For presentation purpose only

NEDO-ADEME Workshop
12. March 2019@ Tokyo Big Sight

Development of sustainable bio jet fuel derived from Microalgae

IHI

IHI Corporation
Solution Headquarters

Agenda

1. Introduction
2. Our Technology Features
3. Current Progress
4. Challenges

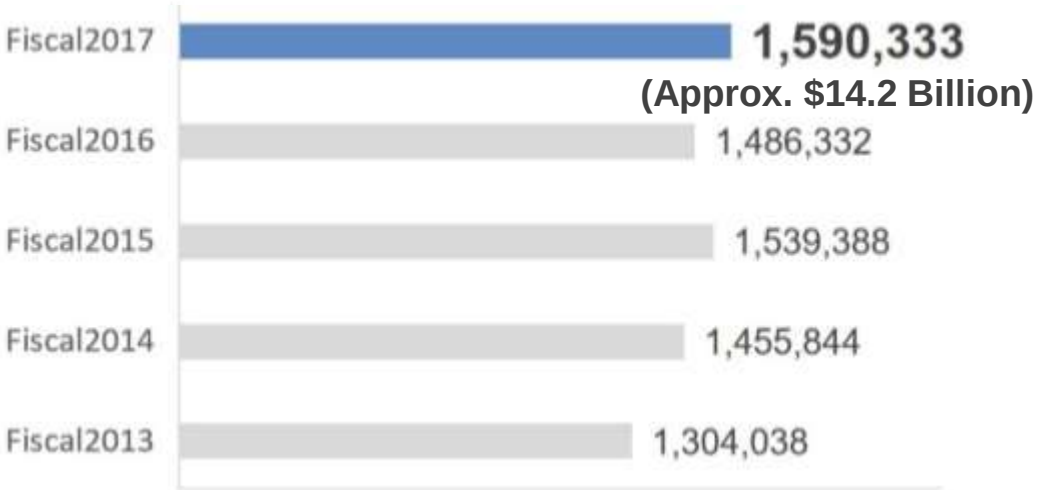
IHI Company Profile

Year of establishment	1853
Capital	107,165 million yen (Approx. $956 Million)
Number of employees (on consolidated basis)	29,659
Works	7
Branches in Japan	8
Overseas representative offices	13

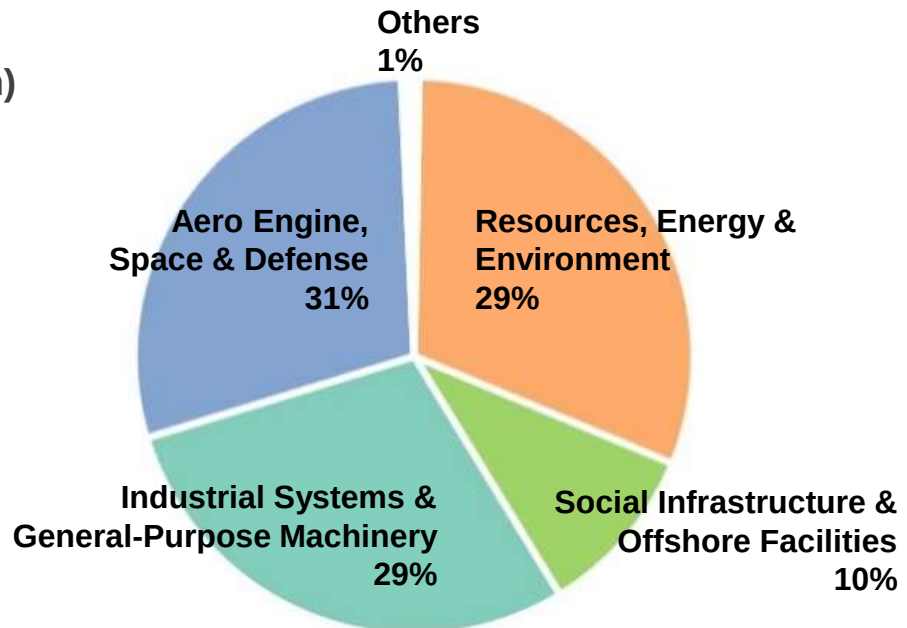
Affiliated companies in Japan	70
Subsidiary companies in Japan	52
Affiliated companies in Japan	18
Overseas affiliates	147
Overseas affiliated companies	120
Associated companies overseas	27

