Technology Strategy Center (TSC) Activities in the Bioeconomy Field

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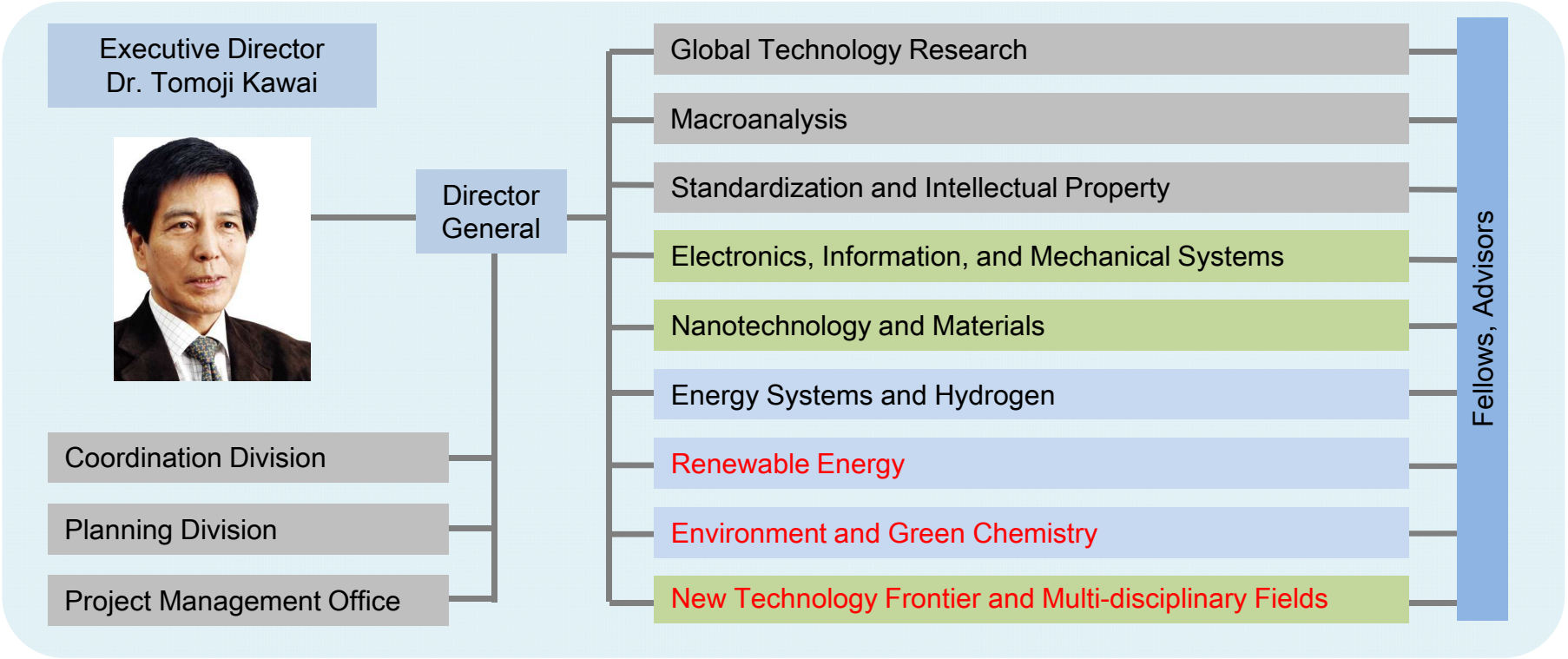
1. **About TSC**
2. Analysis of Case Study
3. Examples of Projects
4. Future Efforts

