Biofuel Policy, Related Guidelines and Regulations

  - The development of cellulosic biomass will be key for expanding the use of bio-ethanol as fuels and lowering dependence on fossil fuels.

- **Cool Earth Innovative Energy Technology Program (adopted by METI, March 2008)**
  - BTL (Biomass to Liquid) is regarded as one of the important technologies that significantly contribute to GHG reduction in 2050.

- **The Law Concerning Sophisticated Methods of Energy Supply Structures (basic policies and criteria of judgment developed by METI, 2010)**
  - An obligation to use a certain amount of biofuel is imposed on oil refiners.
  - The development of next-generation biofuel technology, whose GHG emission reduction is more than 50% compared to fossil fuel, shall be promoted and introduced in the oil refining industry.

- **Strategic Energy Plan (the newest (4th) version approved by the Cabinet, April 2014)**
  - Continues to import biofuels while taking into consideration international situation and technology development of next-generation biofuel.
  - Accelerates to diversify energy resources in the fields of transportation by strategic measures including technology R&D.
The Law Concerning Sophisticated Methods of Energy Supply Structures obligates oil refiners to use a certain amount of bioethanol to be blended with gasoline to produce automotive fuel. The aggregate target amount of bioethanol used by oil refiners for the seven years (from FY2011 through FY2017) of each year shall be as listed in the following chart (crude oil equivalent). The use of bioethanol produced from cellulosic biomass feedstock can be doubled in volume when figuring out achieved target amount. Efforts for promotion of technology development and use of biofuel production from grass and wood cellulose, microalgae, etc. by oil refiners is also encouraged by the Law.

Target volume started to increase from 2013 towards 2017

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</tr>
</thead>
<tbody>
<tr>
<td>as Crude</td>
<td>210</td>
<td>210</td>
<td>260</td>
<td>320</td>
<td>380</td>
<td>440</td>
<td>500</td>
</tr>
<tr>
<td>as Ethanol</td>
<td>346</td>
<td>346</td>
<td>428</td>
<td>527</td>
<td>626</td>
<td>725</td>
<td>824</td>
</tr>
<tr>
<td>as ETBE</td>
<td>817</td>
<td>817</td>
<td>1011</td>
<td>1244</td>
<td>1478</td>
<td>1711</td>
<td>1944</td>
</tr>
</tbody>
</table>
NEDO’s Role in Japan’s Renewable Energy Development

NEDO

Energy Policy

Partnership

METI

Industry
What is NEDO?

As Japan’s largest public R&D management organization, Combining the efforts of industry, government and academia, and leveraging established international networks, NEDO promotes research and development that:
- Contributes to the solution of energy and environmental problems, and
- Further enhances Japan’s industrial competitiveness.

History

1980: Established as the New Energy Development Organization
1988: Reorganized as the New Energy and Industrial Technology Development Organization
2003: Reorganized as an Incorporated Administrative Agency under the Ministry of Economy, Trade and Industry (METI)

Personnel
Approximately 800

Budget: 148.4 billion yen in FY2014

Research & Development (¥138.1 billion)
- Energy and Environment Technologies (Renewable energy, Energy conservation, Others)
- Industrial Technologies (ICT, Life science, Nanotechnology, Others)
- Crossover, Others
- International Project Activities
## NEDO’s R&D Portfolio in Renewable Energy

