ADEME-NEDO
Workshop

NEDO's Projects Related to Bio-based Chemicals

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About NEDO （1）

What's NEDO

- NEDO plays an important role in Japan's economic and industrial policies as one of the largest public research and development management organizations. It has the two basic missions of addressing energy and global environmental problems and enhancing industrial technology.
- NEDO coordinates and integrates the technological capabilities and research abilities of industry, academia, and government instead of employing its own researchers. It also promotes the development of innovative and high-risk technologies. NEDO aims to contribute to the resolution of social issues and market creation by demonstrating and producing practical applications of such technologies.

NEDO's Missions

●Addressing energy and global environmental problems

●Enhancing industrial technology

Positioning of NEDO

In its technology development management, NEDO formulates project plans and establishes project implementation frameworks by combining the capabilities of industry, academia, and government, including public solicitations of project participants. NEDO carries out research and development projects and set targets based on changes in social conditions in order to realize maximum results.

About NEDO （2）

FY2018 Budget

1.45 billion US dollars

(FY2018 tentative budget)

NEDO aims to address energy and global environmental problems and raise the level of industrial technology through integrated management of technological development. This ranges from the discovery of technology seeds to the promotion of mid- to long-term projects and support for practical application.

* As only an outline of NEDO's activities is given below, individual budget amounts do not add up to the total.

Energy Systems (481 million US dollars)

- System provision technology
- Energy storage technology such as batteries
- Technology related to hydrogen production, storage, transport, and use
- Renewable energy technology

Industrial Technology (444 million US dollars)

- Robot and AI technology
- IoT, electronics, and information technology
- Manufacturing technology
- Materials and nanotechnology
- Biotechnology

Energy Conservation and Environment (407 million US dollars)

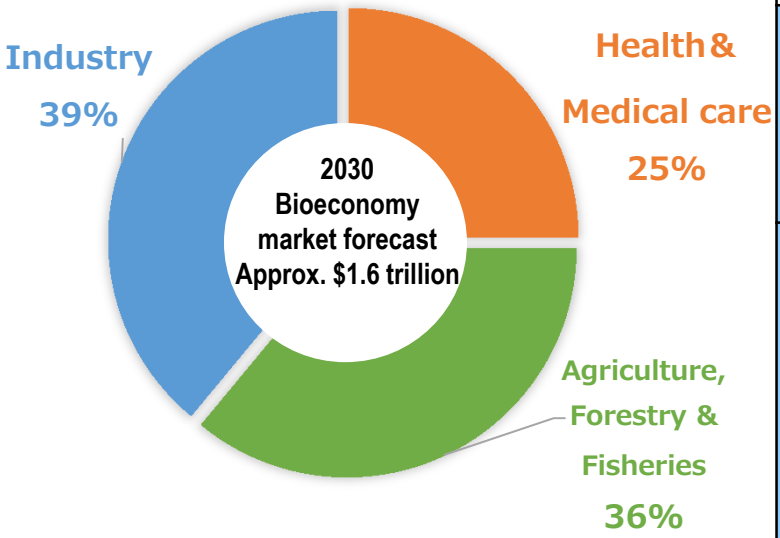
- Technology to harness unutilized thermal energy
- Environmentally-friendly steel manufacturing technology
- Development of high-efficiency coal-fired power generation technology
- Technology related to sequestration of CO2
- Fluorocarbon recovery technology
- 3R technology, including resource screening and metal refining technology
- International demonstrations, Joint Crediting Mechanism activities,

New Industry Creation and Discovery of Technology Seeds (53.6 million US dollars)

- Fostering technology-based startups
- Promotion of open innovation

Bioeconomy policy implementation

- OECD introduce the concept of bioeconomy, combining biotechnology with economic activities. The market is projected to grow to 2.7% of GDP for OECD countries (approx. ¥180 trillion) in 2030, accounting for roughly 40% of the industrial sector.
- Various countries have implemented bioeconomy policies under government initiative at an early stage to promote industrial development through biotechnology and to resolve issues. Activities are spreading into Malaysia, Thailand and other Asian countries.



Source: OECD (2009)
Produced by NEDO based on "The Bioeconomy to 2030"

