ATJ plant project in Chiba Complex

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※This report includes the results of JPNP22100540-0 of the New Energy and Industrial Technology Development Organization (NEDO).

Idemitsu Kosan domestic refineries and petrochemical complex

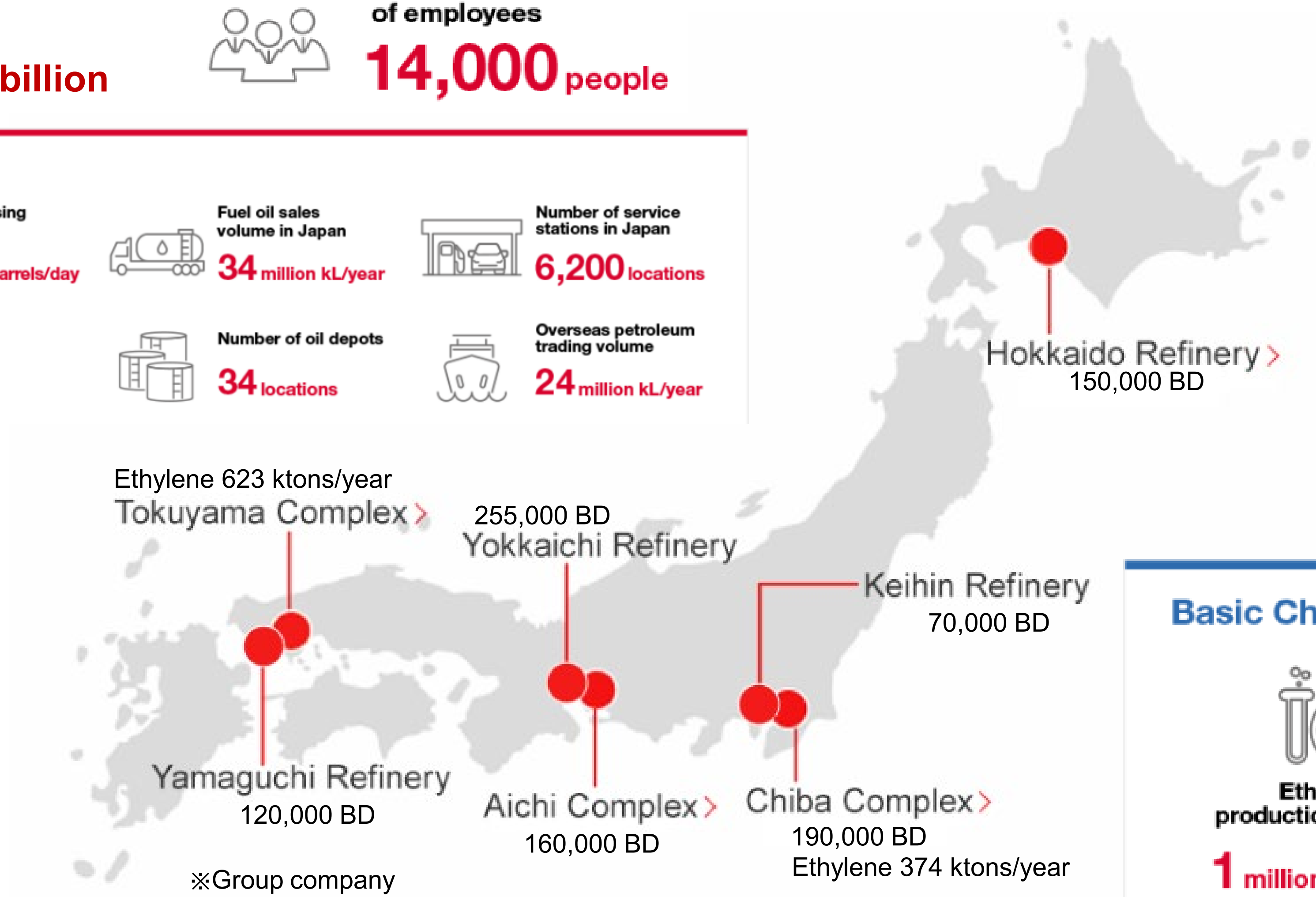
As of the end of March 2023

Consolidated Net Sales
$ 52 billion

Consolidated number of employees
14,000 people

Petroleum

Crude oil processing capacity	945,000 barrels/day
Fuel oil sales volume in Japan	34 million kL/year
Number of service stations in Japan	6,200 locations
Crude oil tankers	21 ships
Number of oil depots	34 locations
Overseas petroleum trading volume	24 million kL/year



※Group company
Keihin Refinery(TOA Oil CO., Ltd.)
Yokkaichi Refinery(Showa Yokkaichi Sekiyu Co., Ltd.)
Yamaguchi Refinery(Seibu Oil CO., Ltd.)

Basic Chemicals

Chiba and Tokuyama Complex

Ethylene production capacity
1 million tons/year

BTX* production capacity
2.5 million tons/year

※Benzene/toluene/xylene BTX

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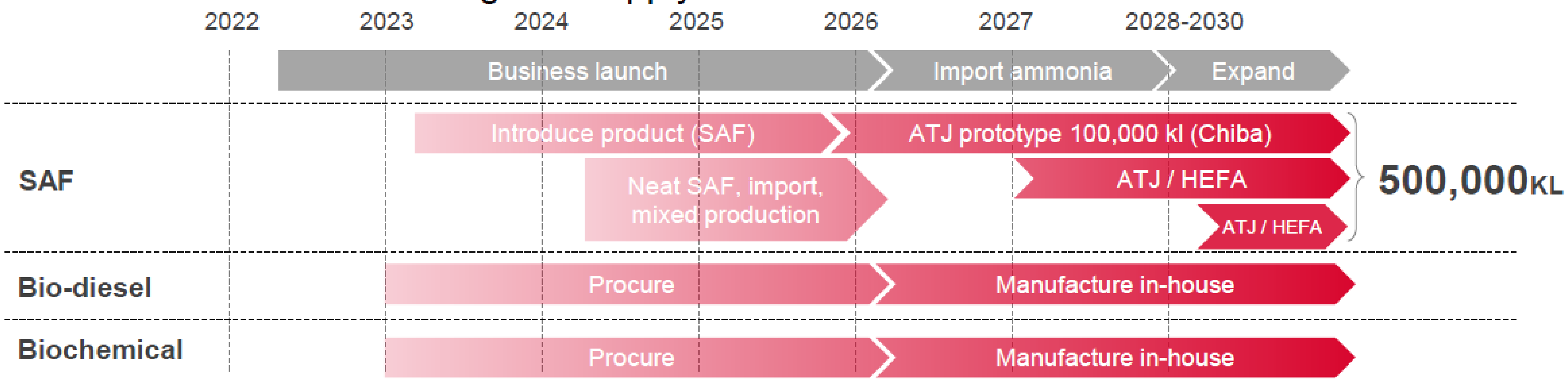
Biomass Introduction Roadmap / Supplying SAF