### R&D Budget for New Energy: 28.1 billion Yen

<table>
<thead>
<tr>
<th>Technology</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV</td>
<td>9.3 billion yen</td>
</tr>
<tr>
<td>Higher efficiency, lower cost PV system. Innovative PV technologies</td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>3.6 billion yen</td>
</tr>
<tr>
<td>Bioethanol from woody biomass, BTL, biodiesel from microalgae</td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>5.0 billion yen</td>
</tr>
<tr>
<td>Offshore wind power generation, 7 MW-class wind turbine</td>
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<tr>
<td>Ocean</td>
<td>2.5 billion yen</td>
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<tr>
<td>Ocean wave power, tidal current power</td>
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<tr>
<td>Geothermal</td>
<td>0.5 billion yen</td>
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<tr>
<td>Binary power system</td>
<td></td>
</tr>
<tr>
<td>Hydrogen and Fuel Cell</td>
<td>7.2 billion yen</td>
</tr>
<tr>
<td>Hydrogen production, transportation and storage, hydrogen infrastructure, SOFC</td>
<td></td>
</tr>
</tbody>
</table>
Programs and Schedule of Biofuels R&D in NEDO

Energy Security Technology Development

A: Fundamental R&D
- Project to develop base technologies for non-edible plant-derived bioethanol (FY2007-FY2012)
- Continued (FY2013-FY2016)

B: Bioethanol & System
- Project to develop integrated production system for ethanol derived from non-edible plant (FY2009-FY2013)
- To Be Continued

C: Next-Gen Biofuels
- Project to develop next-generation biofuels other than ethanol (FY2010-FY2016)

International Demonstration Project
- Bioethanol Production from Cassava Pulp
- Bioethanol Production from Bagasse etc.

R&D Projects
- Cellulosic bioethanol
- Next-gen biofuel

Development in Japan

Commercialization and Demonstration overseas

International Project

7
Biofuels Development Challenges

Currently, fuels in the transportation sector are almost totally dependent on fossil fuels. It is important and urgent to further ensure energy security and diversify fuel sources by introducing biofuels.

**<Sugar cane, Corn, etc. (1st Generation) >**
Biofuels produced from edible farm goods by fermentation technology. The market is already established and widely distributed centering around the main producer country Brazil. On the other hand, as feedstock is edible agri product, it is necessary to develop technology to avoid competing with food resources.

**<Woody plants, Herbaceous plants (Cellulosic Bioethanol: 2nd Generation) >**
Biofuels produced from cellulosic biomass by fermentation technology. Aiming to create a market around 2020, currently making efforts to establish integrated system for low-cost production which does not compete with food and avoid environmental problems.

**<Microalgae, BTL (3rd or Next Generation) >**
In addition to the urgent need to tackle by accumulated technology of fermentation for a long time, in order to ensure further energy security and expand the market at around 2030, conducting R&D on utilization of microalgae biomass and BTL (Biomass to Liquid) technology which can make maximum use of feedstock, etc., to develop high-efficient and high-yield biofuel production technology.

### Cellulosic Bioethanol

- **Biomass**
- **Pretreatment**
- **Saccharification**
- **Ferment.**
- **Condens., Dehydrat.**
- **Ethanol**

### Microalgae

- **Cultivation**
- **Condens., Dehydrat.**
- **Extract., Purificat.**
- **Biofuels**

↑ Change in biofuel prices by introducing technological innovation
NEDO’s Current R&D Project on Next-Gen Biofuels

“Strategic Development of Next-Generation Bioenergy Utilization Technology”

- Aim to further broaden and diversify biofuel resources which do not compete with food supplies by conducting technology R&D on microalgal biofuel production and biomass gasification and liquefaction.

  - Identify and develop high-oil producing strain
  - High-efficiency culture, condensation, extraction technology
  - Low-cost gas refining technology
  - High-efficiency synthesis/reforming technology in low pressure condition, etc.