Net Sales

Consolidated net sales (millions of yen)



Consolidated sales by business areas (FY2017)



Business Area of the IHI Group

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Resources, Energy & Environment Business Area

Minimizing Environmental Impact

- Boilers
- Power system plants
- Large power systems
- Power systems for land and marine use
- Process plants
- Pharmaceutical plants
- Environmental response systems
- Nuclear energy
- Asian base EPC

○ Large-scale tower type boiler

Industrial Systems & General-Purpose Machinery Business Area

Transforming the World's Industrial Infrastructure

- Rotating machinery
- Turbochargers for vehicles
- Heat treatment and surface engineering
- Agricultural machinery and small power systems
- Transport machinery
- Parking
- Logistics and machinery

○ Turbochargers for vehicles

Social Infrastructure & Offshore Facilities Business Area

Underpinning the Essentials of Modern Living

- Bridges and Watergates
- Shield systems
- Concrete construction materials
- Transport systems
- Urban development
- F-LNG

○ Osman Gazi Bridge across Izmit Bay

Aero Engine, Space & Defense Business Area

Opening New Horizons

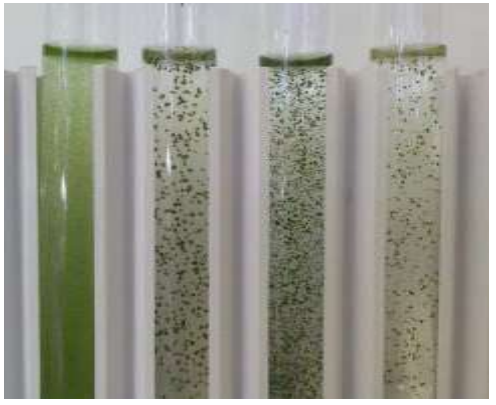
- Aircraft engines
- Defense equipment and systems
- Rocket systems and space exploration

○ GEnx turbofan engine

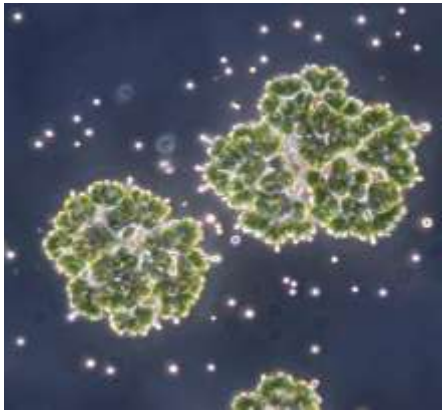
Algae

- **Algae is a generic name for plants growing by photosynthesis and mainly inhabiting in water.**





- **There are countless types of algae. Some species produce oil their body in the course of growing.**



