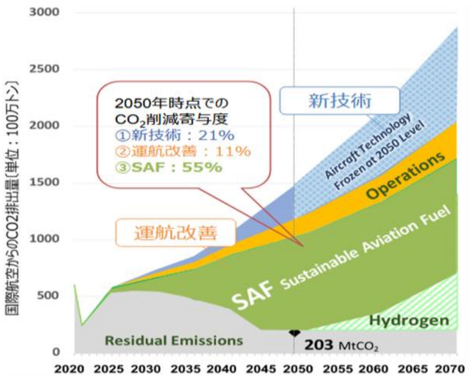
NEDO's efforts toward the social implementation of SAF

Global warming countermeasures/Aircraft/Fuel

The need for SAF (sustainable aviation fuel)

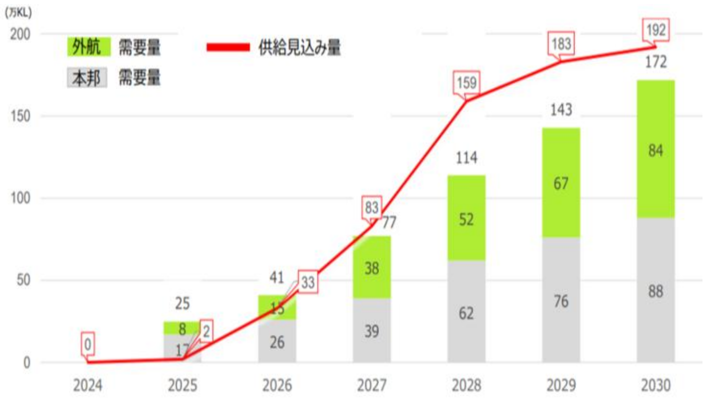
- In order to reduce greenhouse gas emissions in the international aviation sector, the International Civil Aviation Organization (ICAO) has set a goal of reducing the increase greenhouse gas emissions to zero after 2020.
- The main methods of reduction are expected to be the development of new aircraft technology, the improvement of flight routes, and the introduction of SAF (sustainable aviation fuel) made from biomass and other raw materials. Of these, expectations are high for SAF, which is expected to achieve a 55% reduction by 2050.
- In order to achieve ICAO's goal of reducing CO_2 emissions in the international air transport sector, demand for SAF is expected to expand worldwide.



国際航空からのCO2排出量予測と排出削減目標のイメージ
ICAO LTAG Reportから抜粋（IS3: ICAOによる野心的なシナリオ）/経済産業省資料

Domestic SAF trends

- The goal is to replace 10% of domestic jet fuel consumption with SAF by 2030 (equivalent to a demand of 1.72 million kL/year).
- The expected supply volume in 2030 is expected to be approximately 1.92 million kL/year.
- The main products are SAF produced using HEFA technology, which uses waste cooking oil, and ATJ technology, which uses bioethanol as a raw material.