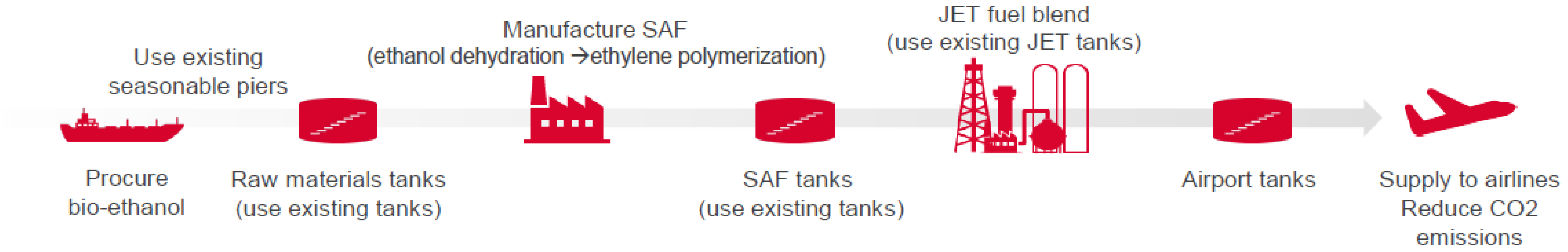
Biomass Introduction Roadmap

- Establish biomass-based green supply chain



Supplying SAF

- Constructing **state-of-the-art SAF manufacturing facility** (production volume: 100,000KL) within the Chiba Complex →expecting to commence supply in 2026
- Planning to achieve **domestic production capacity of 500,000KL/year** by 2030
- The initiative was selected for **NEDO's Green Innovation Fund** ※https://green-innovation.nedo.go.jp/en/

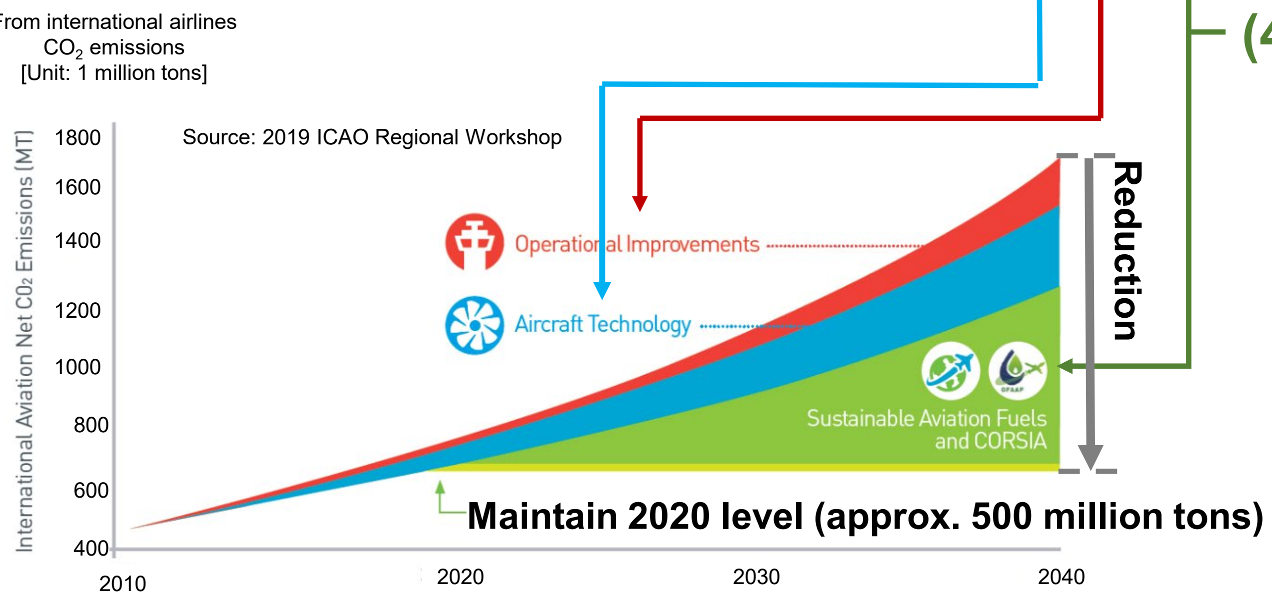


ICAO (International Civil Aviation Organization) targets

The General Meeting of ICAO (2010) examines global targets and countermeasures for reducing CO_2 emissions from international aviation.

[Global targets]

- Improvement the fuel consumption by 2%/year
- Do not increase total CO_2 emissions from international airlines since 2020



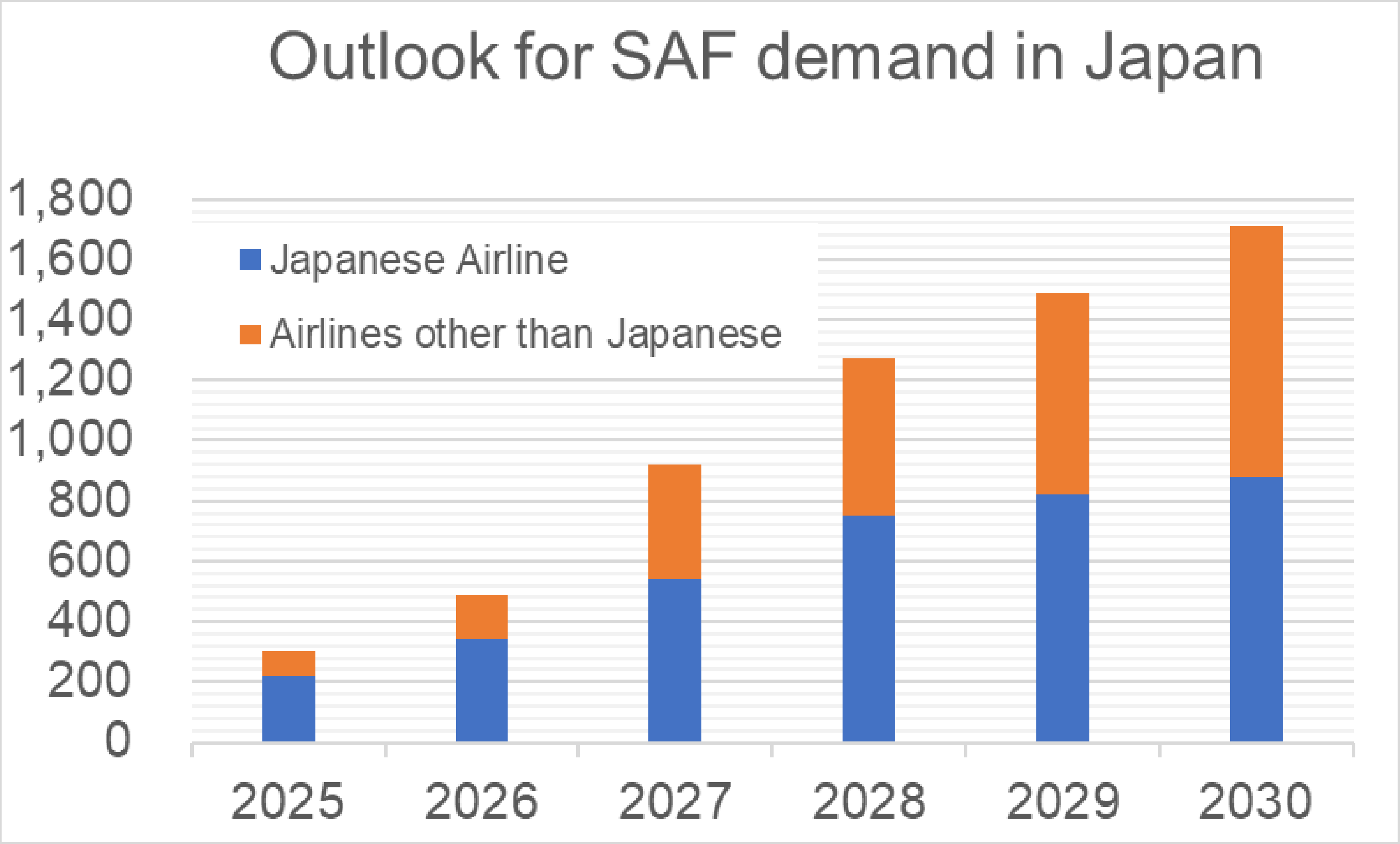
[Countermeasures]