Microalgae → Culture → Condens., Dehydrat. → Extraction, Purification → Biofuels

Cellulosic Biomass → Gasification → Refine → Compress, Synthesis, Reforming → Refine, Separation → Biofuels
### Programs and Schedule of Next-gen Biofuels R&D

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<tbody>
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<td>Selection &amp; Breeding</td>
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<td>Open huge cultivation</td>
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<td>Harvesting</td>
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<td>Improvement of Oil content</td>
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<td>algal biofuels</td>
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<td>Demonstration (Internal) &gt; 1000 ㎡</td>
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<td>BTL</td>
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<td>Gasification</td>
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<tr>
<td>Hydro thermal liquefaction</td>
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<tr>
<td>FT synthesis to bio-jet, bio-diesel</td>
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<tr>
<td>“From cultivation to fuel production” Establishment of consistent process</td>
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<tr>
<td>Demonstration (outside) &gt; 5000 ㎡</td>
<td>scale-up for commercial use</td>
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<td>Current problem is “securing of materials” with cheaply in large quantities</td>
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<tr>
<td>Demonstration (Internal)</td>
<td>scale-up for commercial use</td>
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</tbody>
</table>
## Major R&D Projects regarding Algal Biofuels

<table>
<thead>
<tr>
<th></th>
<th>Algae Species</th>
<th>Lipids (#Carbon)</th>
<th>Cultivation</th>
<th>Scale (m²)</th>
<th>Strain Selection</th>
<th>Oil Refiner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Euglena</em></td>
<td>wax-monoester (C14)</td>
<td>Hitachi</td>
<td>raceway (25)</td>
<td>Euglena</td>
<td>JX</td>
</tr>
<tr>
<td>2</td>
<td><em>Pseudococcomyxa sp.</em> KJ</td>
<td>Glyceride (C16～18)</td>
<td>Denso</td>
<td>raceway (60)</td>
<td>Chuo Univ</td>
<td>Idemitsu</td>
</tr>
<tr>
<td>3</td>
<td><em>Chlamydomonas orbicularis</em> Tai-04</td>
<td>Glyceride (C16～18)</td>
<td>DIC</td>
<td>raceway (50)</td>
<td>Kobe Univ</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td><em>Fistulifera solaris</em> JPCC DA0580</td>
<td>hydrocarbon (C30～32)</td>
<td>J-Power</td>
<td>round-pool (10)</td>
<td>Tokyo U of A&amp;T</td>
<td>—</td>
</tr>
<tr>
<td>5</td>
<td><em>Botryococcus</em> (improved strain)</td>
<td>Glyceride (C16～18)</td>
<td>IHI</td>
<td>square pond (100)</td>
<td>Neo-Morgan</td>
<td>—</td>
</tr>
<tr>
<td>6</td>
<td>Thraustochytrids</td>
<td>Glyceride (C16～18)</td>
<td>Biomaterial in Tokyo</td>
<td>(30 L jar Fermentor)</td>
<td>Miyazaki Univ</td>
<td>Cosmo</td>
</tr>
</tbody>
</table>
R&D project 1: Euglena

In this project, technology development for improving the productivity and oil content of *Euglena*, establishment of ideal culture conditions and basic experiments on mass culture and oil production or analysis of the metabolic pathway for paramylon accumulation, which is a precursor of oil production in *Euglena*, along with the suitability of its oil as jet fuel will be investigated.
The objectives of this R&D are development of automatic cultivation system which can maintain the oil rich microalgae as the dominant species more than two months, development of membrane filtration system for 100-fold cell concentration and development of catalytic conversion technology from bio-crude oil to hydrotreated biofuel.
R&D project 3: Chlamydomonas orbicularis

Novel cultivation system is developed to maximize oil productivity by realizing both high cell density culture and high oil content in the cell. Mass cultivation is also performed with 50 m² pond to develop the optimized system. Economics, material and energy balance are estimated based on the cultivation data. Construction of high-oil producing green alga through metabolic engineering is intended by the development of genomic transformation of *C. orbicularis*.