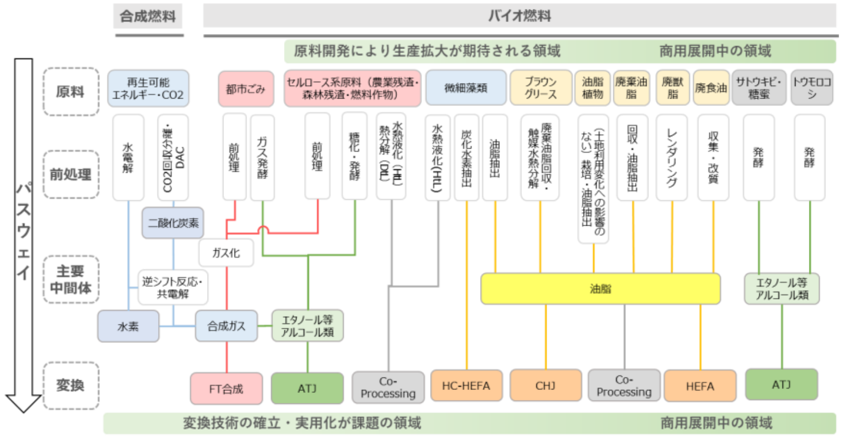


NEDO's efforts toward the social implementation of SAF

Global warming countermeasures/Aircraft/Fuel

SAF manufacturing process

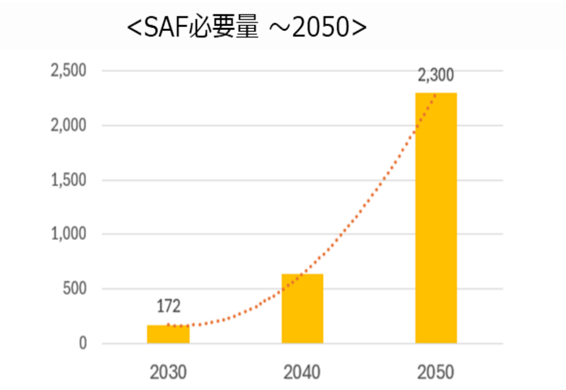
- There are a variety of pathways for the raw materials and manufacturing processes of SAF,including HEFA technology using oil-based raw materials, ATJ technology using bioethanol, gasification and FT synthesis technology using cellulosic raw materials and waste, and e-Fuel using CO_2 and hydrogen.
- Demand for SAF is expected to continue expanding after 2030, and the development of diverse raw materials and processes will be important to ensure a stable supply.



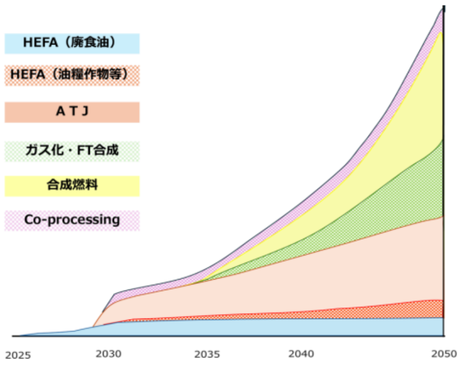
出所：NEDO HP 2022年度～2023年度成果報告書: 国内外におけるSAFの製造技術ならびに低コスト化技術に係る動向調査

Future SAF manufacturing technology forecast

- Regarding the SAF manufacturing process, it is expected that HEFA (waste cooking oil) and ATJ will be introduced first until 2030.
- In addition to these, from 2030 onwards, it is expected that the introduction of co-processing, the application of new oil crops to HEFA, and the application of cellulosic bioethanol to ATJ will become concrete.
- From around 2035, it is expected that cellulosic feedstocks will be gasified and applied to FT synthesis, and synthetic fuels will become a reality.



出典：2050年航空輸送におけるCO2排出実質ゼロへ向けて JAL/ANA共同レポート



NEDO Project: Development Project for Stable and Efficient Production Technologies of Sustainable Aviation Fuel (SAF)

Contact Information: NEDO Renewable Energy Department, Biomass Unit

NEDO's efforts toward the social implementation of SAF

Global warming countermeasures/Aircraft/Fuel

Biojet Fuel Production Technology Development Project

Research and development items (1) Pilot-scale testing of integrated manufacturing processes (2017～2021)

Implementation details

In order to establish an SAF manufacturing process that is expected to be commercialized by around 2030, we will combine the elemental technologies cultivated in the previous project, verify the integrated manufacturing process from raw materials to SAF through pilot-scale testing, and achieve stable, long-term continuous operation.

【Raw material: microalgae】

①Development of an integrated process for producing pure biojet fuel using fast-growing Botryococcus

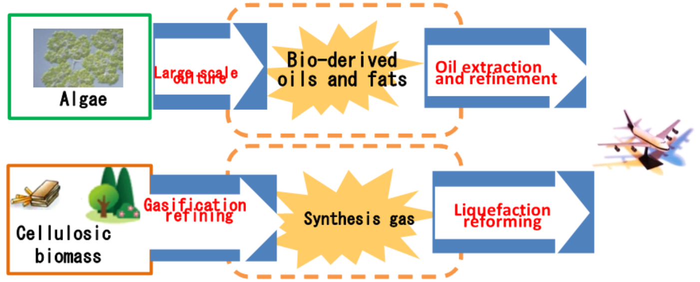
【Outsourced】IHI Corporation、Kobe University　Raw material: woody biomass