Microalgae as High Potential Feedstock

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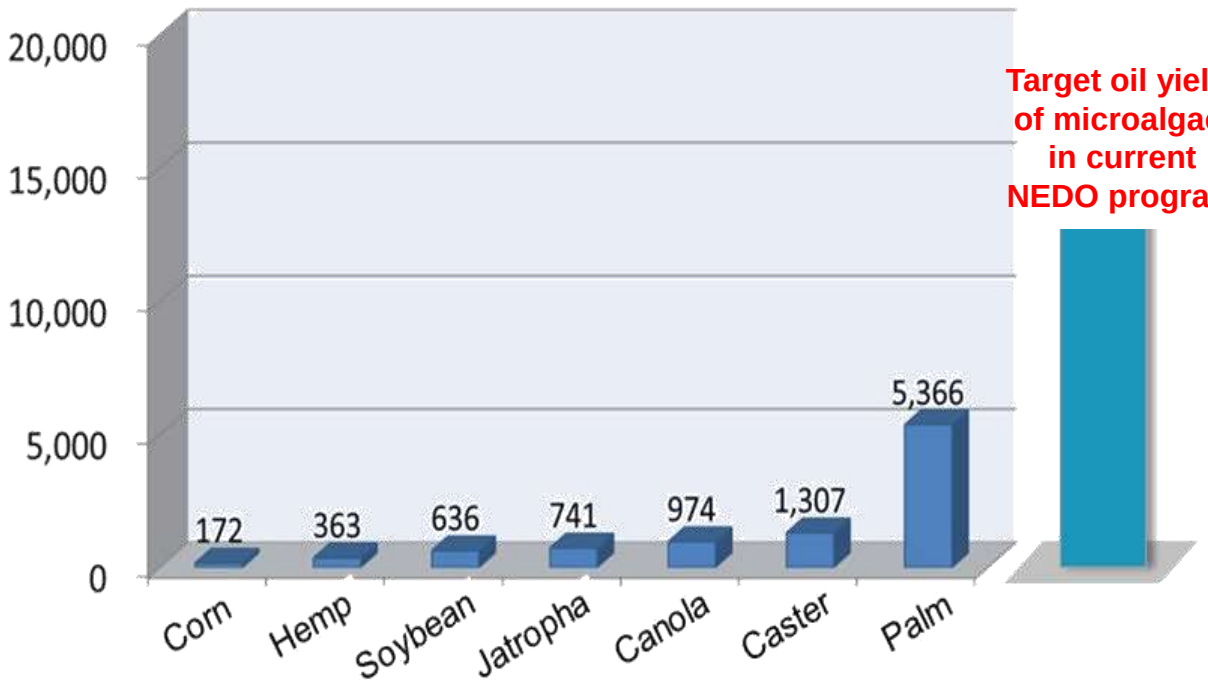
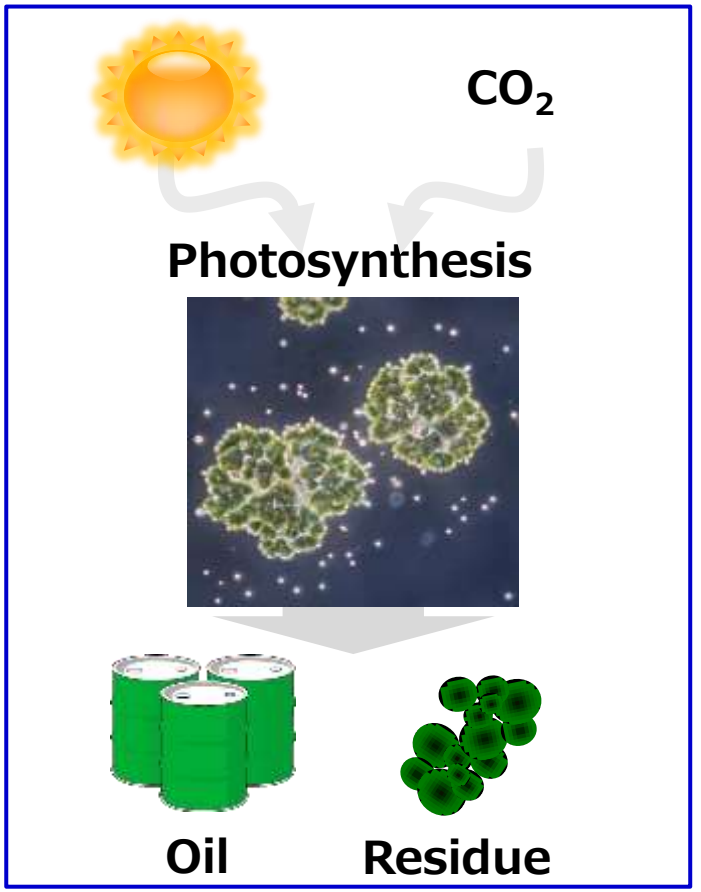
- **Oil yield per unit area that algae produce is recognized to be higher than other plants, so considered as one of the promising feedstock.**