(1) Adoption of new fuel-efficient aircraft
(2) Improvement of operation methods
(3) Use of biofuels (SAF)
(4) Application of economic measures

At the 39th General Meeting of ICAO held in 2016, the measures described in (1) to (3) are not sufficient to achieve carbon neutrality after 2020.
Adopted the Global Emission Reduction System (CORSIA: Carbon Offset and Reduction Scheme for International Civil Aviation) to embody the economic instruments of (4).

※CORSIA(Carbon Offsetting and Reduction Scheme for International Aviation

Outlook for SAF demand in Japan



1,710 thousand KL/y

Source: Ministry of Land, Infrastructure and Transport Japan

Commitments of major Japanese airlines

They pledging to cooperate in increasing the share of SAF in the global aviation industry to 10% by 2030.

ANA Inspiration of JAPAN

JAPAN AIRLINES

ANA and Japan Airlines Towards 2050 Carbon Neutral Joint Report on SAF

- ANA and JAL have developed a joint report “Toward Virtually Zero CO2 Emissions from Air Transport in 2050,” with the aim of expanding awareness and promoting understanding of Sustainable Aviation Fuel.
- The two airlines will work together to raise awareness on the production and usage of SAF, as well as the importance of air transportation as critical social infrastructure connecting Japan and the world for future generations.
- ANA and JAL will work together with the Japanese government and other interested parties to promote SAF, while cooperating to promote other environmental measures also.
- Both companies are committed to protecting the environment through reducing carbon emissions and contributing to the sustainable growth of the Japanese economy.

https://press.jal.co.jp/en/release/202110/006262.html

Main requirements for jet fuel

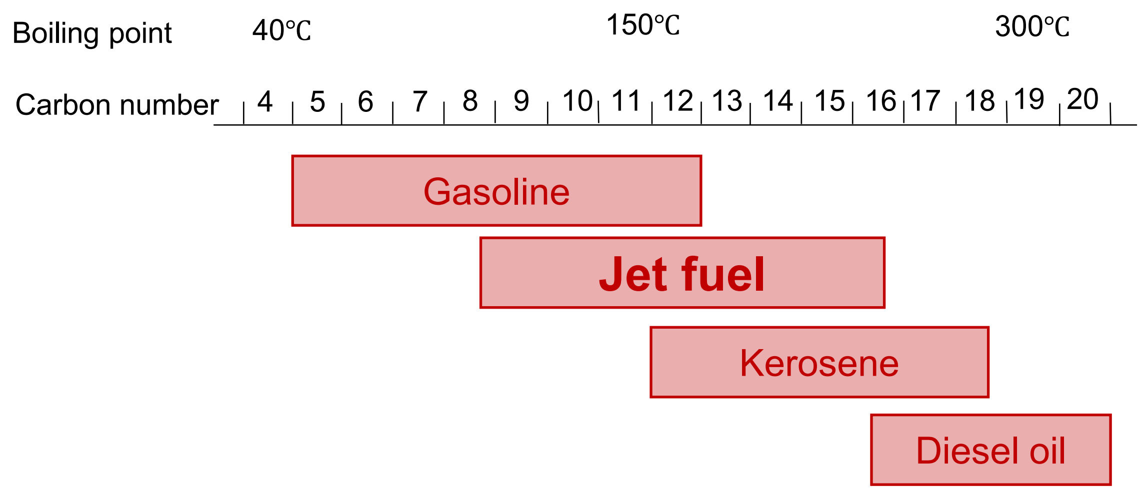
◆ Main requirements

- No wax or moisture deposit even at low temperatures
- Thermal stability (no tar generated at high temperature)
- Brightness control during burning

◆TYPICAL STANDARDS AND COMPOSITION (JET-A1)

- Flash point : 38°C or higher
- Density (15 ° C.) : 0.775 to 0.840
- Aromatic content : 26.5vol% or less
- n-paraffin-free(with high boiling points)
- Complete removal of water
- Carbon-number C8~C16

[Distillation range (example)]



SAF(Sustainable Aviation Fuel)

" SAF are defined as renewable or waste-derived aviation fuels that meets sustainability criteria "

◆Major Terms of sustainability criteria

lifecycle carbon emissions reductions, no competition with needed food production and no deforestation.