②Research and development of a pilot plant for producing pure biojet fuel using high-performance entrained-flow gasification and FT synthesis

【Outsourced company】Mitsubishi Heavy Industries, Ltd.、Toyo Engineering Corporation,JERA Co., Ltd., Japan Aerospace Exploration Agency (JAXA)

Assignment

- Building an integrated manufacturing process that combines elemental technologies
- Stable operation of manufacturing systems



NEDO Project: Development Project for Stable and Efficient Production Technologies of Sustainable Aviation Fuel (SAF)

Contact Information: NEDO Renewable Energy Department, Biomass Unit

NEDO's efforts toward the social implementation of SAF

Global warming countermeasures/Aircraft/Fuel

Biojet Fuel Production Technology Development Project

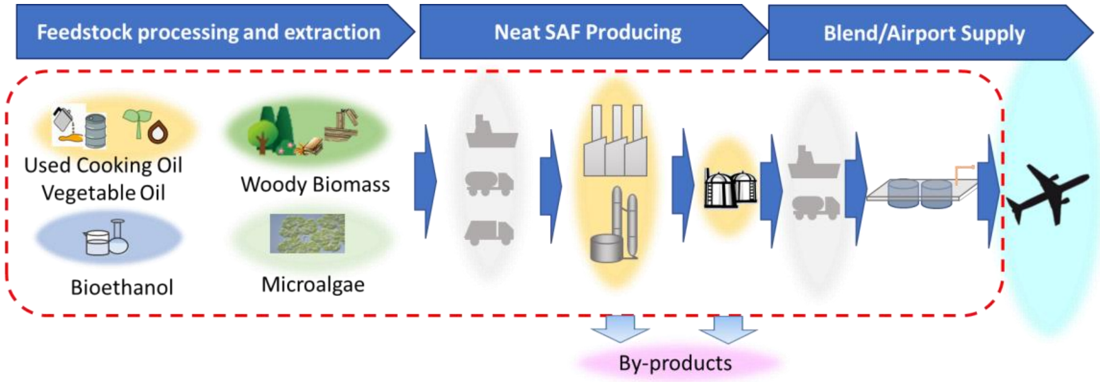
Research and development items （2） Building a supply chain model through demonstration （2020～2024）

Implementation details

- ✓ It is expected that integrated manufacturing technology will be established and SAF will be certified to the international standard (ASTM D7566) by around 2030. This is expected to reduce greenhouse gas emissions compared to the greenhouse gas emissions over the life cycle of existing jet fuel, and the business necessary to build a supply chain will be centered on SAF manufacturing technology that is technically feasible for the anticipated future production scale.
- ✓ Developing businesses by raw material: ①Woody biomass ②Microalgae ③Waste cooking oil/vegetable oil ④Domestic second-generation bioethanol

Assignment

- ➢ Unearthing unused domestic resources
- ➢ Stable supply of raw materials from overseas
- ➢ Increasing the number of examples of supply chain models
- ➢ Consideration of large-scale production and cost reduction



NEDO's efforts toward the social implementation of SAF

Global warming countermeasures/Aircraft/Fuel

Biojet Fuel Production Technology Development Project

Building a supply chain model through demonstration

Research and development theme	Implementing company
Establishment of a commercial supply chain for biojet fuel using oil-based processes and reduction of manufacturing costs (FY2020-2021)	Euglena Co., Ltd.
Building a supply chain model for biojet fuel production using domestically produced waste cooking oil (FY2021-2024)	JGC HOLDINGS CORPORATION、JGC JAPAN CORPORATION、REVO International Inc.、Cosmo Oil Co., Ltd.
Demonstration project for integrated domestic production of SAF from pulp and construction of a supply chain (FY2020-2022,2022-2024)	Biomaterial in Tokyo Co.,Ltd.、Sanyu Plant Service Co., Ltd.
Business model verification of SAF production technology using gasification FT synthesis process utilizing BECCS (FY2023-2024)	Mitsubishi Heavy Industries, Ltd.、Toyo Engineering Corporation
Empirical research to build and expand an SAF supply chain model using vegetable oils that do not compete with food （FY2022-2023,2023-2024）	J-OIL MILLS, INC.
Construction of a plant-based SAF demonstration supply chain model using a low-pressure, low-hydrogen-consumption multifunctional catalyst （FY2022-2024）	Green Power Development Corporation of Japan (GPD)