Technology Strategy Center (TSC) Established April 2014

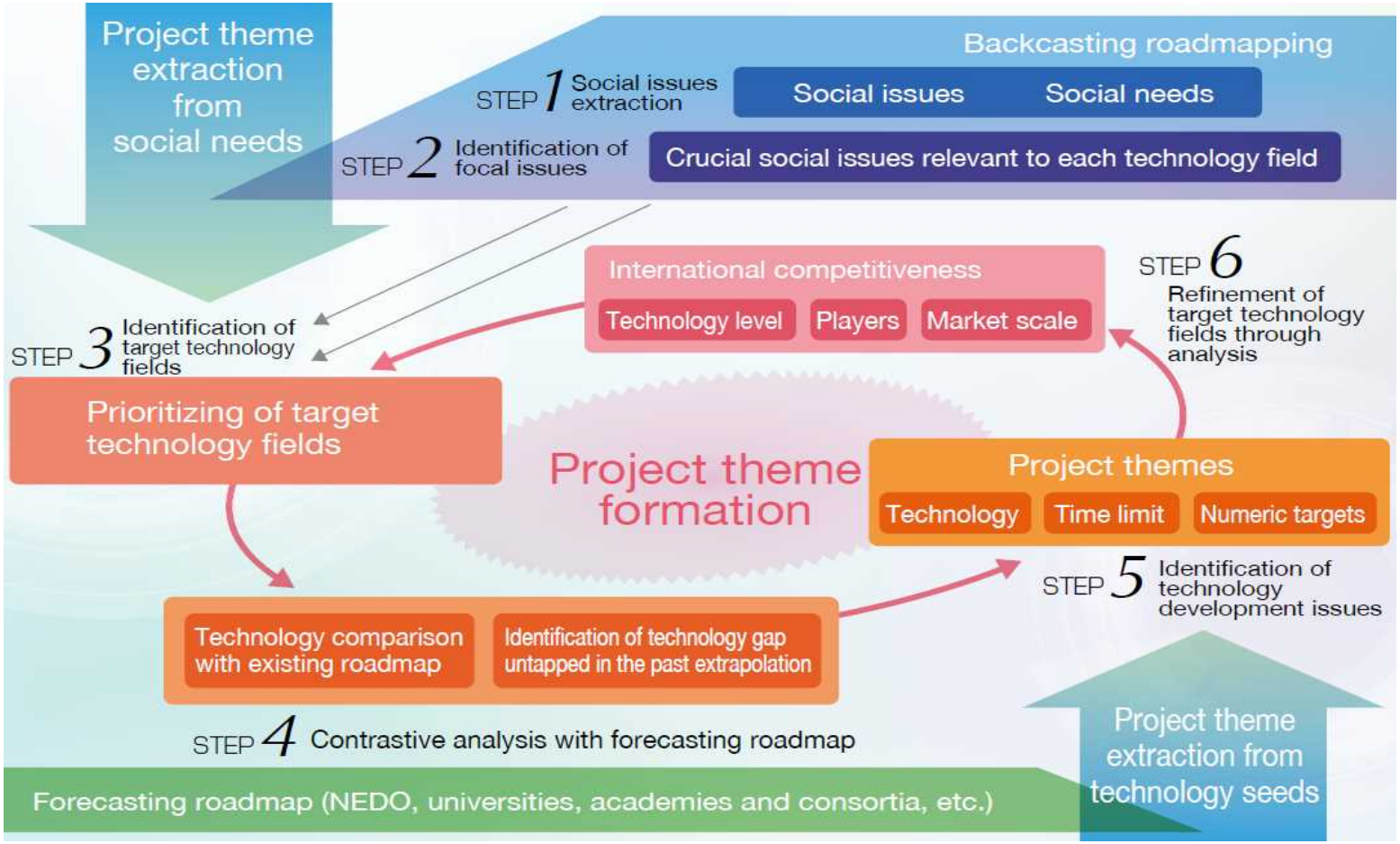
Activities:

1. Conducting surveys and analysis of domestic and international technology trends
2. Formulating technology strategies in key fields
3. Planning and designing strategy-based NEDO projects
4. Developing and improving management methods for cross-sectoral technology development and relevant tools, including databases
5. Fostering human resources capable of project management
6. Increasing the awareness of technology development strategies in society by appropriately disseminating relevant information