Comparison of oil productivity



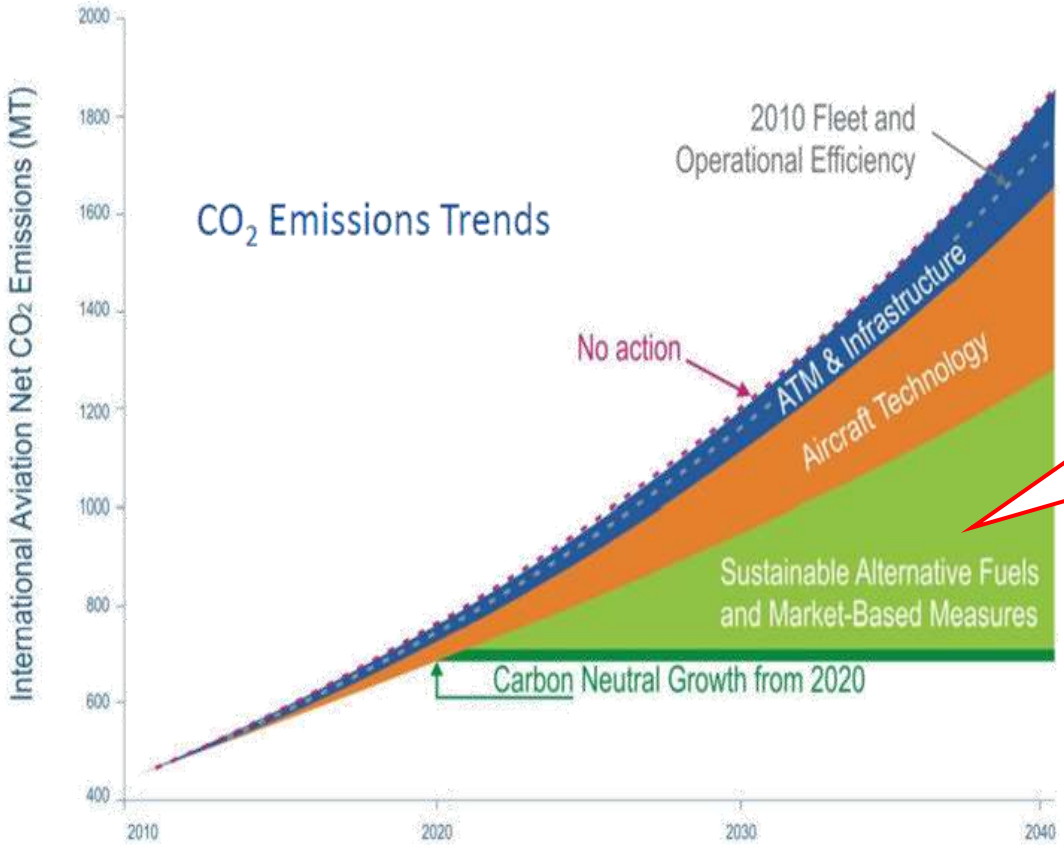
"Microalgae for biodiesel production and other applications: A review"
Renewable and Sustainable Energy Reviews ,14 (2010) 217–232



- **Maximizing the potential of algae, we convert sunlight and carbon dioxide into energy via algae.**

Needs for GHG Emission Reduction

- As aviation sector, ICAO(International commercial aviation organization) sets the aspirational goal of "*Carbon Neutral Growth 2020*" .
- Sustainable alternative fuels are thought to contribute greatly to the suppression of CO2 increase.



Sustainable Alternative Fuels are required in;
- ✓ **low carbon footprint**
- ✓ **Drop-in fuel without changing infrastructure**

出典:Philippe Novelli(ICAO), "Sustainable Alternative Fuels For Aviation", 2014

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Sustainable Jet Fuel from Microalgae