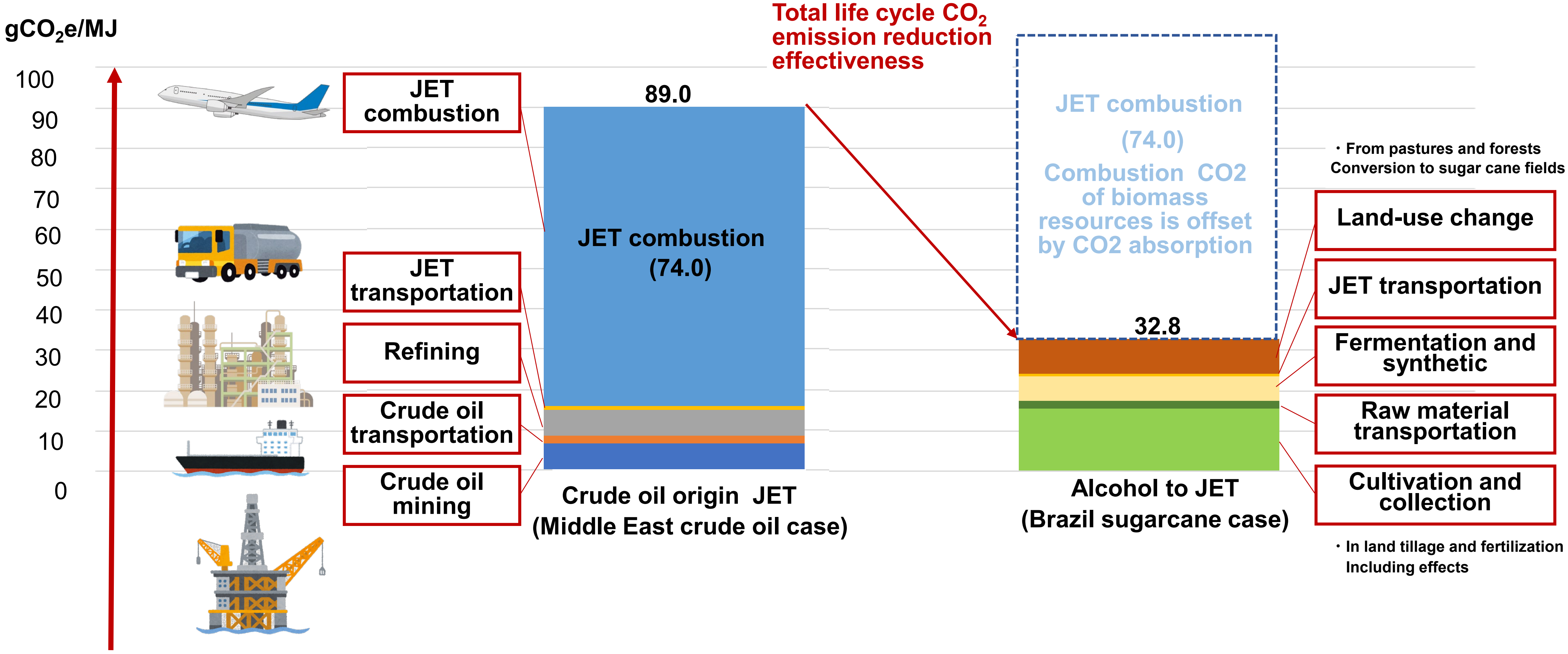
Summary of SAF

Raw materials	Carbon and hydrogen in waste, biomass, and Used cooking oil
Certification	ASTM standard certification required (ICAO certification required to reduce CO_2)
CO_2 emissions	CO_2 at burning is the same as existing jet. However, since biomass can offset the amount of CO_2 absorbed in the production process, CO_2 emissions are reduced throughout the life cycle.
Infrastructure (Airport and Aircraft)	ASTM certified SAF are considered the same as existing jet fuels, so existing infrastructures can be used

ASTM certified Feedstocks and Technologies

ASTM reference	Abbreviation	Possible Feedstocks	Blending ratio (upper limit)	Conversion process
Annex1	FT-SPK	Organic matter such as waste and woody biomass	50%	Raw material gasification ⇒ FT synthesis
Annex2	Bio-SPK HEFA	Biological oils and fats such as animal and vegetable oils and used cooking oils	50%	Hydrogenation of Fatty Acid Esters
Annex3	SIP	Biomass sugar	10%	Hydrogenation of farnesene obtained by sugar fermentation
Annex4	SPK/A	Woody biomass	50%	Gasification ⇒ FT Synthesis ⇒ Aromatic Addition
Annex5	ATJ-SPK	Alcohol	50%	Alcohol dehydration⇒ low-carbon hydrocarbons ⇒ polymerize
Annex6	CHJ	Microalgae and used cooking oil	50%	Hydrothermal decomposition of fatty acid esters
Annex7	HC-HEFA	Microalgae	10%	Hydrogenation of fatty acid esters and hydrocarbons

Estimation of CEF: "Well-to-Wing" approach

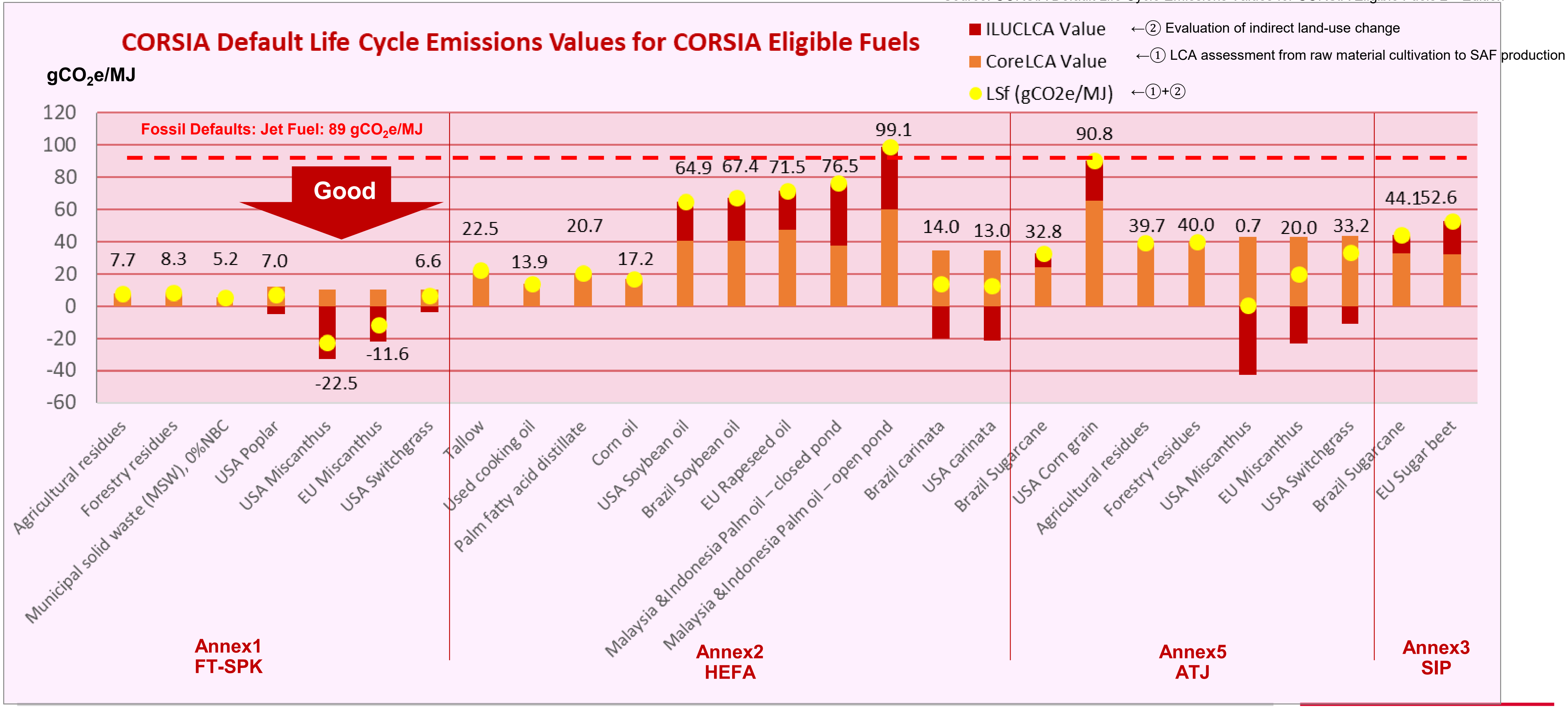


Well-to-Wheel/Wake/Wing: "from production wells to driving/navigation/flight"