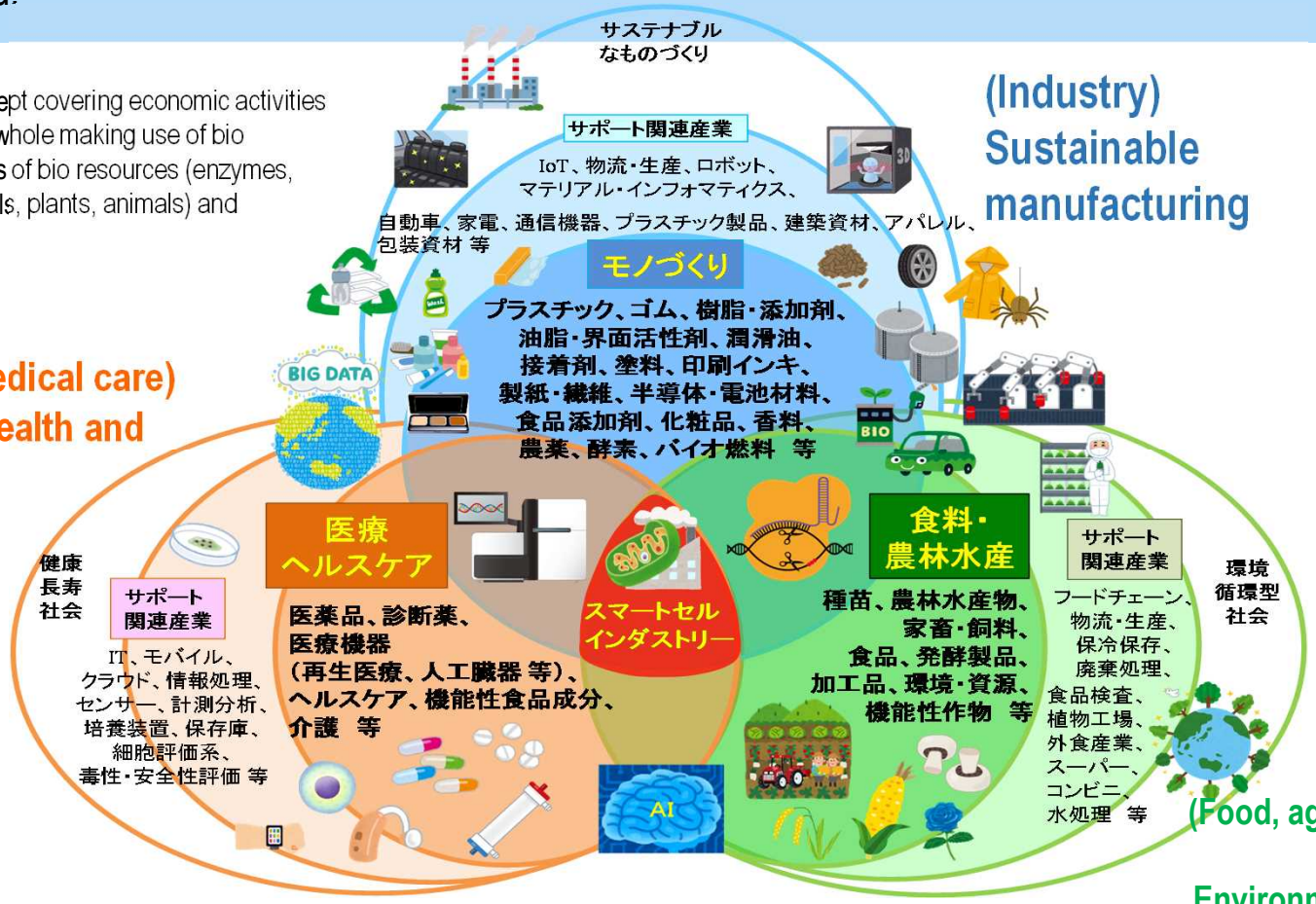
	Europe	US
Latest bioeconomy policies	Innovation for Sustainable Growth: A Bioeconomy for Europe, 2012	National Bioeconomy Blueprint（2012） Federal Activities Report on the Bioeconomy（2016）
Government targets	[2030 targets] · Approx. ¥518 billion to be invested in seven years · 30% of petroleum-derived products to be replaced by bio-derived alternatives · 25% of transport fuel to be replaced by bio-derived alternatives	[2030 targets] · 1 billion tons of biomass used to replace 25% of fossil-derived fuel, produce 23 million tons of bio-derived products and supply 85 billion kWh of electric power · Create 1.7 million jobs and market worth $200 billion

Source: Analysis on the Current Situation of Bioeconomy and the Future Vision Created by Smart Cell, FY2016 NEDO-commissioned study by Mitsubishi Chemical Techno-Research Corporation

Vitalizing bioeconomy in Japan

- With UN's Sustainable Development Goals (SDGs) adopted in 2015, the growing gravity of environmental issues, etc., must be resolved in building a sustainable society.
- Technologies that accelerate sustainable manufacturing become necessary, and Japan's bioeconomy must be vitalized.

*Bioeconomy: Concept covering economic activities and industries as a whole making use of bio resources, functions of bio resources (enzymes, microorganisms, cells, plants, animals) and biotechnology



Source: Analysis on the Current Situation of Bioeconomy and the Future Vision Created by Smart Cell, FY2016 NEDO-commissioned study (Commissioned to Mitsubishi Chemical Techno-Research Corporation, 2016)

NEDO's Projects Related to Bio-based Chemicals

Project 1 : Development of Technologies for Manufacturing Processes of Chemicals Derived from Inedible Plants

Theme (1) : Development of Integrated Manufacturing Process of Ligno CNF as well as Structural Components Manufacturing by Composing it (Ligno CNF PJ)

Theme (2) : Development of Technologies for Manufacturing Processes of Chemicals Derived from Inedible Plants (Biomass Refinery PJ)

Project 2 :Development of Production Techniques for Highly Functional Biomaterials Using Smart Cells of Plants and Other Organisms (Smart Cell Project)

Project 1. Development of Technologies for Manufacturing Processes of Chemicals Derived from Inedible Plants

