Introduction to Efficient Energy Use and Renewable Energy R&D in Japan

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Menu

- What is AIST?
- Green Innovation in Japan
- Energy Savings in Petroleum Industry
- New Research Center in Fukushima
What is AIST?
National Institute of Advanced Industrial Science and Technology (AIST)

Six Research Fields
life science, electronics, nanotechnology, environment and energy, geological survey, and metrology and measurement science
“Full Research” from Basic Research to Product Realization

AIST plays the role of mediator between academia and industry through “Full Research” from basic research to product realization, and promotes the creation of innovation.

Seamless “Full Research” – From Basic Research to Product Realization –

Type I Basic Research: Discovering and understanding universal principles for unknown phenomena
Type II Basic Research: Research to identify specific ways of achieving defined goals by combining knowledge already established for specific needs
### AIST DATA – Staff

**As of April 1, 2012; total number of employees: 2,949**

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Researchers (International)</td>
<td>2,288 (82)</td>
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<tr>
<td>- Permanent</td>
<td>2,046</td>
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<tr>
<td>- Fixed term</td>
<td>242</td>
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<tr>
<td>Administrative employees</td>
<td>661</td>
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</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executives</td>
<td>13 (82)</td>
</tr>
<tr>
<td>Visiting researchers</td>
<td>177</td>
</tr>
<tr>
<td>Postdoctoral researchers</td>
<td>274</td>
</tr>
<tr>
<td>Technical staff</td>
<td>1,533</td>
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</tbody>
</table>

**Number of researchers accepted through industry/academia/government partnerships**

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Companies</td>
<td>Approx. 1,500</td>
</tr>
<tr>
<td>Universities</td>
<td>Approx. 2,000</td>
</tr>
<tr>
<td>Other organizations</td>
<td>Approx. 900 (500 from overseas)</td>
</tr>
</tbody>
</table>

(Total number of researchers accepted in FY 2011)

**Composition of research staff by research field**

- **Geological Survey and Applied Geoscience**: 24%
- **Metrology and Measurement Science**: 16%
- **Nanotechnology, Materials, and Manufacturing**: 17%
- **Environmental and Energy**: 17%
- **Life Science and Biotechnology**: 15%
- **Information Technology and Electronics**: 11%
- **Total**: 100%
Revenue and Expenditure for FY 2012  
(Unit: million yen)

Revenue:
- Comissioned research funds: 11,217
- Facility maintenance grants: 837
- Miscellaneous: 7,601
- Subsidy: 60,078
- Total Revenue: 79,734

Expenditure:
- Research costs: 35,646
- Research infrastructure development costs: 8,260
- General management costs: 3,600
- Employment costs: 31,391
- Facility management costs: 837
- Total Expenditure: 79,734

(Total revenue reported for FY 2010: 96,985 (unit: million yen))
Integration of Organizations, Systems, and Human Resources to Realize the “Open Innovation Hub” Strategy

AIST is enhancing its “open innovation hub” functions by using its human resources and platforms in order to bring industries, academia, and government together to engage in research, technical evaluations, and standardization efforts.
Active International Partnerships

- AIST is strengthening its research networks in Asia and bilateral cooperation with major research institutes in the world through agreements (strengthening of complementary core research competence).
  - Signing of memoranda on comprehensive research cooperation with major research institutes abroad. (See ★ below.)
  - Signing of memoranda on research cooperation in specific research fields. (See ● below. Some are excerpted.)
- AIST plans to form an international research cooperation network with AIST serving as the hub to build a sustainable development system to work on global issues.
- AIST offers opportunities to foreign researchers including those in Asia using its comprehensive capabilities, and is preparing suitable environments for the reception of foreign researchers.
- AIST is strengthening the security export control system and its management.
For the purpose of green innovation, AIST is promoting the development of various new technologies.

Examples:

- Photovoltaic module
- Reliability and extended lifetime of photovoltaic modules
- Reflected efforts of reliability tests to international standard
- Methane hydrate
- Bioethanol production plant by the non-sulfuric acid method (Oji Holdings Corporation)
- Photocatalytic hydrogen production
- Inverter for photovoltaic generation (based on Si devices)
  - Output power density: about 0.1 W/cm$^2$
- High voltage/large capacity power converter using SiC diode
  - Output power density: about 7 W/cm$^2$
- SiC power electronic device
  - Prototype inverter (based on SiC diodes)
- Light-illuminated photoelectrode
- Wired counter electrode
- Inverter for photovoltaic generation (based on Si devices)
  - Output power density: about 0.1 W/cm$^2$
- Prototype inverter (based on SiC diodes)
  - Output power density: about 7 W/cm$^2$
- Ozone concentration distribution in Kanto region by atmospheric model
- Methane hydrate
- Bioethanol production plant by the non-sulfuric acid method (Oji Holdings Corporation)
Scientific facilities damaged in the earthquake in AIST Tsukuba

- Fume hood ducts and air scrubbers
- The research wastewater piping system
- A water purification system
- A mass spectrometer
- Office
- A transmission electron microscope
Green innovation in Japan
Toward green innovation

For the purpose of green innovation, Japan is promoting the development of technologies for increased use of renewable energy and energy saving to reduce greenhouse gas emissions, the securing and effective use of natural resources, reduction of environmental loads of industry, and evaluation and risk management of various new technologies.
R&D of Photovoltaics ~Aiming for high efficiency and low cost ~

PV modules and system

Si thin-film solar cell

Flexible CIGS solar cell module

CIGS thin-film solar cell

Dye-sensitized tandem solar cell

Organic thin-film solar cell
Wind Power Generation

World Wind Power Deployment

GW

200
180
160
140
120
100
80
60
40
20
0

2004 2005 2006 2007 2008 2009 2010

ROW
India
Spain
Germany
China
US

Japan
2.4GW

Nunobiki wind farm in Fukushima
(66MW=2MWx33)

Shin-Izumo wind farm in Shimane
(78MW=3MW x 26)
Wind Power in Japan

Climate Issues

- Complicated Surface, Typhoons ➔ need domestic standards

- Off-shore potential is rather high ➔ Off-shore on-float wind turbine project in Fukushima by Tokyo Univ. MHI, etc.