CEF's CO_2 savings: CEF defaults

Effect in reducing CO_2 varies depending on Feedstocks /Conversion process

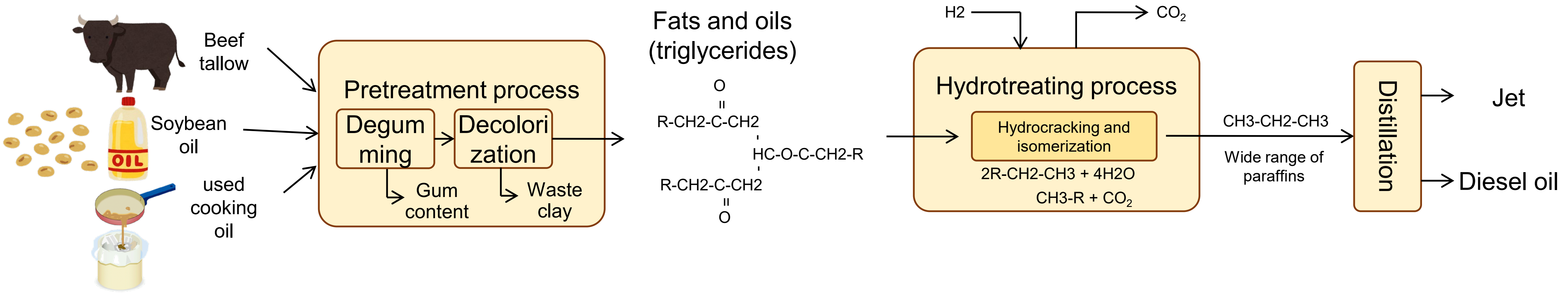
Source: CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels 2nd Edition



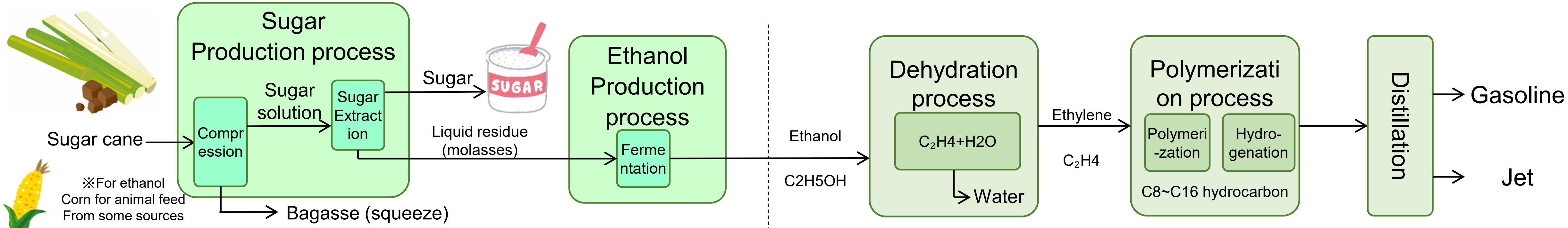
HEFA and ATJ

◆HEFA(Hydroprocessed Esters and Fatty Acids)

・Waste water /waste clay must be treated
・Hydrogen required (Hydrogenation of oxygen)



◆ATJ(Alcohol to JET) ※ Ethanol case



ATJ →

・Ethanol production from residue after sugar production

・Only water is a by-product
・Distillate adjustment possible with polymerization control

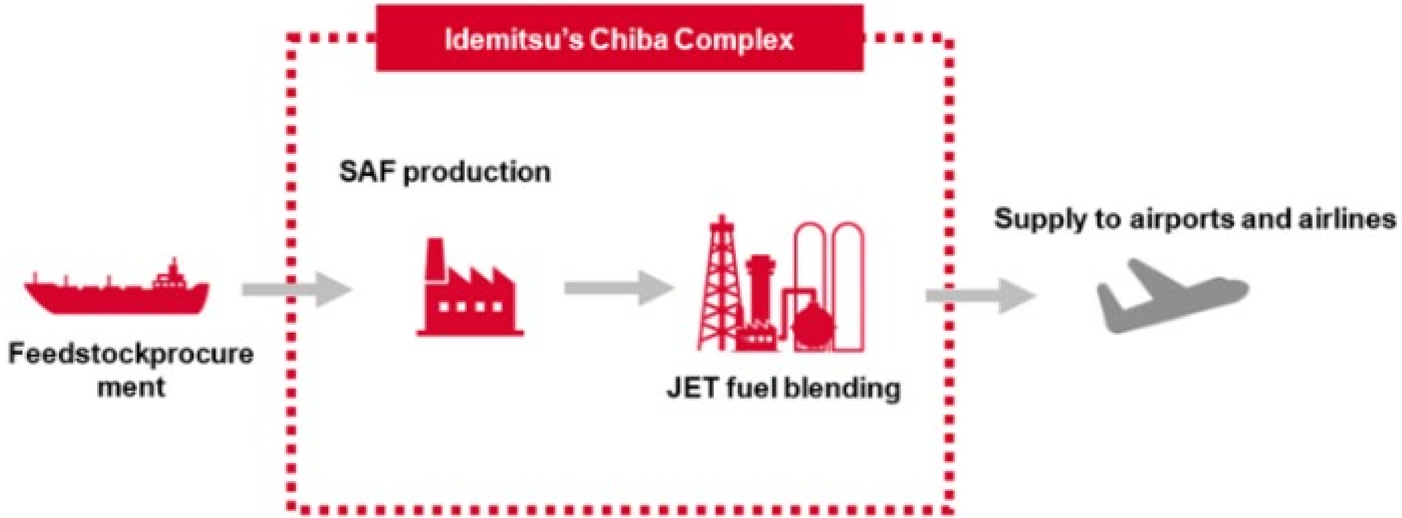
Idemitsu's "NEDO Green Innovation Fund Projects "

"Developing ATJ demonstration facilities using ATJ(Alcohol to Jet) processing technology"