NEDO Project: Development Project for Stable and Efficient Production Technologies of Sustainable Aviation Fuel (SAF)

Contact Information: NEDO Renewable Energy Department, Biomass Unit

NEDO's efforts toward the social implementation of SAF

Global warming countermeasures/Aircraft/Fuel

Biojet Fuel Production Technology Development Project

Research and development items （3） Microalgae basic technology development （2020～2024）

Implementation details

[2-1]Microalgae basic technology demonstration

In order to establish stable mass cultivation technology for microalgae, three model demonstration projects will be carried out on a scale that will serve as one unit for practical application.

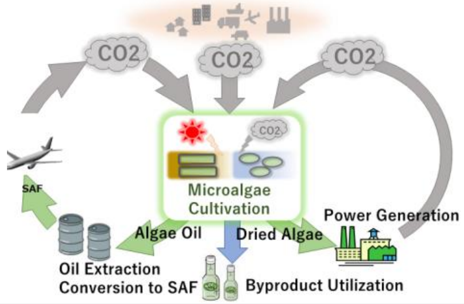
①Cascade use of generated materials ②Use of marine diatoms ③Use of exhaust gas from power plants

[2-2]④Fundamental technology development at the Microalgae Research Center (IMAT)

A research base will be established on Osakikamijima Island in Hiroshima Prefecture, including a test bed that will enable the acquisition of verification data for each algae species under various conditions. The base will then investigate methods to resolve issues related to commercialization and improve CO_2 utilization efficiency during the cultivation process.

Assignment

- Demonstration of mass cultivation technology for microalgae
- Development of cascade utilization technology
- Development and standardization of basic research centers
- LCA evaluation method (aeration CO_2, etc.)



NEDO's efforts toward the social implementation of SAF

Global warming countermeasures/Aircraft/Fuel

Biojet Fuel Production Technology Development Project

Microalgae basic technology development [Microalgae basic technology demonstration]

Research and development theme	Implementing company
Demonstration research on a next-generation biojet fuel business model based on cascade utilization of microalgae biomass (FY2020-2022)	Euglena Co., Ltd.、Denso Corporation、ITOCHU Corporation、Mitsubishi Chemical Group Corporation
Research and development related to the construction of a large-scale microalgae cultivation system using power plant exhaust gas and flexible plastic film photobioreactor technology in a tropical outdoor environment, and long-term large-scale demonstration. (FY2020-2024)	Chitose Laboratory Corporation
Development of open-closed hybrid culture technology for marine diatoms (FY2020-2024)	J-POWER

Microalgae basic technology development [Basic technology development at the microalgae research center]

Research and development theme	Implementing company
Establishment and development of a research center and fundamental technologies that contribute to the industrialization of biojet fuel production derived from microalgae and the improvement of CO_2 utilization efficiency (FY2020-2024)	Institute of Microalgal Technology, Japan