Bidirectional approach to determine key target technology fields and projects:

- Technology forecasting
- Backcasting from a desirable future society
- Positioning analysis



Positioning Analysis

Other nations' policy studies

(US, EU, UK, FR, DE, CN, KR, others)

Japanese policy studies

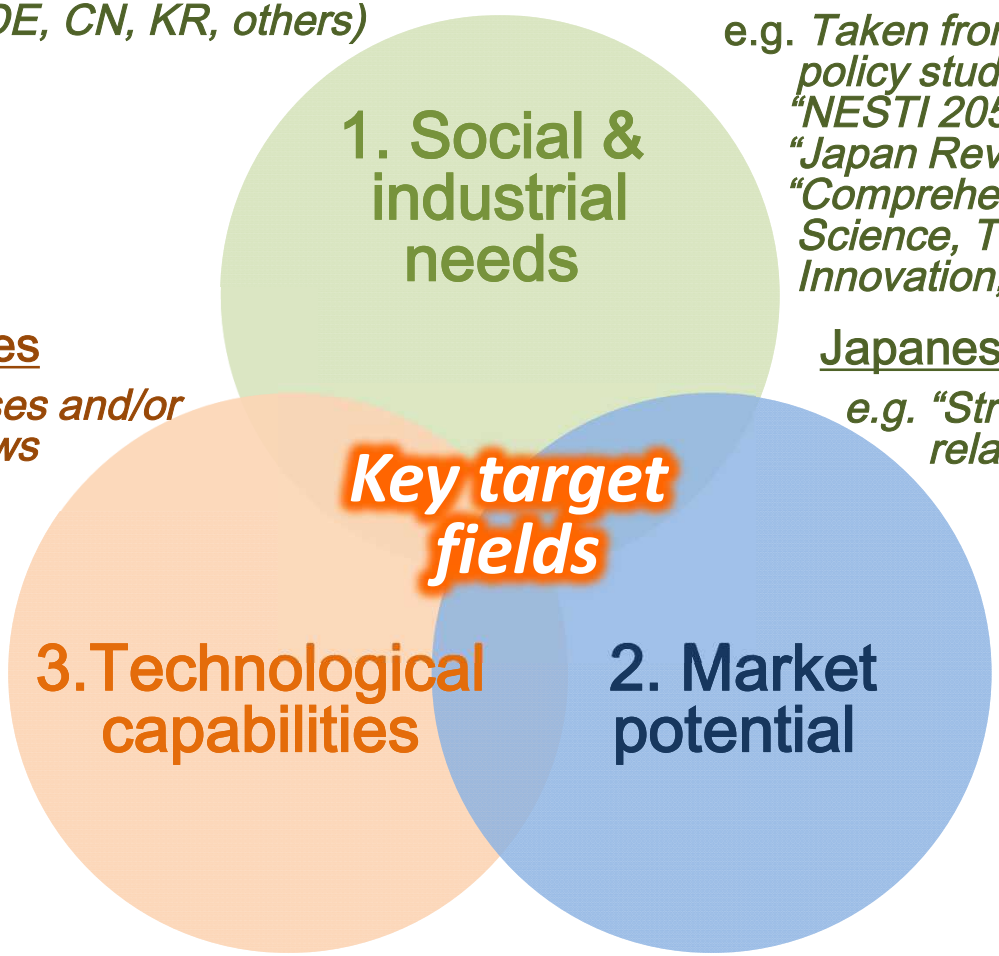
e.g. *Taken from government policy studies: "NESTI 2050;" "Japan Revitalization Strategy;" "Comprehensive Strategy on Science, Technology and Innovation," and others*

Key player analyses

e.g. Patent analyses and/or direct interviews

Japanese energy policy studies

e.g. "Strategic Energy Plan," and related energy strategies



Advanced technology analyses

e.g. Analyses of papers and/or workshops in specific areas

Surveys of global market trends

e.g. Global market surveys to identify Japan's position; "bubble chart"

Project Management

TSC

Start

Information Gathering and Creation of Roadmaps

1-2 years

Strategy Formulation and Project Planning

Promotion Dept.