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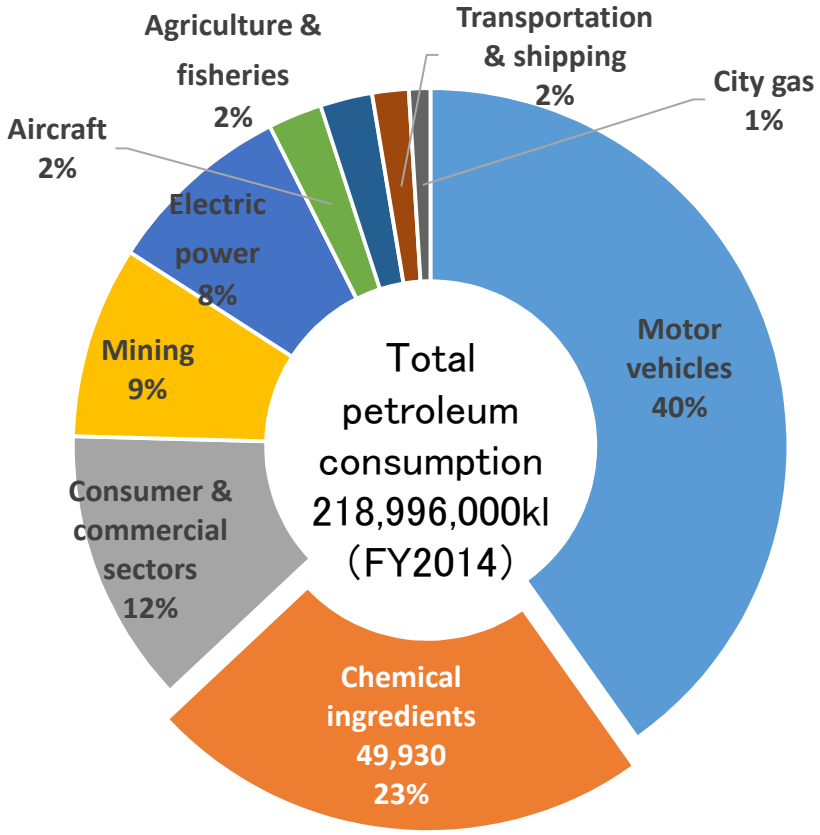
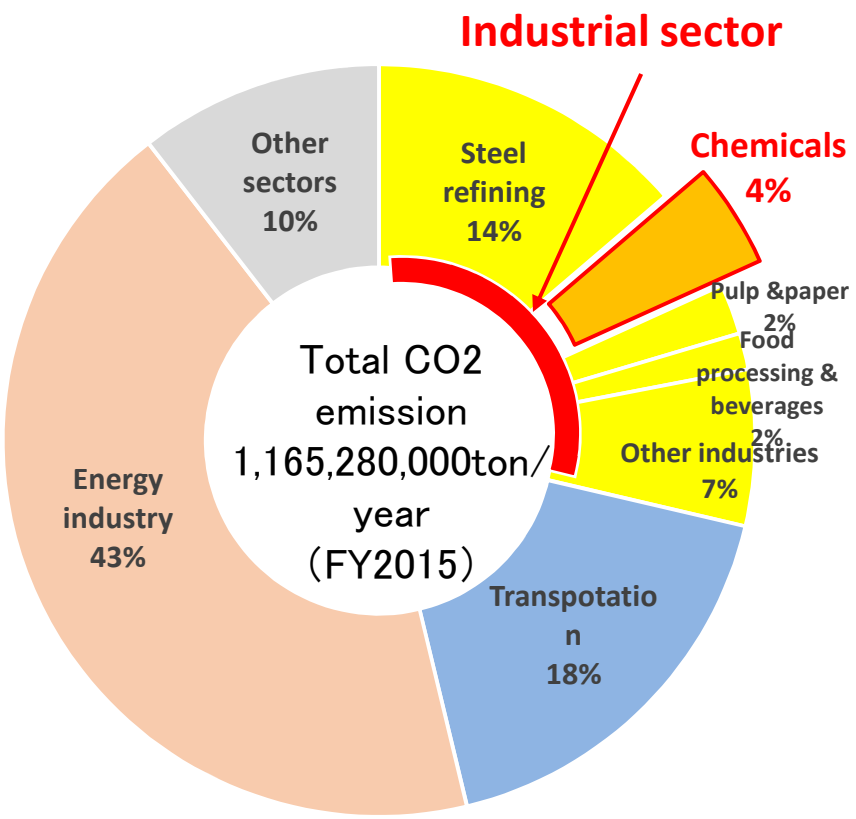
Project Background : The Chemical Industry in Japan

- Demand in the area of raw ingredients used in chemical applications accounts for roughly 23% of that for all petroleum products.
- Carbon dioxide emission by the chemical industry is the 2nd largest in the industrial sector, accounting for approximately 4% of Japan as a whole.