1. Period
   Started : April 2022
   End (planned) : March 2027

2. Final goal

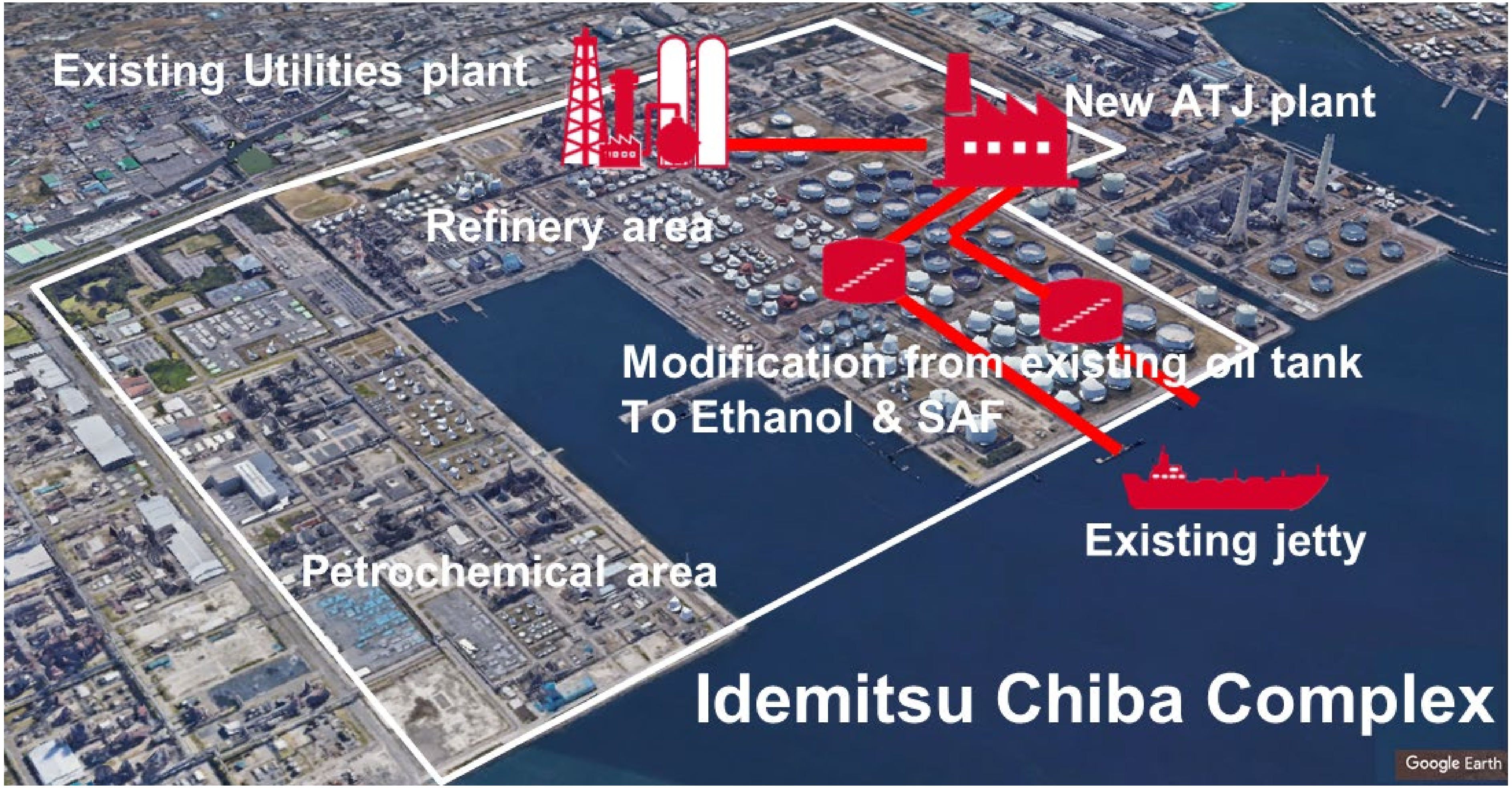
- Established manufacturing technology (ASTM D7566 Annex5 ATJ) by 2026.
- Achieved 57% neat SAF yield and keep the sales price below 200 yen per liter.
- Stable production of 100,000kL neat SAF annually



Location: Chiba Complex

Integration with existing refinery

・Reuse of existing refinery equipment(Utilities, Tanks, Offsite)
⇒ Minimize CAPEX / Large-capacity Ethanol tanks that make large lot

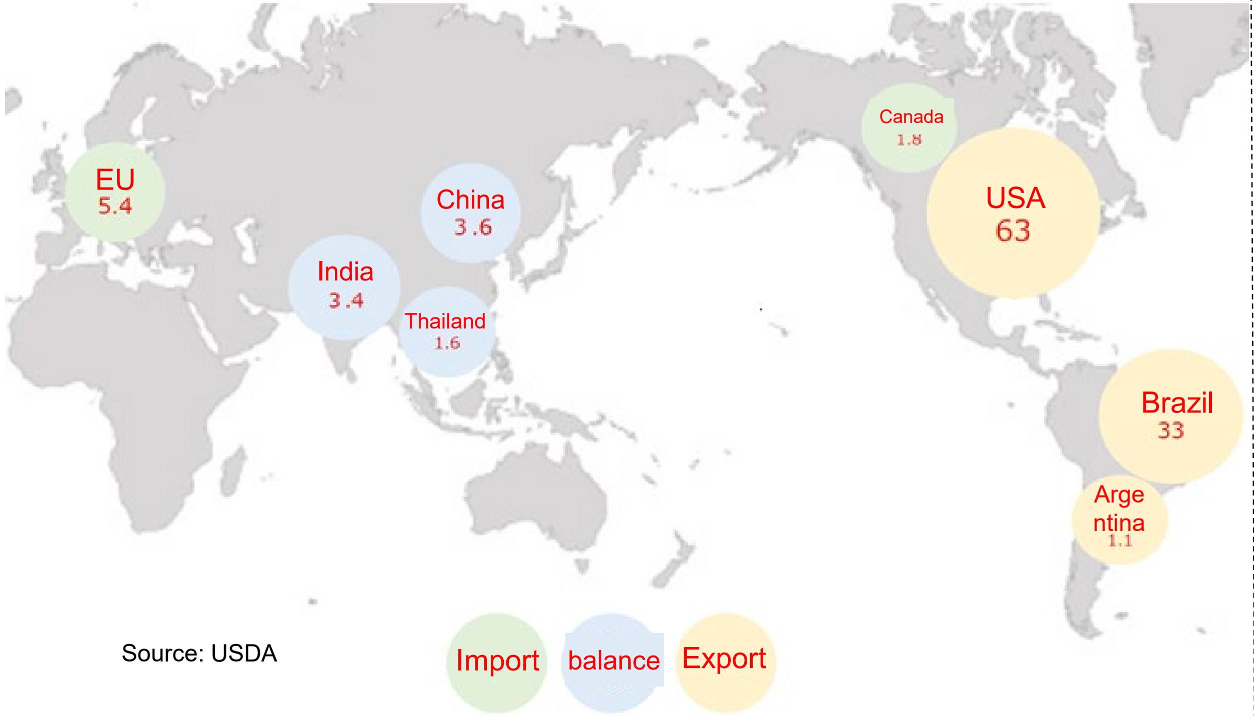


Potential and Challenges of ATJ Processing

[Potential]

Millions of kL

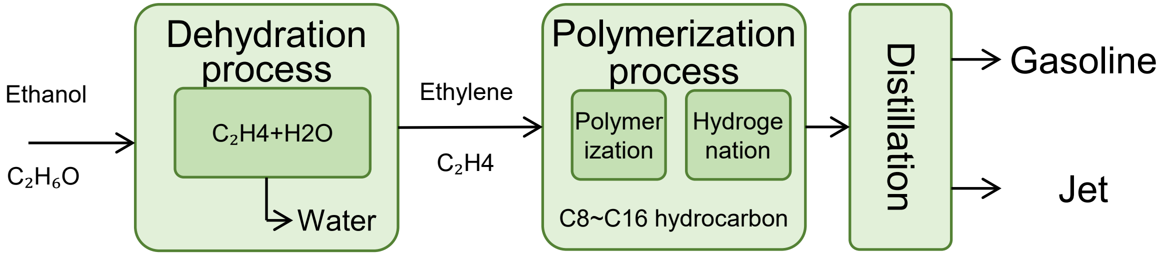
Global ethanol-production volume 120 million kL