2-6 years

Technology Development and Demonstration Testing

Evaluation Dept.

10 years

Review and Follow-up Investigation

Features of NEDO projects:

- Mid- to long-term time frame
- Technology development coordinated with standardization
- Cross-industrial cooperation and integrated fields
- Full-scale demonstration
- International cooperation

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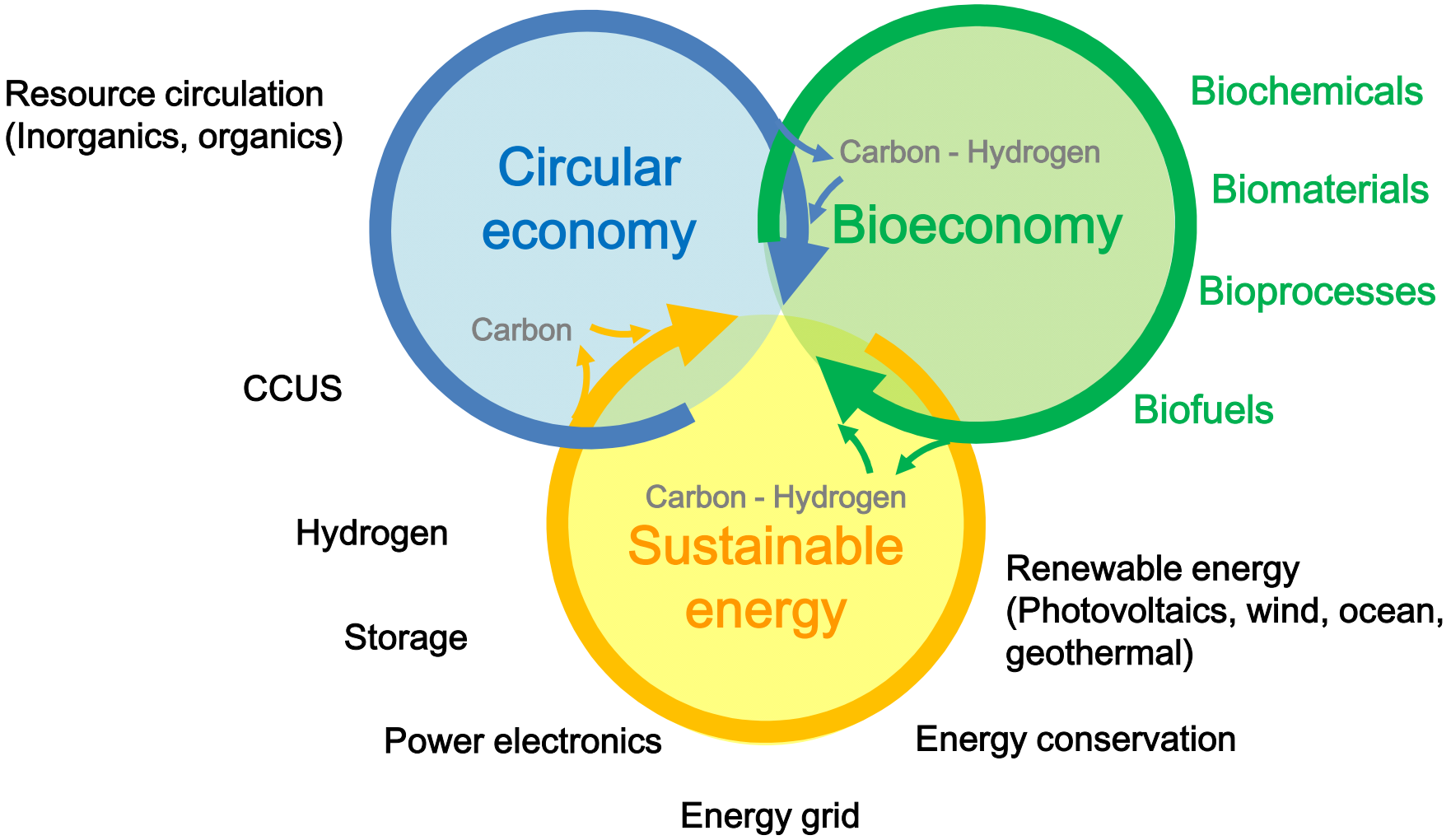
Bioeconomy-Related Activities