Petroleum product consumption based on application



Breakdown of CO2 emission by energy source



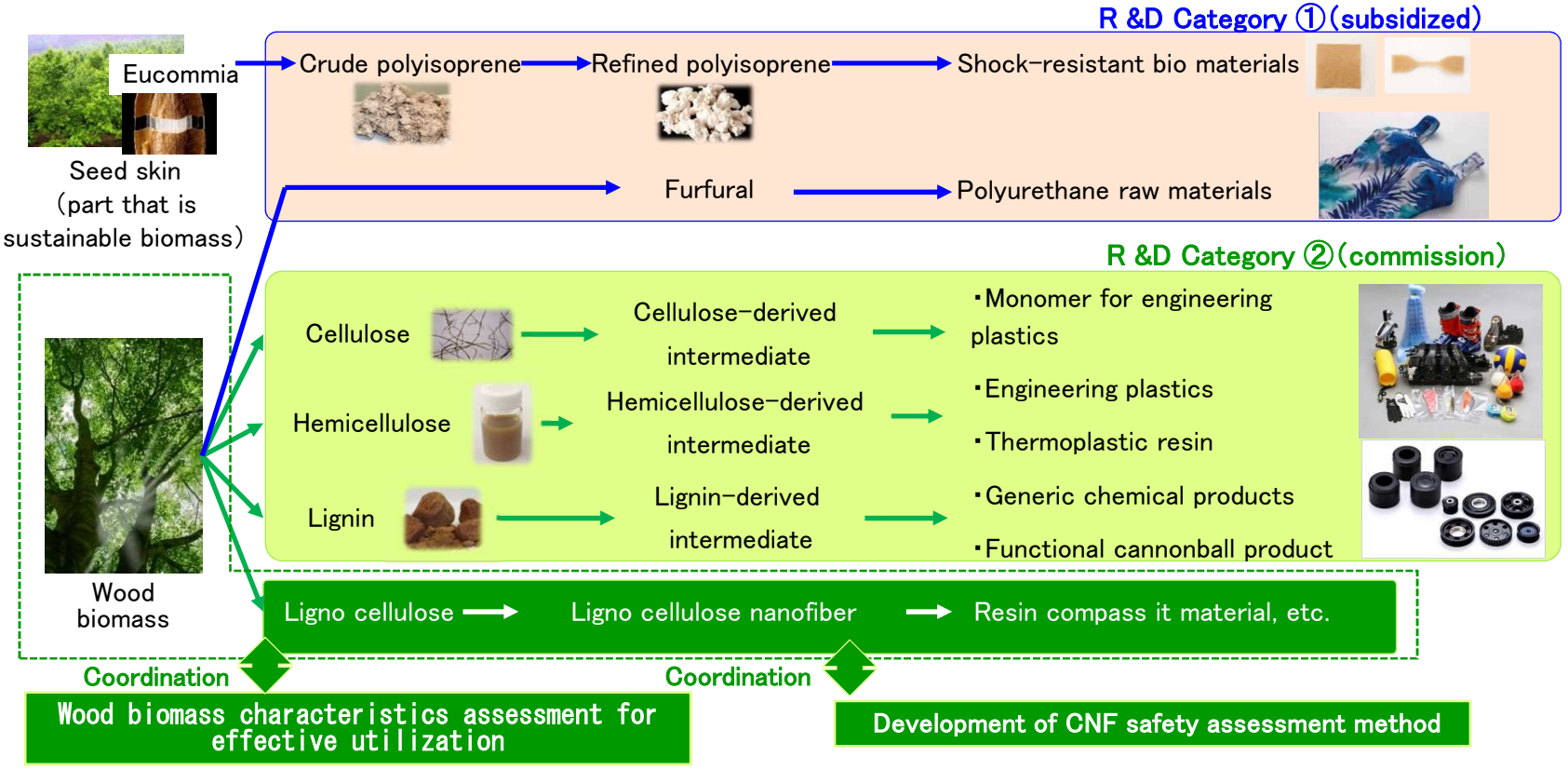
Importance of raw material conversion and reduction in CO2 emission

Project outline (1)

The objective of the project is to develop an integrated manufacturing process of nonedible biomass, that is highly cost-competitive, from raw ingredient to final chemical product, in the drive to shift from petroleum-based resources to nonedible biomass ingredients.

It focuses in particular on cellulose nanofibers (CNF) that is expected to a new material possessing the potential of diverse applications. In order to upgrade its reliability and strengthen raw material supply and quality control and therefore accelerate social implementation, assessment of its safety and application characteristics started in FY2017.

Additionally, it aims at the creation of a sustainable, low-carbon society by creating an energy-saving chemical product manufacturing process utilizing the renewable resource of nonedible biomass and therefore reducing carbon dioxide emission.



Project outline (2)

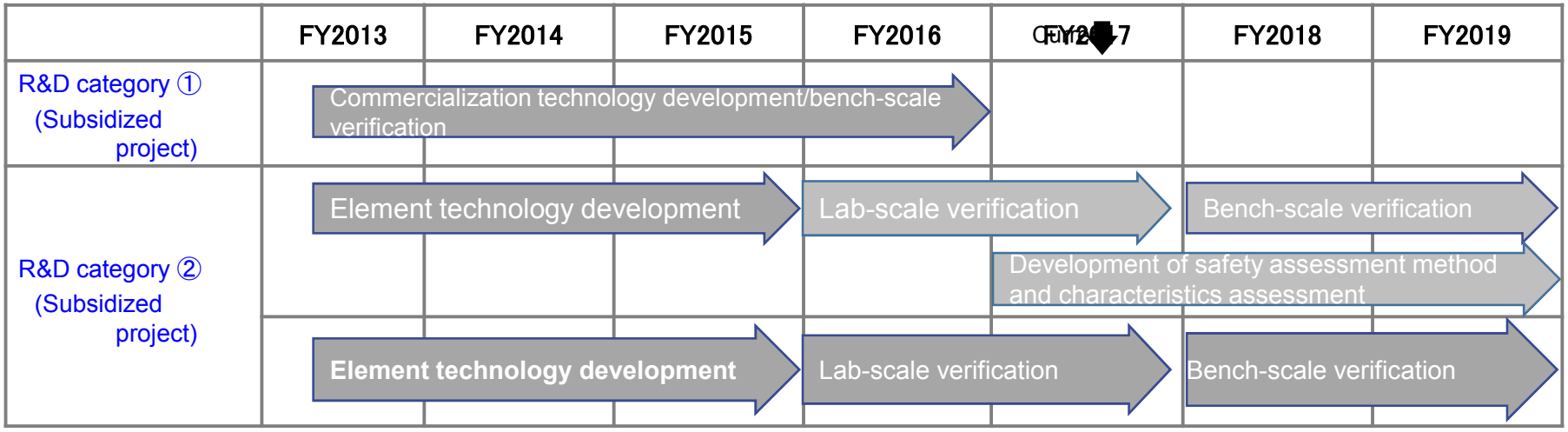
Development of Manufacturing Process Technologies for Non-Edible, Plant-Derived Chemical Products

R&D categories ① (subsidized project) (2013-2016; 4 years; completed)

· Development of plant isoprenoid-derived, high-performance biopolymer
· Development of THF manufacturing technology based on nonedible biomass-derived furfural method

R&D categories ② (subsidized project) (2013-2019; 7 years; completed)

・Technology for the integrated production process of ligno cellulose nanofibers and their applications for the structural members
・Development of safety assessment methods for cellulose nanofibers (2017-2019)
・Assessment of characteristics for effective use of wood biomass（2017-2019)
・Development of an integrated manufacturing process from wood biomass to chemicals