NEDO's efforts toward the social implementation of SAF

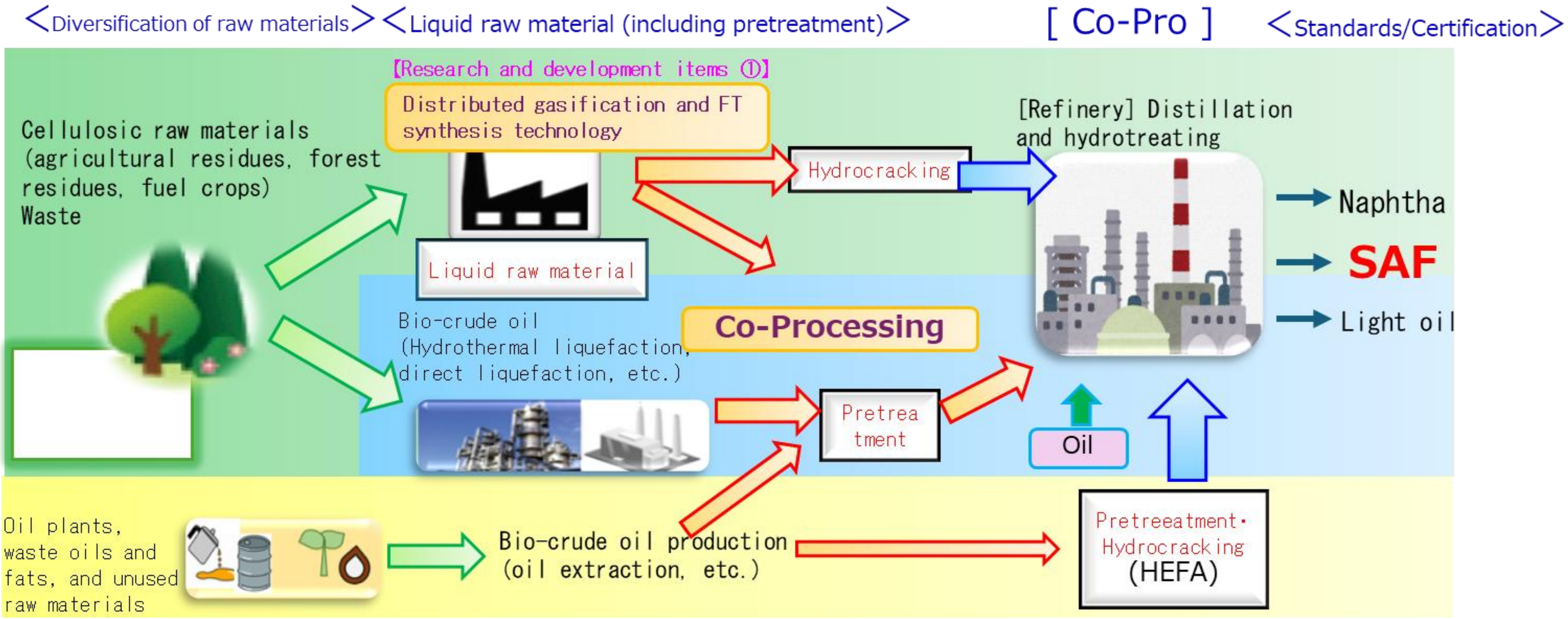
Global warming countermeasures/Aircraft/Fuel

Development of stable and efficient production technology such as SAF

FY2025～2029（5 years）

○Implementation details

①Development of SAF manufacturing technology (gasification and FT) that can utilize a variety of raw materials (cellulosic raw materials)
②Development of innovative SAF manufacturing technology that can process bio-crude oil by utilizing co-processing
③Diversifying SAF ingredients by developing unused raw materials



NEDO's efforts toward the social implementation of SAF

Global warming countermeasures/Aircraft/Fuel

Development of stable and efficient production technology such as SAF

	Research and development items	Research and development theme	Implementing company
①	Development of SAF manufacturing technology (gasification and FT) that can utilize a variety of raw materials (cellulosic raw materials)	Distributed local production and consumption SAF manufacturing technology using gasification and FT synthesis technology, using wood resources and waste from Akita Prefecture as raw materials	United Planning Co., Ltd.
		Gasification using expanded raw materials FT synthesis SAF and eSAF production feasibility study project	Toyo Engineering Corporation
		Feasibility study of local production and consumption of SAF at Narita International Airport and surrounding areas	Narita International Airport
②	Development of innovative SAF manufacturing technology that can process bio-crude oil by utilizing co-processing	Development of SAF production technology by co-processing woody biomass pyrolysis oil and heavy oil	Japan Petroleum Energy Center、JGC Catalysts and Chemicals Ltd.、ENEOS Corporation、Tokyo University of Agriculture and Technology, TUAT
③	Diversifying SAF ingredients by developing unused raw materials	Feasibility study to utilize rubber seed oil as raw material for SAF	NOMURA JIMUSHO, INC.