Year	Activities/events around the world	Bioeconomy-related activities in Japan
2002		Biotechnology Strategy Guidelines Biomass Nippon Strategy
2005	EU research commissioner announces bioeconomy concept Kyoto Protocol goes into effect	
2006		Biomass Nippon Strategy (revised version)
2007	Germany releases En Route to the Knowledge-Based Bio-Economy	
2008	BioteCanada releases Beyond Moose and Mountain	Dream Biotechnology Japan
2009	OECD releases The Bioeconomy to 2030	Basic Law on Utilization of Biomass
2010	Germany releases national research strategy Bioeconomy 2030	Biomass Utilization Promotion Basic Plan
2011	EU releases Horizon 2020	
2012	EU releases Bioeconomy Strategy US releases National Bioeconomy Blueprint	Biomass Commercialization Strategy
2013	Germany, Netherlands, Brazil, South Africa, Malaysia, Sweden, and Belgium formulate bioeconomy strategies	
2014	Finland and Sweden formulate bioeconomy strategies	4th Basic Energy Plan
2015	UN adopts Sustainable Development Goals 1st Global Bioeconomy Summit in Berlin COP-21 adopts Paris Agreement Spain and Indonesia formulate bioeconomy strategies	Japan Revitalization Strategy 2015
2016	India, Thailand, Italy, and Norway formulate bioeconomy strategies US releases Bioeconomy Review	Japan Revitalization Strategy 2016 Global warming prevention law New Utilization Promotion Basic Plan National Energy and Environment Strategy for Technological Innovation Towards 2050
2017	France formulates bioeconomy strategy EU formulates bioeconomy review	Growth Strategy 2017
2018	2nd Global Bioeconomy Summit in Berlin EU formulates new bioeconomy strategy UK releases Bioeconomy Strategy	Growth Strategy 2018 5th Basic Energy Plan Interim Bio Strategy
2019		Final Bio Strategy (planned)
2020	3rd Global Bioeconomy Summit (planned)	

NEDO's Views on Global Trends Toward a Sustainable Society

- Three important approaches are being carried out for the realization of a sustainable society and global market led by environmental policies and/or initiatives.



TSC Outreach Activities

- **Preparing "TSC Foresight" publications which describe the latest developments in technology trends and identify issues to be addressed**
  (http://www.nedo.go.jp/library/foresight.html)

Vol.1 Nanocarbon Materials
Vol.2 Functional Materials
Vol.3 Hydrogen Energy
Vol.4 Superconductivity
Vol.5 Automotive Rechargeable Battery
Vol.6 Global Warming Solution (HFC)
Vol.7 Advanced Robotics
Vol.8 Artificial Intelligence
Vol.9 Computing, Electron Devices and Materials
Vol.10 Power Laser
Vol.11 Photovoltaics
Vol.12 Geothermal Power Generation
Vol.13 Metal Recycling
Vol.14 Chemicals Manufacturing Process
Vol.15 Self-assembly and Self-organization for Material Manufacturing
Vol.16 Advanced Technologies in Biomanufacturing of Chemicals
Vol.17 Unmanned Aircraft Systems (UAS)
Vol.18 IoT Software
Vol.19 Energy Systems with Super-distributed Energy Resources and Demands (Integration Study)
Vol.20 Energy Storage
Vol.21 Next-Generation Biofuels (Bio-Jet Fuels)
Vol.22 Chemicals Production from Biomass Resources
Vol.23 Novel Devices that use Biological Functions (Living Devices)
Vol.24 Artificial Intelligence in Food Industry
Vol.25 Structural Materials
Vol.26 Instruments for Measurement and Analysis