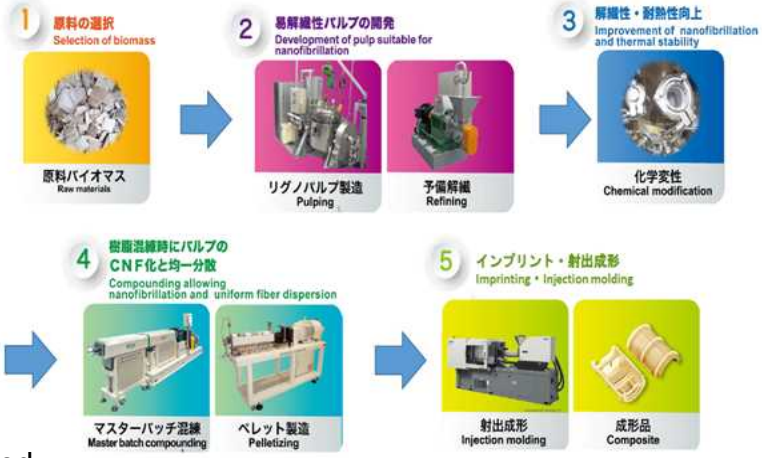


Development of Integrated Manufacturing Process of Ligno CNF as well as Structural Components Manufacturing by Composing it (Ligno CNF PJ)

· Regarding CNF which is anticipated to become a new material with diverse applications, improvement of its reliability and reinforcement of raw material supply and quality control are necessary to help accelerate practical use and wider dissemination.
· Starting in FY2018, the project engages in the development of safety assessment methods for CNF and assessment of wood biomass characteristics for effective utilization, in coordination with existing project to develop an integrated manufacturing process and structural member technology for ligno (lignin-containing) CNF.

Technology for the integrated production process of ligno cellulose nanofibers and their applications for the structural members [FY2013-FY2019]

· Development of an integrated manufacturing process for high-performance ligno CNF by isolating effective substances from wood, bamboo and other wood-based biomass.
· Additionally, development of thermoplastic molded body with high plant content, high elasticity and low linear thermal expansion characteristics, utilizing lignin's thermoplastic characteristics.



Samples provided

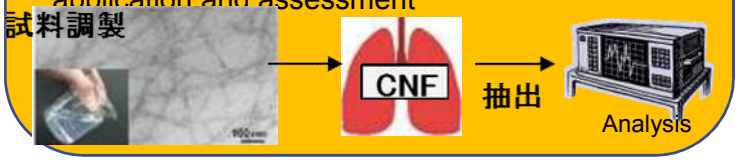
Report of results

Report of results

Samples provided

Development of safety assessment methods for cellulose nanofibers [FY2017-FY2019]

· Development of analysis and toxicity test methods, as well as development of release & exposure assessment methods
· Development of procedural manuals, etc., compiling methodologies and case studies on application and assessment



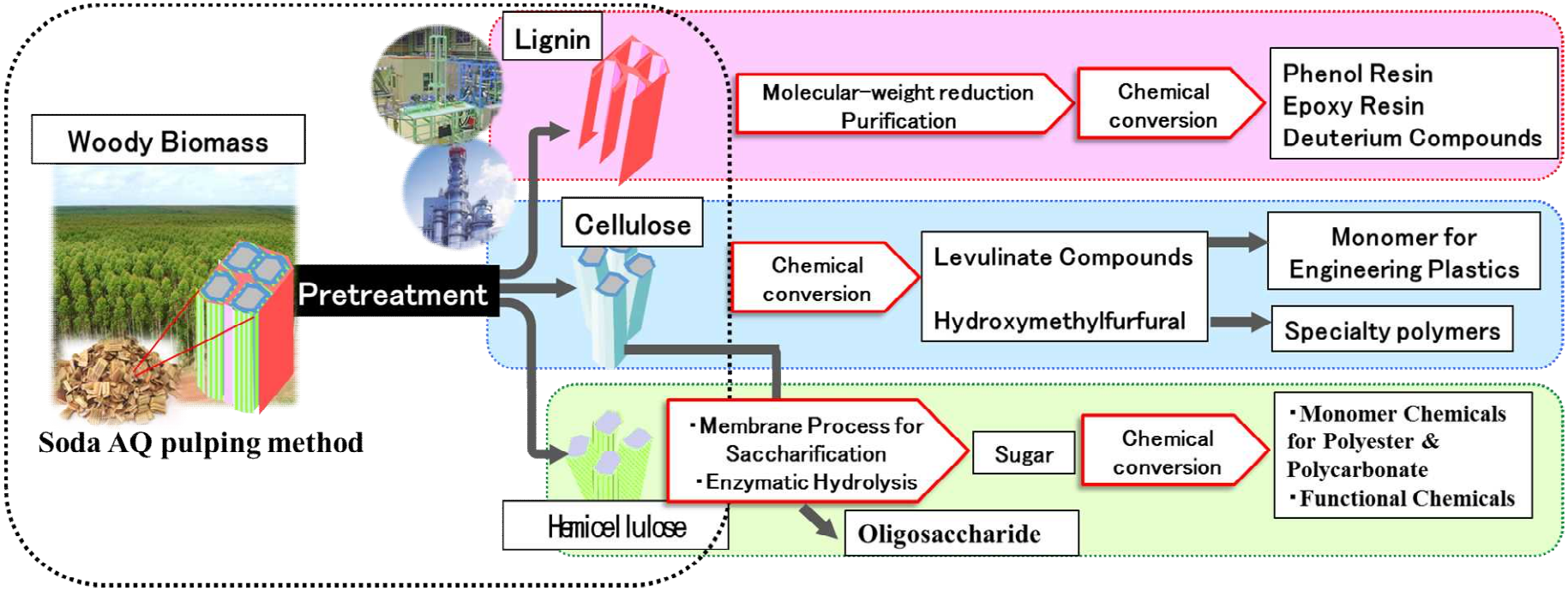
Assessment of characteristics for effective use of wood biomass [2017-2019]