Source: USDA

Gasoline Mixing (Fuel) Market

[Challenges]



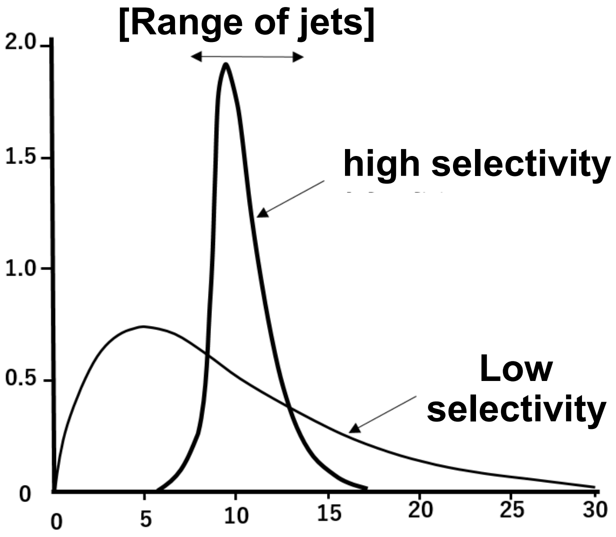
Development of advanced reaction processes

[Dehydration process]

- **Loss minimization**
- **Energy saving**

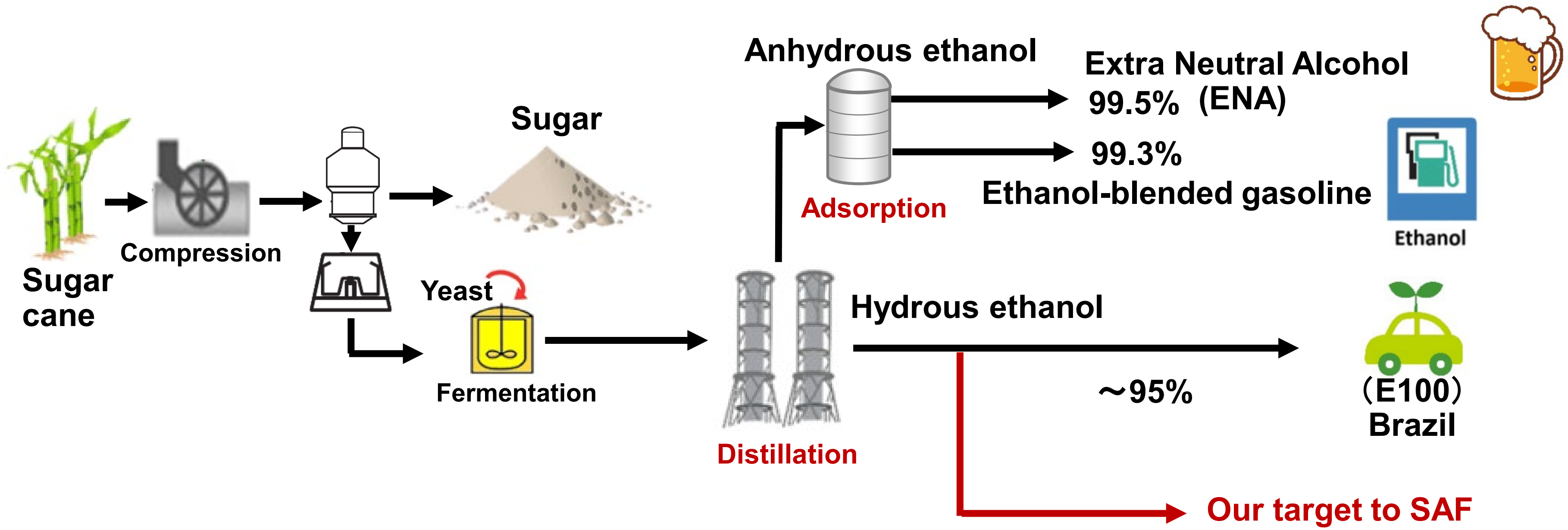
[Polymerization Process]