- **Holding TSC Foresight Seminars**

- **Co-hosting workshops with JST-LCS***
  Topic: Analysis of renewable energy and reduction of its costs

*) JST-LCS : Japan Science and Technology Agency - Center for Low Carbon Society Strategy

Case Study-1: Chemical Production Using Biomass-Derived Resources

- Chemical products and polymers derived from sugars and oils are being used commercially

Commercialization trends for chemical production using biomass-derived resources

Raw materials	Chemicals	Companies	Commercialization trends
Glucose	Lactic acid, ethanol, succinic acid, itaconic acid, ethyl acetate and others	Many companies including those from the United States, Canada, Brazil, China, and other Asian countries	• Commercialization of organic acid alcohol production mainly by fermentation (bioprocess) method from edible sugar
Glucose	Perfume, high performance polymer and others	Evolva (Switzerland)	• Production difficult for functional monomers with aromatic rings from petroleum by fermentation method (use of bioprocesses preferred)
Bio-oils	Oil-derived polymer Glycerol-based monomer	Arkema (France), Mitsui Chemicals, Toyobo, Unitika, Solvay (Belgium), Dow Dupont (US) and others	• Surfactants, polyamide, polyurethane, and others • Epichlorohydrin from glycerol as a by-product of biodiesel
Cellulose	Cellulose nanofibers (CNFs)	Nippon Paper Industries, Oji Holdings, Daio Paper, Chuetsu Pulp Industry and others	• Various types of physically and chemically defibrillated cellulose nanofibers being commercialized
Hemicellulose	Furfural	Companies in China, India, Europe and others	• Furfural taken from hemicellulose being commercialized by many companies
Lignin	Vanillin	Borregard (Norway)	• Commercialization of vanillin (for flavor/polymer applications), an aromatic high-value-added monomer, taken from lignin

Source: TSC Foresight Vol.22 Chemicals Production from Biomass Resources

Case Study-2:Chemical Production Using Biomass-Derived Resources

- Japanese companies have been working on bioplastics for more than 30 years and have developed high-performance products that take advantage of plant-derived features.

Industrialized bioplastics

Classification	Polymer	Companies	Raw material (monomer)	Main properties	Production capacity (t/y)
General petroleum alternative resins	PET	Many Asian companies (Thailand, Taiwan, and others)	Sugar (ethylene glycol)	Same as petroleum-derived PET	460,000
	PE	Braschem (Brazil)	Sugar (ethylene)	Same as petroleum-derived PE	200,000
	PLA (polylactic acid)	Nature Works (US) Hisun (China) and others	Sugar (lactic acid)	Biodegradability, low heat resistance	170,000
Plant-derived high-performance resins	PA (polyamide)	Arkema (France)	Castor oil	Heat resistance, chemical resistance	60,000
		Unitika	Castor oil	Heat resistance, high crystallinity, low water absorption	500
		Toyobo	Castor oil	Heat resistance, durability, low water absorption	1,000
	PTT(polytrimethylene terephthalate)	Dow DuPont (US)	Sugar (1,3-propanediol)	Durability, elasticity	120,000
	PBS (polybutylsuccinate)	Mitsubishi Chemical	Sugar (succinic acid, butanediol)	Biodegradability, processability	4,000
	PHA (hydrocicarboxylic acid polymer)	Danimer Scientific (US)	Sugar (3-hydroxyalkanoic acid)	Biodegradability	30,000
		Kaneka	Oil (3-hydroxyhexane-butyric-acid)	Marine biodegradability, processability	1,000
	PC (polycarbonate)	Mitsubishi Chemical	Sugar (isosorbide)	Light transmittance, strength resistance, impact resistance	5,000