· Comprehensive analysis of results obtained from analysis of wood biomass characteristics, pulp characteristics and CNF characteristics and assessment of suitability of CNF application.
· Establishment of raw material assessment method that enables efficient production of high-performance CNF based on application

Development of Technologies for Manufacturing Processes of Chemicals Derived from Inedible Plants (Biomass Refinery PJ)

■ Sustainable chemical product manufacturing to move away from fossil resource dependence
Development of an integrated manufacturing process utilizing the renewable wood biomass, as the alternative to petroleum-derived chemicals

■ Development of an integrated process utilizing the strengths of papermaking and chemical businesses
Technologies that are fundamental to wood biomass defibrillation technology and chemical manufacturing utilizing fibrillated materials to be brought together
for development of a lab-scale integrated manufacturing process from wood biomass to chemical product ingredients



Project 2. Development of Production Techniques for Highly Functional Biomaterials Using Smart Cells of Plants and Other Organisms (Smart Cell Project)

Project background (Technical innovation in biotechnology)

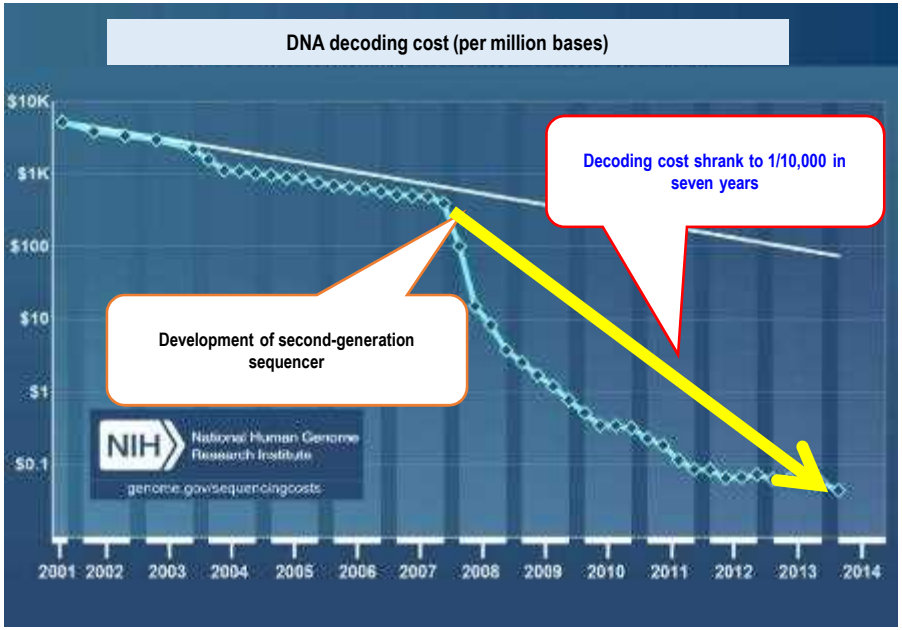
- New currents spurring the growth of the bioeconomy through major technological innovations in the biotech sector, such as faster and cheaper data aggregation, mass and high-speed data analysis and genome design and new tools that realize function control with high accuracy and at low cost.

Advances in genome decoding technology

At the time of Human Genome Project (1990)
13 years; $3 billion

→

Present
1 day; $1000



Development of next-generation sequencer (DNA analyzer)
- Low-cost digitalization of living organism genetic data (unique characteristics and changes)
- Magnification in volume of accumulated data (20 times that of 5 years ago)

Advances in IT/AI technologies

Progress toward commercial level
· High-precision extraction from massive data, key genetic information, etc.
· Genome design based on extracted data

Advances in genome editing technology

Introduction of the next-generation genome editing technology (CRISPR/Cas) Possibility of realizing biological functions with greater accuracy and at low cost
· Greater ease in gene splicing and editing becomes possible
· Creation of living creature with artificially added unique characteristics

Source: Partially modified data from Bio-Industry Subcommittee, Commerce Distribution and Information Committee, Industrial Structure Council, METI

Project objective

- Realizability of "transition in material production from chemical processes to bio processes" and "production of substances that are difficult to synthesize with chemical processes" has increased with technical innovations.
- Prospects of application to material production and accompanying growth of the industrial application market Greater competitiveness urgently needed.
- Growing demand to reduce environmental impact, cutdown CO2 emission, build a carbon cycle society, etc., to address environmental issues that are aggravating on the global scale.

Technologies that accelerate sustainable manufacturing
to revitalize Japan's bioeconomy

Biological processes to be modified into highly controlled industrial production technology
In order to establish production technology for advanced-function-products at low cost and with less energy.
contribute to reduced C(They are to realize to manufacturer of beneficial substances that are difficult to produce with chemical synthesis, overwhelming advances in productivity over conventional methods and reduction in environmental impact and therefore O2 emission, creation of carbon-cycle society, realization of sustainable society, creation of smart cell industry, etc.)

Project outline

Development of fundamental technologies for smart cell development

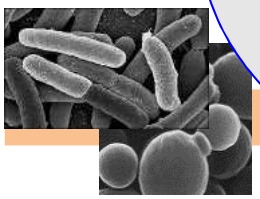
Designing biological functions

Uncovering potential biological functions

Controlling function manifestation

Plant cells

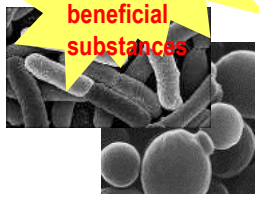
Microbial cells



・Upgrading productivity of beneficial substances
Designing metabolic systems (Augmentation, control & blocking metabolic reaction by gene manifestation control, enzyme design, etc.)
・Optimizing environmental conditions
(Cultivation conditions, cultivation environment, cultivation technology application)
etc.