Innovative technology development required for concentration of sorghum syrup for ATJ

ATJ Raw Material / Bioethanol / Sorghum

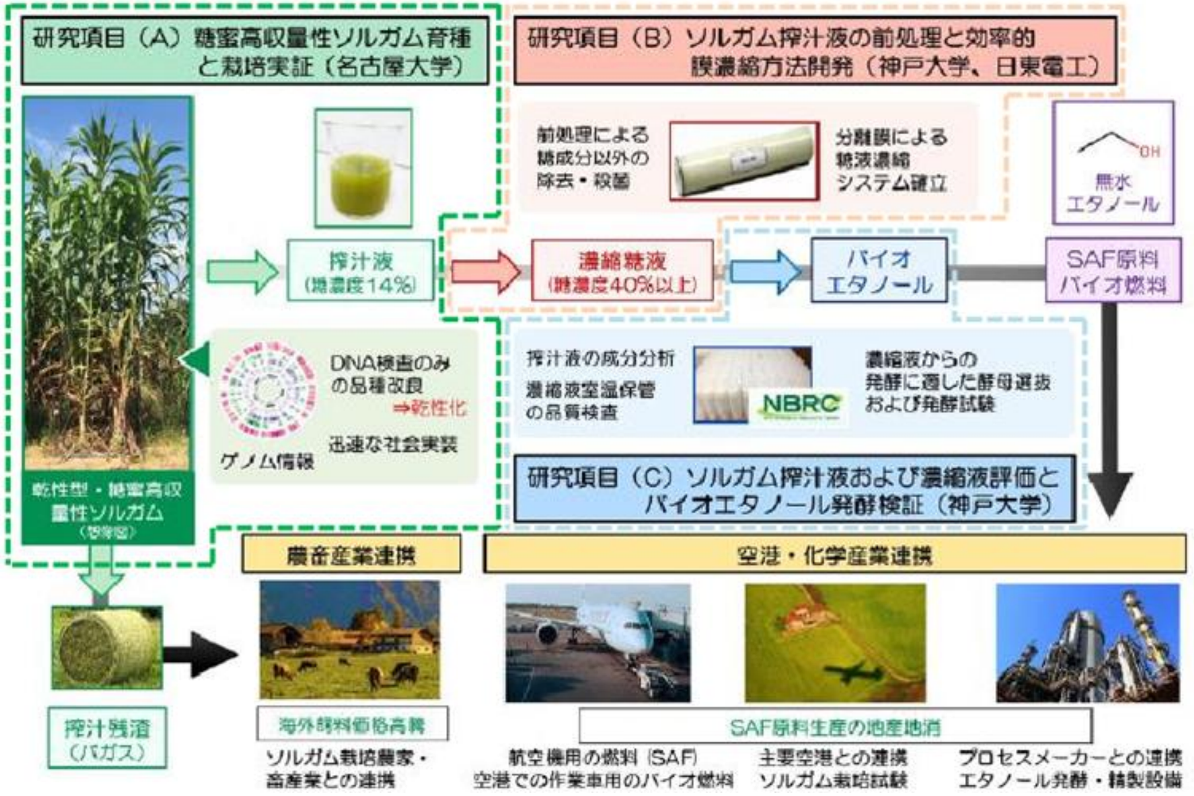
Overview / Achievements

In the production of bioethanol used as a feedstock for SAF*2 via ATJ*1, we focus on non-food sorghum syrup and will undertake the following initiatives:

・Breeding and development of a dry-type sorghum variety with high sugar yield
・Optimization of pretreatment and membrane concentration technologies for sorghum expressed juice
・Selection of yeast strains suitable for the fermentation of sorghum syrup

Through these efforts, we aim to establish a second-generation bioethanol production technology that does not compete with food resources.

*1：Sustainable Aviation Fuel
*2：Alcohol to JET



Innovative technology development required for concentration of sorghum syrup for ATJ

ATJ Raw Material / Bioethanol / Sorghum

Current Status / Background

Amid the global momentum toward building a decarbonized society, the need for domestic production of sustainable aviation fuel (SAF) is increasing. Accordingly, large-scale production of bioethanol, which is an essential feedstock for SAF manufacturing via ATJ technology, is of critical importance.

Social Issues

Currently, bioethanol used as a feedstock for SAF production via ATJ technology is mainly produced from sucrose derived from sugarcane in Brazil and starch derived from corn in the United States. However, this approach faces the challenge of competition with food resources.