Source: TSC Foresight Vol.22 Chemicals Production from Biomass Resources

Case Study-3: Chemical Production Using Biomass-Derived Resources

- Most cellulose nanofibers (CNF) contain micro-sized nano-fibril structures
- In Japan, the primary focus is on developing high-performance products

Industrialized cellulose nanofiber

Company/university	Country	Production capacity (t/y)	Production focus/methods
Borregaard	Norway	1,000	• CNF containing microfibril cellulose
University of Maine	United States	300	• Refiner treatment used as base, resin reinforcing agent, humectant, and oil proof agent
American Process	United States	150	• Cellulose nano-fibril/cellulose nanocrystal
Innventia	Sweden	30	• CNF nano-fiberized by enzymatic/mechanical treatment, carboxymethylated, and cationized CNF also produced
Nippon Paper	Japan	540	• Single nano-fiberized CNF (500 tons/year), reinforced resin CNF (10 tons/year) and food use CNF (30 tons/year)
Chuetsu Pulp Industry	Japan	100	• Counter injection of pulp suspension with two nozzles, CNF disintegrated by collision pressure
Daio Paper	Japan	100	• From fibrous to machine energy · energy saving by fibrillating • Dry CNF for resin mixing also provided
Oji Paper	Japan	40	• CNFs nano-fiberized by introducing phosphate group, an ionic exchange group, to CNF surface of pulp to increase electrostatic repulsion between CNFs

Source: TSC Foresight Vol.22 Chemicals Production from Biomass Resources

Case Study-4: Chemical Production Using Biomass-Derived Resources

- For expansion of chemical production using biomass-derived resources in Japan, the following three steps need to be followed:
  1. Development of stable supplies of inexpensive biomass-derived raw materials
  2. Development of high-value-added applications
  3. Creation of market push and pull for biomass-derived products

Issues to be addressed for the production of chemicals derived from biomass resources

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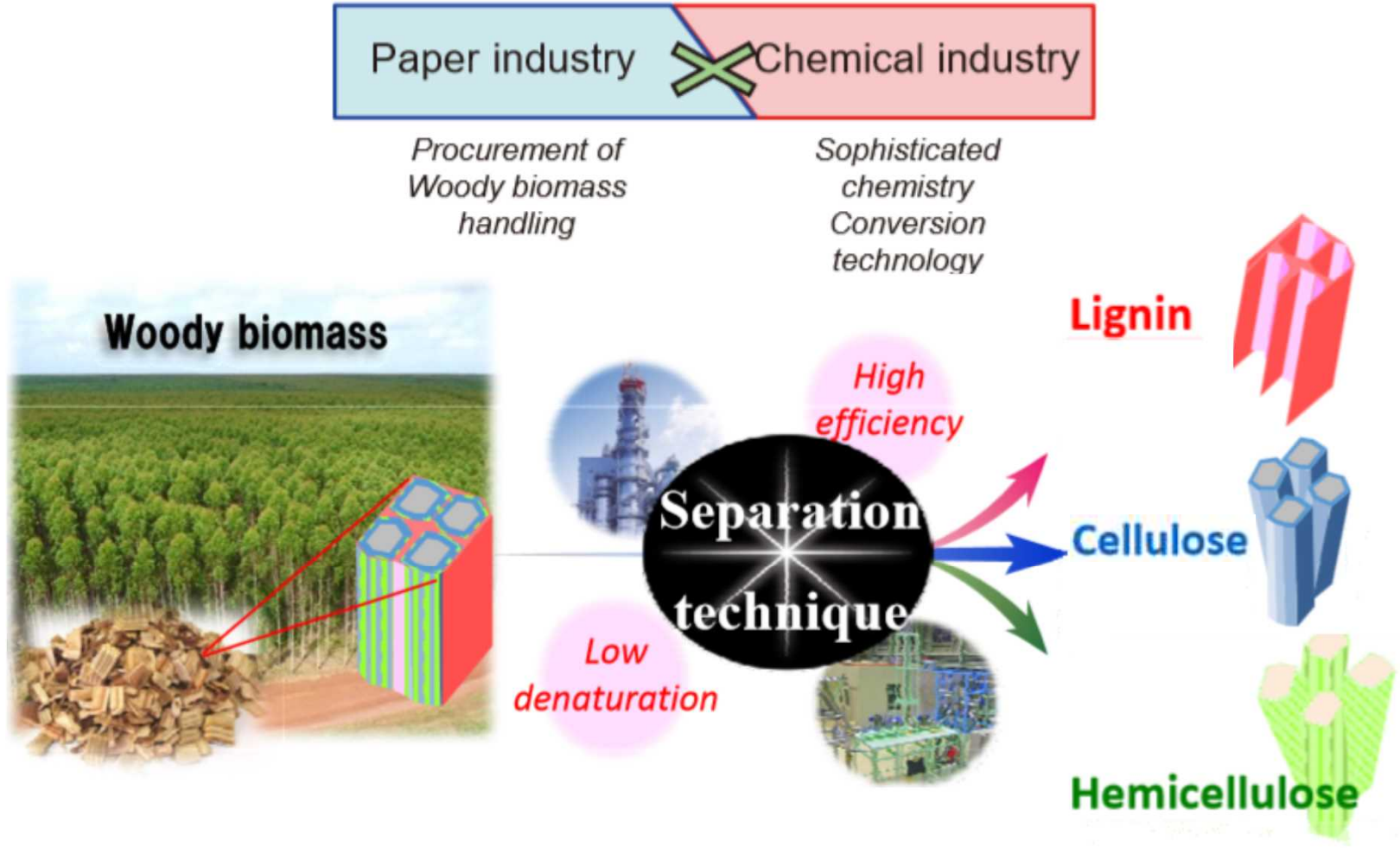
Collaboration Between Paper and Chemical Industries

