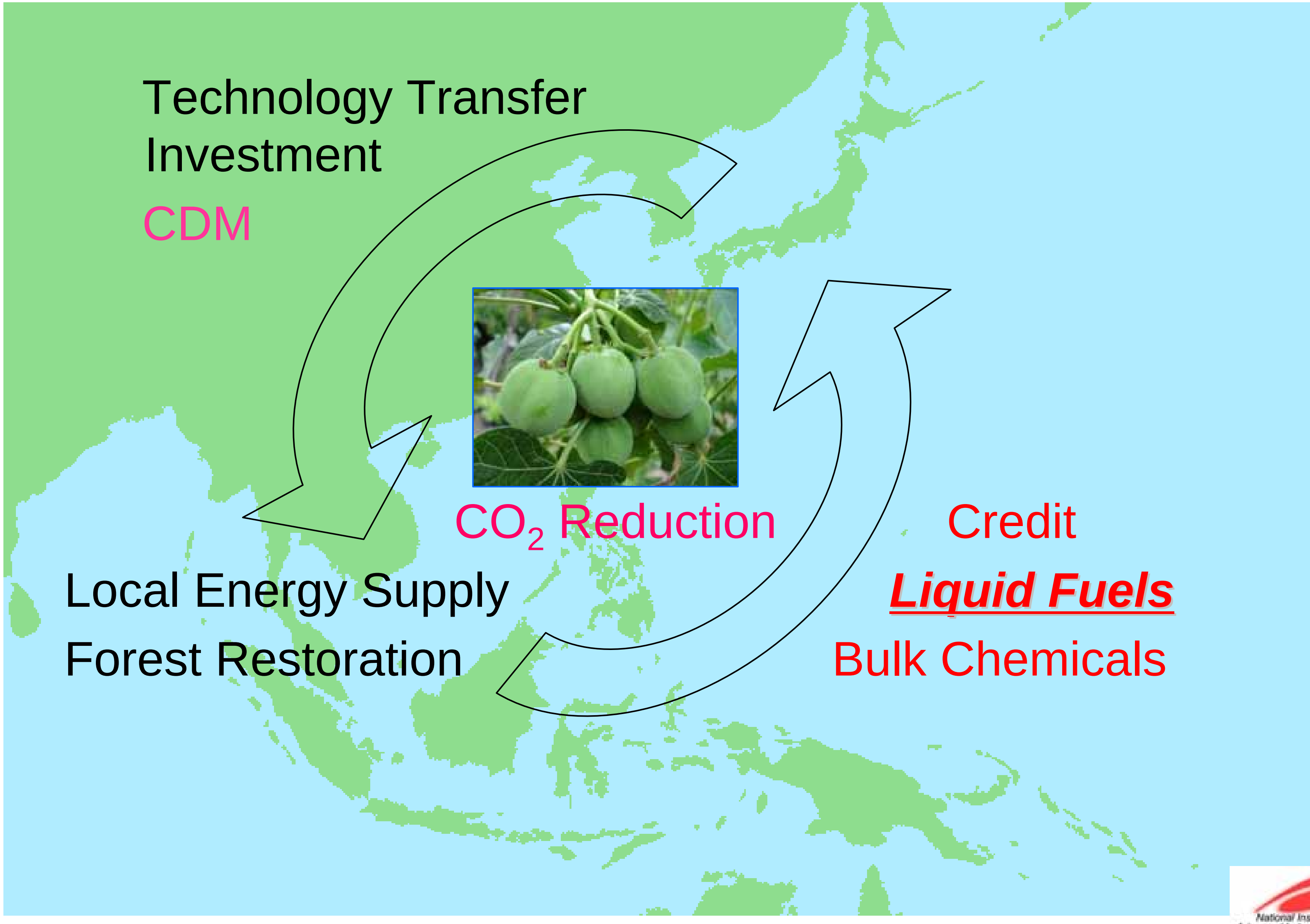
Fruitful Collaborations Using Biomass



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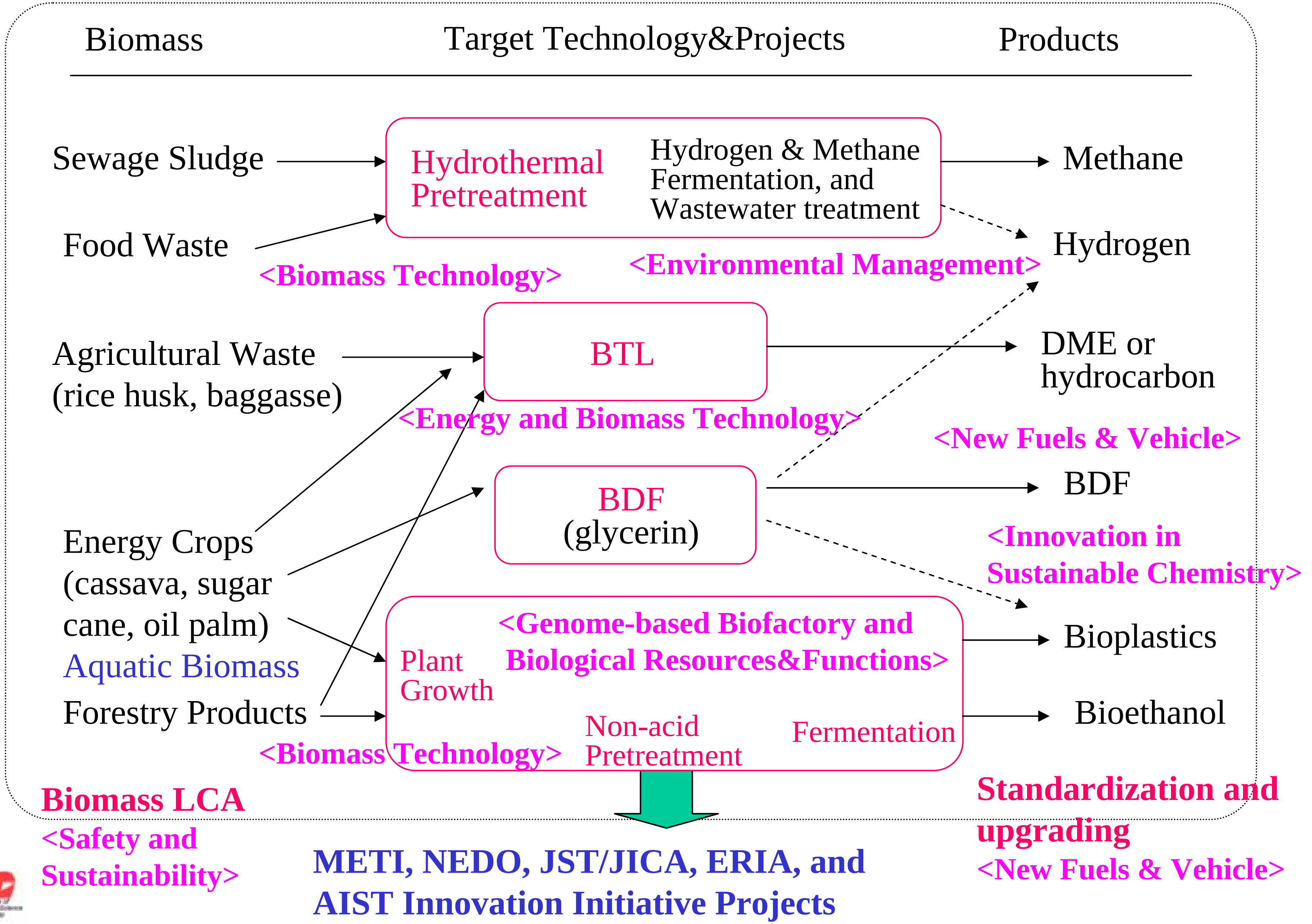
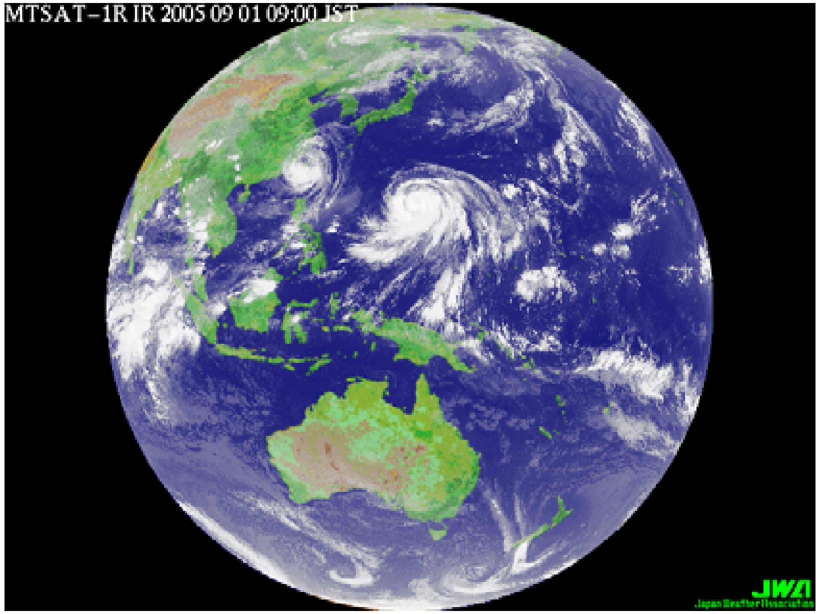
Integration of AIST Research Units for Biomass Utilization



BTRC



“Green Biomass for Cool Earth”

Thank you very much for your attention !

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