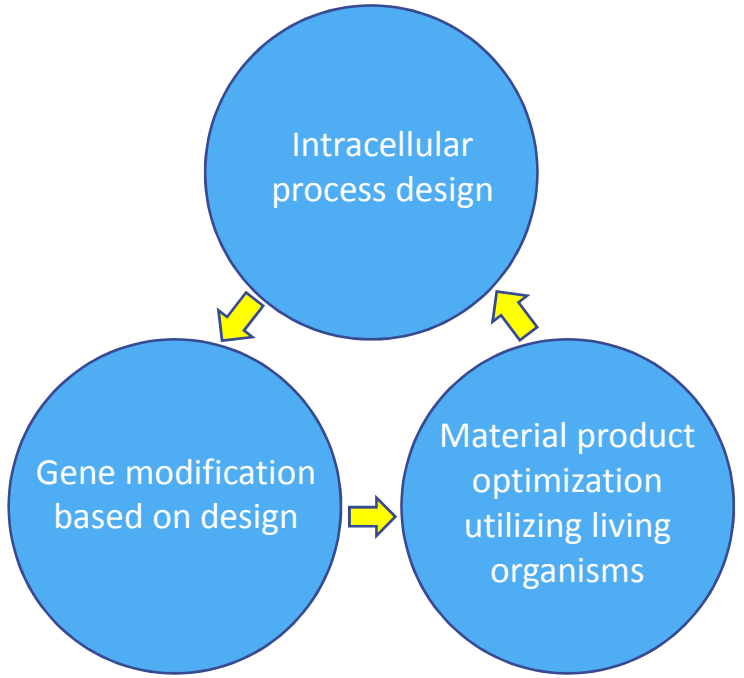
Smart cell*

Dramatic improvement in productivity of beneficial substances



＊Smart cell: Living cells designed for advanced function, with material production capability artificially increase to the maximum

Data analysis system that realizes rational design



Domestic tools not dependent on foreign technologies

Manifestation control technology optimizing production of target substance

Issues in industrial use and definition of R&D categories (1)

Issues: Industrial use of foreign technology requires huge patent fees

- 1970s: Genetic engineering is born, enabling biogenome modification and use
- 1990s: Technology with improved accuracy and specificity developed.
  (Issues are need for time, know-how and effort)
- 2013: Introduction of more convenient, more efficient genome editing technology (CRISPR/Cas)

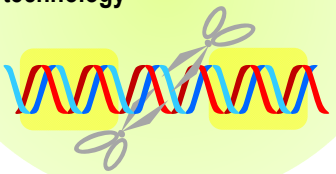
<Research examples>

・Muscular dystrophy in mice improved with genome editing

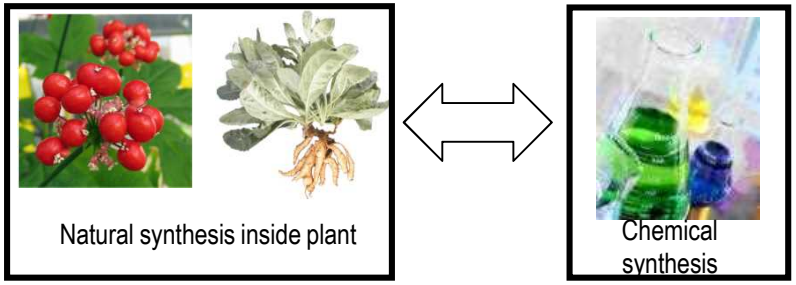
・Tiger puffer fish growing at double speed

Development of domestic tools not dependent on foreign technologies

(1) Development of domestic genome editing technology



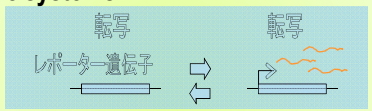
Issues: Production of beneficial substance production from plants involve issues in volume, stability and cost
(Minute production output, long growth period for plants, cultivation technology undeveloped, inadequate domestic biological resources & supply, details of various metabolic systems unknown, etc.)



Plants synthesize 200,000 to 1,000,000 types of compounds and has very high potential as natural resources for industrial use.

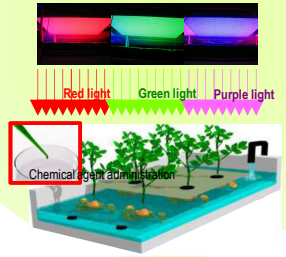
Manifestation control technology optimizing production of target substance

(2) Gene manifestation control technology for metabolic systems



(Hop lupulin = oil gland)

(3) Manifestation control technology based on cultivation & growth environments



Issues in industrial use and definition of R&D categories (2)

Issue: Production of beneficial substance production from microbe involve issues in volume, stability and cost
(Increase in trial-and-error factors, long development period, huge cost, substances that cannot be manufactured, etc.)