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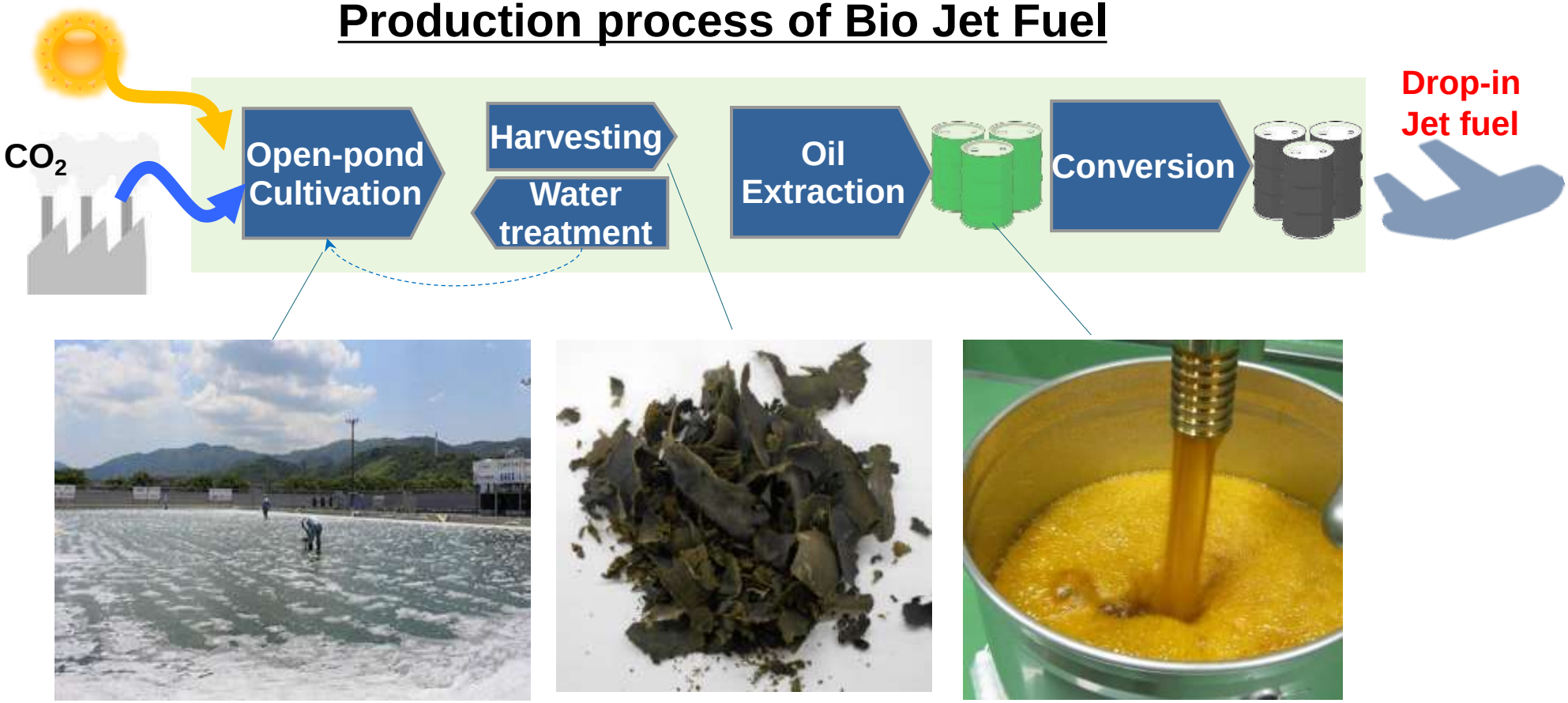
- We aim to contribute to the society by sustainably supplying fuel through the possibility of microalgae.

Production process of Bio Jet Fuel



Our Technology Features (1/2)

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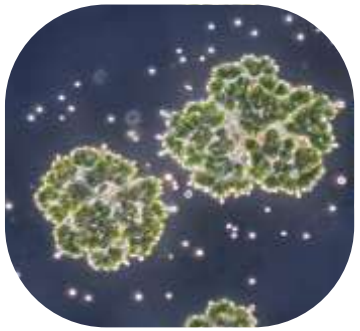
■ **For the practical application to biofuels, we see technological key points as:**

1 *Strain*

➢ **Focused *Botryococcus braunii* *among thousands kind of microalgae* for its unique characteristics.**

Botryococcus braunii



✓ **Above 50%- oil content in dry basis**

✓ **Hydrocarbon oil produced in its body**

➢ **Strain improvement without genetically modifyed**

✓ **Over 1,000 times faster growth than other *Botryococcus* strain***

✓ **Further increase of oil content**

* The strain has been developed by Gene and Gene Technology Corporation Limited .