- Developing cost-competitive manufacturing processes for chemicals using renewable resources

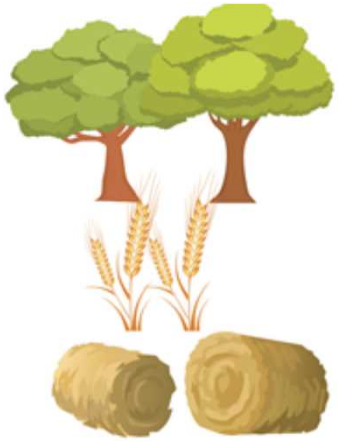
Development of Technologies for Manufacturing Processes of Chemicals
Derived from Inedible Plants (FY2013–2019, 7.1 billion yen)



Realization of Bioindustry Using Unutilized Domestic Biomass

- Separation of biomass-derived raw materials with high yields and maximized value
- Utilization of chemical ingredients and matching supply with demand
- Standardization to ensure the quality of biomass-derived chemical raw materials

Unutilized biomass



Maximizing yield and added value

Regional feasibility

Biomass-derived raw materials

- Modified lignin
- Hemicellulose-derived sugar
- Crystalline cellulose
- Cellulose-derived sugar
- Terpenes

Matching supply with demand

High-value-added chemicals

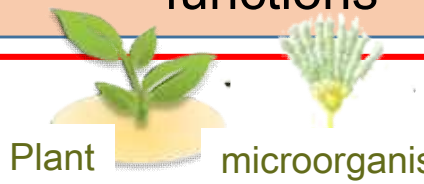
- Modified lignin derivatives
- Hemicellulose-derived sugar/derivatives
- Crystalline cellulose derivatives
- Cellulose-derived sugar/ derivatives
- Terpene derivatives

Innovative Synthetic Biology Process

Designing biological functions

Extracting potential biological functions

Controlling function expression



Plant microorganisms

Information analysis system enabling rational design

Intracellular process design

Expression control technology to optimize production of target substance

Design-based genetic modification

Optimization of material production using organisms

Development of domestic tools

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Key Issues to Realize Bioeconomy-Related Technologies