<table>
<thead>
<tr>
<th>Species</th>
<th><em>Chlamydomonas orbicularis</em> Tai-04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale</td>
<td>raceway (50m²)</td>
</tr>
<tr>
<td>Lipids</td>
<td>TGA</td>
</tr>
<tr>
<td>Company</td>
<td>DIC, Kobe Univ, Nat’l Inst of Basic Biology</td>
</tr>
</tbody>
</table>

Under seawater environment, to form the oil droplets after the nitrogen source consumption
This project aims to create new basic system for green oil production throughout the year using mesophilic and cryophilic oil producing diatoms. Based on the considerations of four factors described above, the entire process for green oil production will be designed to improve the EPR (Energy Payback Ratio) and the cost-performance. Furthermore, the metabolic engineering by genetic engineering will be performed to enhance the oil productivity in candidate strains.
R&D project 5: High-yield Botryococcus

R&D Theme

To produce algae oil at low cost and with minimal energy, it is necessary to increase cell size, optimize density and reduce byproducts. Also, development of recombinant DNA technology for algae is very important for a breeding method. In this R&D, these traits are being added for high-speed cultivation of *Botryococcus* to improve economic efficiency and the energy balance by constructing a large-scale cultivation system.

<table>
<thead>
<tr>
<th>Species</th>
<th><em>Botryococcus</em> (improved strain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale</td>
<td>Square open pond (100m²)</td>
</tr>
<tr>
<td>Lipids</td>
<td>hydrocarbon</td>
</tr>
<tr>
<td>Company</td>
<td>IHI, Neo Morgan Lab, Kobe Univ.</td>
</tr>
</tbody>
</table>

Recent Topics: leading to “Energy-saving harvest”

- Particle size was increased (left: original strain, others: improved strains)
- Flotation ratio was improved (left: original strain, others: improved strains)
R&D project 6: Thraustochytrids

This project aims at developing a production system with thraustochytrids that are genetically modified to utilize lignocellulose-derived (corn fiber, rice straw, etc.) sugar solutions efficiently. Other areas such as production cost, methods of oil extraction, fuel quality, and energy conversion will also be examined.

---

**R&D Theme**

- **Species**: Thraustochytrids
- **Scale**: reacter (30L)
- **Lipids**: TGA
- **Company**: Biomaterial in Tokyo Co., Ltd. Miyazaki Univ

---

**Diagram**

1. **Generation of saccharified biomass-compatible thraustochytrids strain**
   - Genetic modification to allow pentose metabolism (addition of portion in red)

2. **Assessment of cultivation methods**
   - Analysis of oils made by thraustochytrids
   - Evaluation of industrial-scale production methods

3. **Evaluation of fuel suitability**

---

**Diagram: Flowchart**

- **Saccharified lignocellulose**
  - Thraustochytrids
  - Hexose transporter
  - Hexose metabolic system
  - Hexose transporter
  - Pentose metabolic system
  - Pentose transporter
  - Pentose phosphate pathway
  - Glycolytic pathway
  - Oil production system
  - Acetyl CoA
  - Oil
  - Cell membrane

---

**Species and Company Information**

<table>
<thead>
<tr>
<th>Species</th>
<th>Thraustochytrids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale</td>
<td>reacter (30L)</td>
</tr>
<tr>
<td>Lipids</td>
<td>TGA</td>
</tr>
<tr>
<td>Company</td>
<td>Biomaterial in Tokyo Co., Ltd. Miyazaki Univ</td>
</tr>
</tbody>
</table>
The commercialization of biomass to liquid (BTL) technology requires not only development of stand alone processes but a total system solution. This R&D targets the development of an innovative biojet fuel production system. This R&D focuses on the development of entrained flow gasifiers suitable for BTL and FT synthesis catalysts for biojet fuel with high selectivity and durability. This development is aimed at improving efficiency and reducing the cost of BTL systems, which are challenges in biomass energy consumption.
... Advancing step by step, METI/NEDO have been tackling various challenges with the spirit of

“Slow but Steady Win the Race”.

- Above all, crucial to establish a solid, large-scale cultivation system to prove its feasibility – before moving into whole integrated production system;
- Simultaneously further promote development of cost/energy-efficient process technology;
- Once proved, speeding up decision making and stepping forward to next stage is absolutely necessary!!!