In addition, reliance on imported feedstocks and the limited number of procurement routes pose challenges from the perspective of energy security.

Technical Issues

Sugar-producing crops that can be cultivated domestically are limited to sugarcane, sugar beet, and sweet sorghum. From the perspective of energy security, local production and local consumption of feedstocks are desirable. When considering crops that can be cultivated in Honshu, Shikoku, and Kyushu, sweet sorghum emerges as the only viable option. The Nagoya University–bred variety "Enryu" has achieved a dramatic increase in sugar yield compared with conventional sweet sorghum varieties. The next challenge lies in the high water content of the expressed juice. By reducing this water content, transportation efficiency and practical options for storage locations and methods can be realized, thereby facilitating social implementation. In this context, membrane concentration technologies and further breeding are key factors. In addition, the selection of yeast strains suitable for fermentation of the sorghum syrup remains an important challenge.

NEDO Project: NEDO Feasibility Study Program /Feasibility Study Program on Energy and New Environmental Technology

Contact Information: NEDO Renewable Energy Department, Biomass Unit

Innovative technology development required for concentration of sorghum syrup for ATJ

ATJ Raw Material / Bioethanol / Sorghum

NEDO Initiatives

Research Item A: Breeding and Cultivation of High Sugar Yield Sorghum

The high-sugar-yield sorghum variety "Enryu" will be improved through crossbreeding to convert it from a juicy type to a dry type. The newly developed lines (dry-type Enryu) will be subjected to field trials aimed at social implementation.

Research Item B: Development of Pretreatment and Efficient Membrane Concentration Methods for Sorghum Expressed Juice

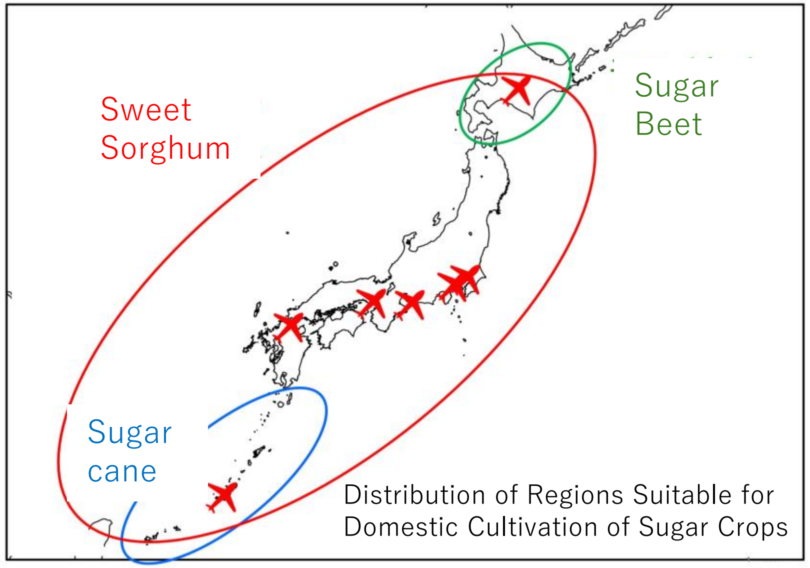
A pretreatment process to remove soluble proteins and microorganisms from sorghum expressed juice and a membrane-based concentration system will be developed.

Research Item C: Evaluation of Sorghum-Pressed Juice and syrup, and Verification of Bioethanol Fermentation

The composition of sorghum expressed juice and its concentrates will be analyzed, variability among harvest years and storage quality at room temperature will be assessed, and suitable yeast strains will be selected to evaluate ethanol fermentation performance.

Future Prospects

Sweet sorghum is a sugar crop that can be cultivated in temperate regions and is therefore suitable for cultivation across most of Japan. As the variety "Enryu" has an established track record as livestock feed, it is expected to replace a significant share of the approximately 11,000 ha (2025) currently used for sorghum cultivation for domestic livestock feed.



Distribution of Regions Suitable for Domestic Cultivation of Sugar Crops

NEDO Project: NEDO Feasibility Study Program /Feasibility Study Program on Energy and New Environmental Technology

Contact Information: NEDO Renewable Energy Department, Biomass Unit