- **Polymerization control (Molecular weight control)**



Flory–Schulz distribution

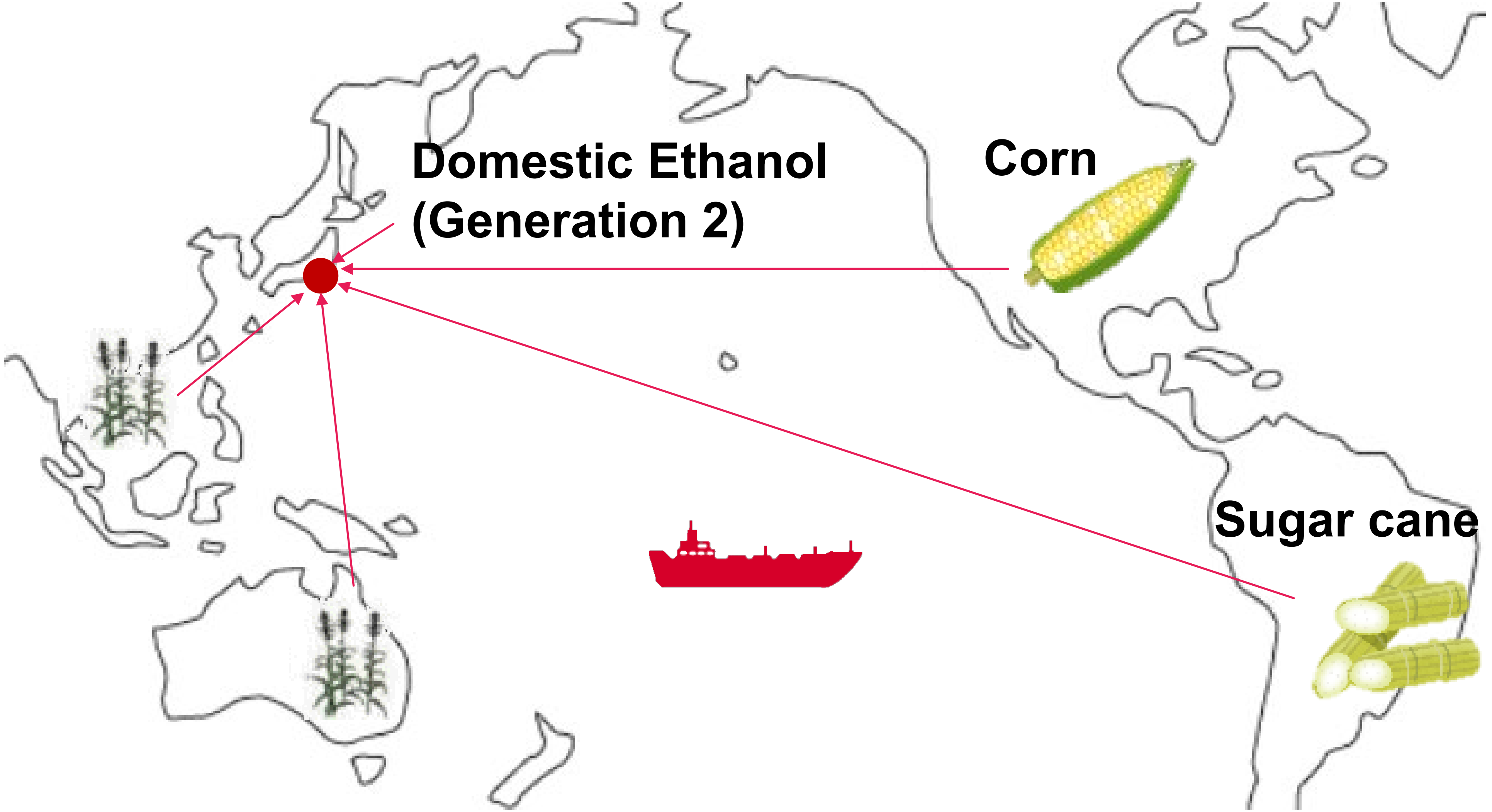
Hydrous and anhydrous ethanol



Hydrous ethanol does not require any special purification process.

Ethanol Procurement

- We purchase directly from Hydrous ethanol producers to Japan.

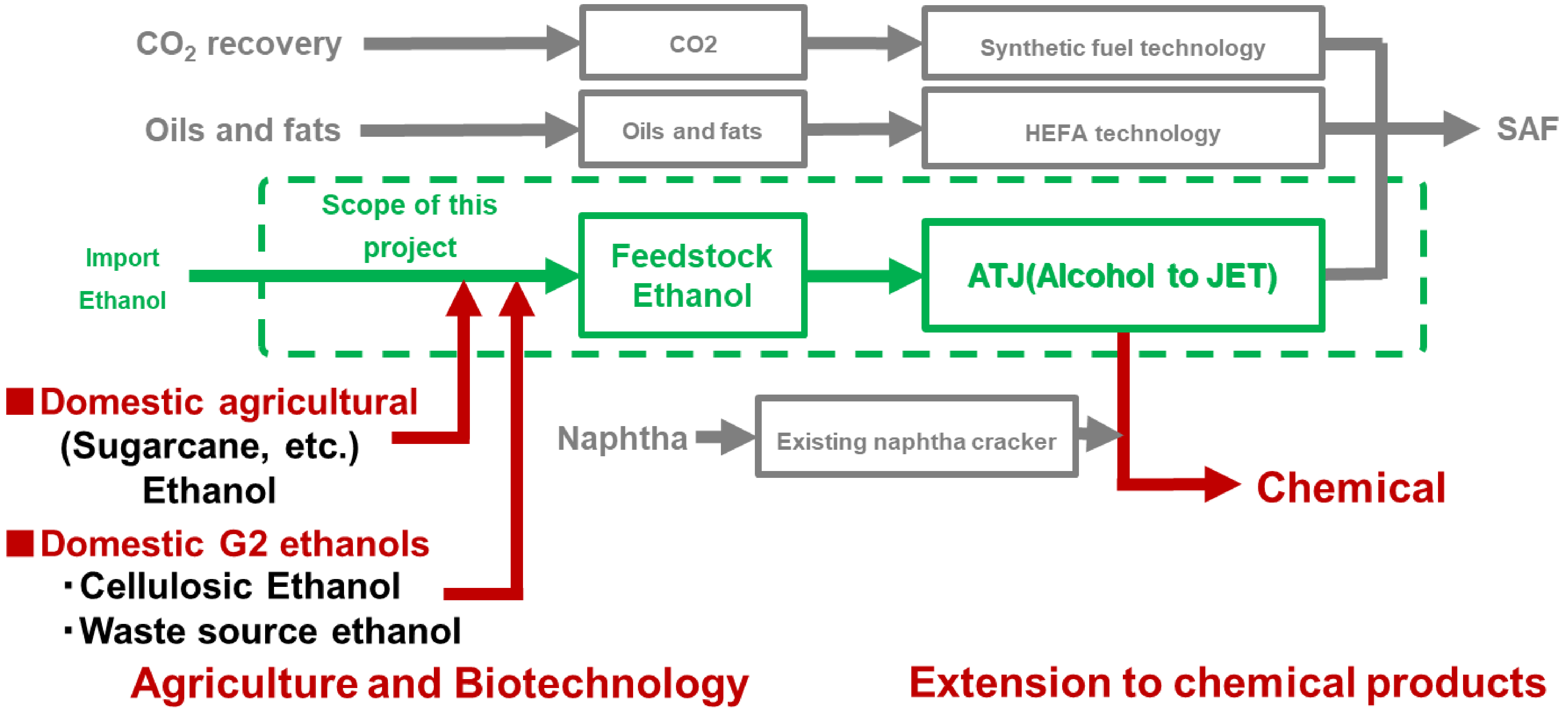


Ethanol composition survey

We are investigating the properties of suppliers around the world.

Sample production area		A	B	C	D	E	C
Type		unhydrous	unhydrous	unhydrous	Hydrous	Hydrous	Hydrous
CHARACTERRISTIC	Unit						
Ethyl acetate	μg/ml	40	110	120	15	25	91
Acetaldehyde	μg/ml	27	290	53	19	8.6	29
Methanol	μg/ml	58	91	46	19	18	16
1-propanol	μg/ml	480	770	360	90	140	290
2-propanol	μg/ml	<2.5	<3	<2.5	<2.5	<2.5	<2.5
1-butanol	μg/ml	<2.5	21	17.0	<2.5	<2.5	<2.5
2-butanol	μg/ml	<2.5	<3	<2.5	<2.5	15	<2.5
2-methyl-1propanol	μg/ml	110	300	160	23	9	42
2-methyl-1butanol	μg/ml	<2.5	6	34	<2.5	<2.5	16
3-methyl-1butanol	μg/ml	<2.5	<3	44	<2.5	<2.5	24
furfural	μg/ml	9.0	<3	16	<2.5	<2.5	13
5-Hydroxymethylfurfural	μg/ml	<2.5	<3	<2.5	<2.5	<2.5	<2.5
Benzaldehyde	μg/ml	<2.5	<3	<2.5	<2.5	<2.5	<2.5
Acetal	μg/ml	370	140	38	9.8	<1	32
Total-S	wt.ppm	1	<1	3.7	<1	<1	4.7
Acetic acid	mg/L	2	20	1	1>	<1	1
Ca	wt.ppm	1>	<1	1>	1>	<1	1>
Cu	wt.ppm	1>	<1	1>	1>	<1	1>
Fe	wt.ppm	1>	<1	1>	1>	<1	1>
Na	wt.ppm	1>	2	1>	1>	3	1>
Zn	wt.ppm	1>	<1	1>	1>	<1	1>

Expansion of ethanol biovalue chain



Thank you !