Our Technology Features (2/2)

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2 *Low Energy & Sustainable Process*

- Developed Low energy harvesting process with **floating capability, enlarged colony size**
- Better sustainability with **recycling of culture water**, **drying in open air**

3 *Robust Industrial Operation*

- Developed large scale cultivation know-how under various **open environmental conditions**, such as **rain and foreign organisms**

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Development history with NEDO

■ **We started R&D in 2011 and are moving to pilot scale production to examine all the process through from cultivation to jet fuel under NEDO program.**

"Strategic Development of Next-generation Bioenergy Utilization Technology"

(By IHI, Chitose Laboratory, and Kobe University)

"Development of Bio Jet Fuel production system"

(By IHI and Kobe University)

2011~	2013~	2015~	2017~	202X~
Basic Experiment	**Elemental technology**	**1,500㎡-scale pond**	**Pilot scale with integrated process**	**Expansion of production scale in industrial process**

Current NEDO Program

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- **We combine individual technical elements and establish a pilot scale integrated manufacturing process.**

Feedstock production

- ✓ **Stable cultivation of algae, with certain productivity under natural environment**

Fuel conversion

- ✓ **Applying existing technology in oil conversion**
- ✓ **Drop-in jet fuel align to international standard of ASTM D7566**

- ✓ **Low carbon footprint in total**
- ✓ **Reasonable production cost**

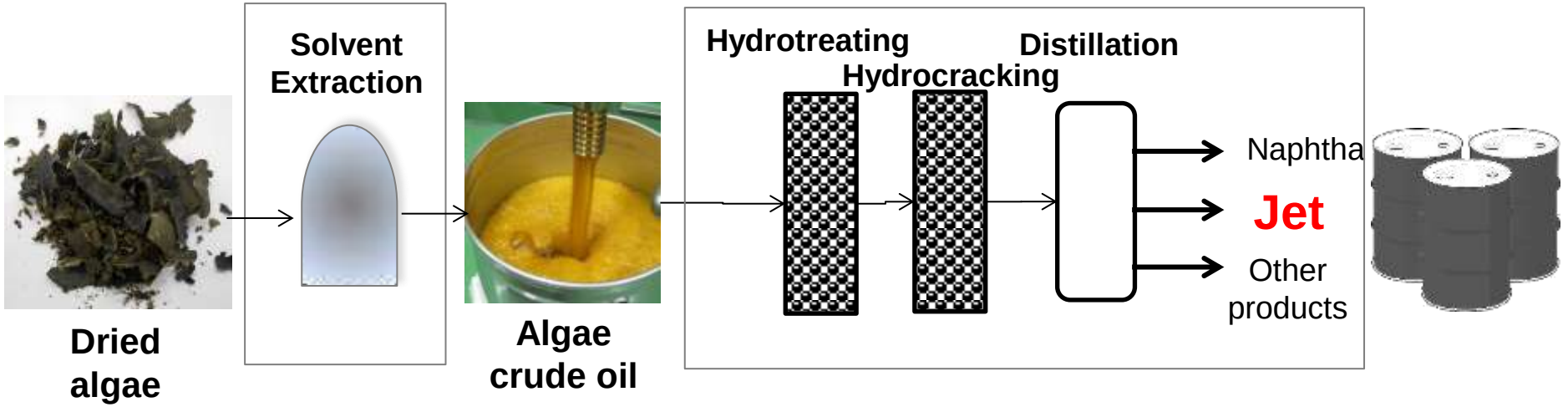
Current NEDO Program
- Feedstock Production

- **In the feedstock production, stable production under a large scale in the natural environment is a problem.**

- **Pilot scale cultivation facility @Saraburi, Tahiland**
- **Utilizing idle land owned by local company**
- **Approx. 1.5ha cultivation ponds**

Current NEDO Program
Fuel conversion

- **The latter process adopt an approach to apply existing technology and ensure product quality.**



✓ **Stable oil quality**

✓ **Drop-in jet fuel align to ASTM D7566**

➢ **Applying existing certified process of Annex2, we expect to acquire the early qualification in new hydrocarbon oil derived from HGBb.**

Alternative jet fuel production process (ASTM D7566)

Annex	Method
1	FT Hydroprocessed SPK*1
2	SPK from HEFA*2
3	SIP*3 Fuel
4	SPK plus aromatics
5	ATJ*4 (iso-butanol)

*1:Synthetic Paraffinic Kerosine
*2:Hydroprocessed Ester and Fatty Acids
*3:Synthetic Iso-paraffinic Kerosine
*4:Alchohol To Jet

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Challenges for Industrialization

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For this technology being industrialized, challenges are still ahead to come over.

- **Stable cultivation in longer term with higher productivity**
- **Lower GHG emission process**
- **Fuel specification meets ASTM D7566**
- **Economically viable production cost**

IHI

Realize your dreams