Identification of functions based on gene & biological seed research and molecular biology analysis

Extraction of beneficial genes

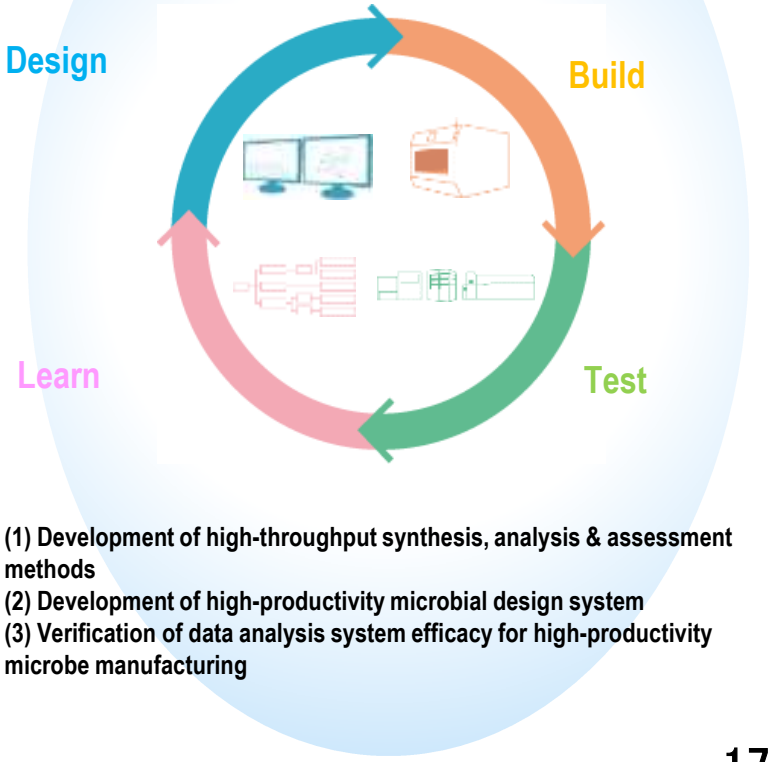
Genetic engineering

Productivity of target substance may not be adequate; propagation of engineered body may be curbed; or synthesis of complex chemical compounds may be difficult

Embedded gene

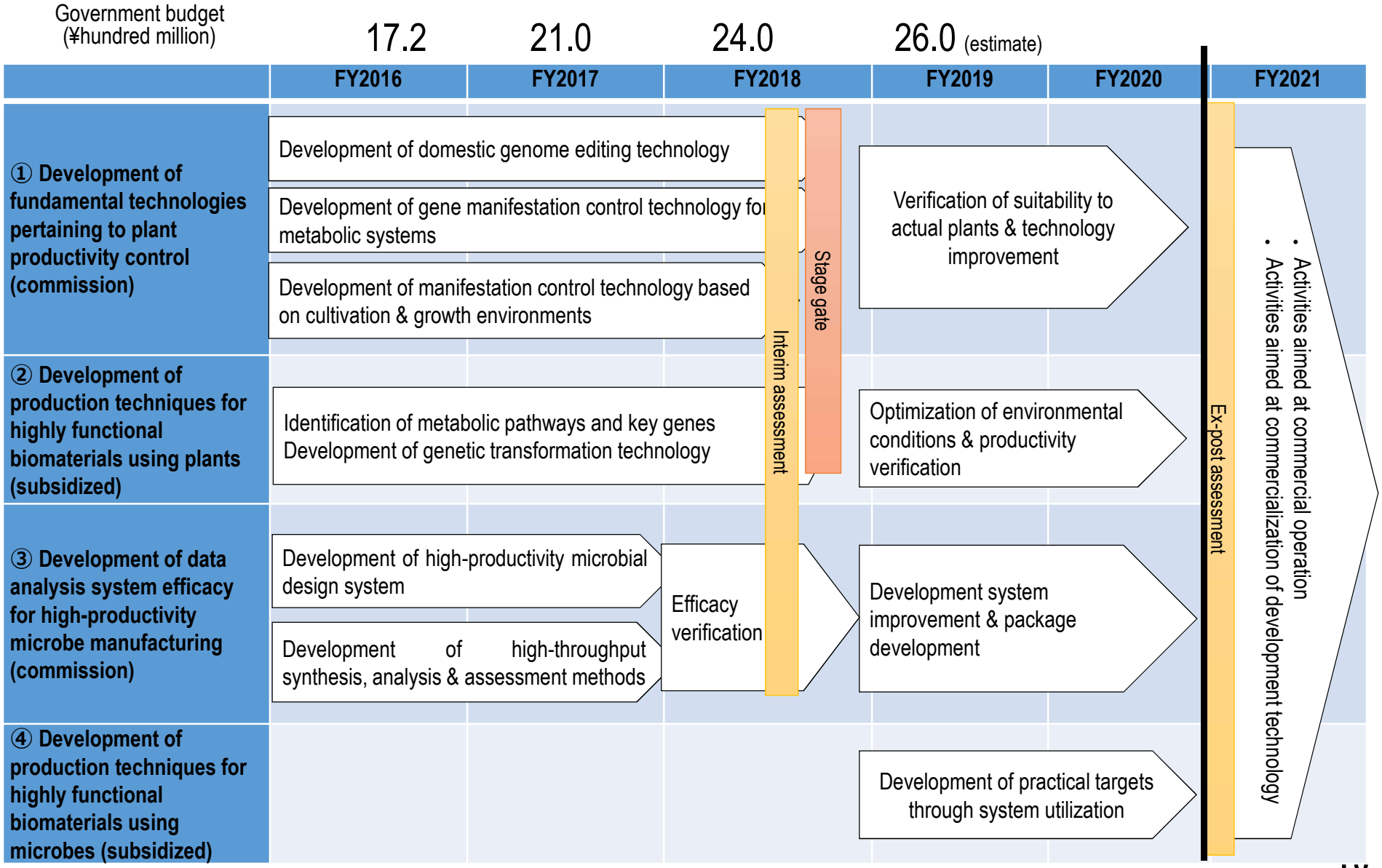
Conventional genetic engineering technology

Platform centered on data analysis system that realizes rational design



(1) Development of high-throughput synthesis, analysis & assessment methods
(2) Development of high-productivity microbial design system
(3) Verification of data analysis system efficacy for high-productivity microbe manufacturing

Project budget and general plan



Future Image of Generic Application of Fundamental Technologies