Wind Map of Japan
Development of hydrogen energy technology

Studies on
- Hydrogen damage
- Mechanism of hydrogen embrittlement

Hydrogen production

Safety/Measurement

Hydrogen storage/transport

Basic Technology

Metal Hydrides

Compact/highly efficient hydrogen storage/transport technology

Hydrogen station

Hydrogen storage tank for vehicle use

Hydrogen station

Industrial use
Fuel cell vehicle
Power storage system

Collaboration with companies

Energy Technology Research Institute
Joint research with Los Alamos Natl. Lab (USA)
Manufacturing technology of liquid fuel from biomass

Wood chips (200 kg wood/day) → Steaming/hydrothermal treatment → Pulverization (Continuous treatment) → Preprocessing → Enzyme (fungi) (on-site production) → Genetically modified yeast → Enzymatic saccharification/ethanol fermentation → Ethanol (60L/day)

(Biomass Refinery Research Center) → Collaboration → Quality assessment and standardization

Bioethanol manufacturing plant

RC for New Fuels and Vehicle Technology
Development of distributed energy network

- Solar cells
- Wind Power
- Hydrogen
- Electric power
- Thermal energy
- Fuel cells
- SiC Inverter
- Demonstration experiments
  - PEFC network in housing complexes
  - Cogeneration in Sapporo City University
  - 1 MW PV Generation in AIST Tsukuba
- Rechargeable batteries
- Biomass
- Fuel cells (SOFC)
Smart Community Projects in Japan

Demonstration Projects
- smart energy/traffic system management
- energy / CO2 emission reduction
- renewable energy deployment

Hydrogen town in Maebaru, Fukuoka

Solar Town in Ohta, Gunma

Kita-kyushu

Keihanna

Yokohama

Toyota
Progress of Batteries in HEV and EV

**TOYOTA / PRIUS (HV)**
- Ni-H Battery
- Stored Energy: 1.3kWh
- Cruising distance: -

**MITSUBISHI / i-MiEV (EV)**
- Li ion Battery
- Stored Energy: 16kWh
- Cruising distance: 160km (10.15 mode)

**NISSAN / Leaf (EV)**
- Li ion Battery
- Stored Energy: 24kWh
- Cruising distance: 200km (JC08 mode)

**Progress of Stored Energy**

**TOYOTA / Plug-in Hybrid (PHV)**
- Li ion battery
- Stored Energy: 5.2kWh
- Cruising distance: 23.4km (JC08 mode)
Principle and Structure of Li ion Battery

- Lithium-ion battery
  - Cathode:
    - $C_6 + xLi^+$
    - $Li_xC_6$
  - Anode:
    - $Li_{1-x}CoO_2 + xLi^+$
    - $Li_{1-x}AO_2$
  - Organic electrolyte
  - Gasket
  - Anode tab
  - Gas leak valve
  - Cathode tab
  - Cathode plug plate
  - Separator
  - Separation

Issues:
- Higher energy/power
- Longer life time
- Safety
- Lower cost

Applications:
- Mobile phone
- Digital camera
- Electric vehicle

Japan Battery Industry Association
PV & Battery Integration into Smart Community

Responding to electrification of energy consumption
Doubling the current level of electrification ratio in 2050
(20% → 40%)
New electricity demand of 500 bil. kWh or more will be created
PV is a domestic resource without resource issues or CO₂ burdens

Community energy management systems (Community EMS)

Power source for automated manufacturing at plants and for agriculture, etc.

Fuel switch to electric vehicles (EVs), power source for charging

Smart Community projects: Yokohama, Toyota, Keihanna, Kitakyushu, and more

Figure 3 Images of future use of PV power generation
From PV2030+
Securing and effective use of natural resources

Securing and efficient use of diverse natural resources, such as biomass and mineral resources, must be ensured to achieve a material-recycling society. We are developing and improving processes to produce chemicals and fuels from biomass and other renewable sources. We are also developing technologies for the efficient use of exhaustible fossil resources such as coal and methane hydrates, and mineral resources such as rare metals, as well as recycling technologies.

Methane hydrate that exists under bottom of the ocean etc., and is paid attention to as new natural gas resources

Effective use of biomass for producing chemicals

- glucose
- cellulose
- fat etc.

- polylactic acid
- levulinic acid
- glycerin derivative etc.

chemical process

bioprocess

hydrothermal treatment, mechanochemical treatment, enzyme

biomass
Reduction of environmental loads

Manufacturing processes in various industries must be improved for higher efficiency and for the reduction of the environmental load. We are developing green sustainable chemistry technologies to minimize environmental emissions from chemical manufacturing processes and improve the energy efficiency of processes. We are also developing technologies to reduce the environmental load generated by industrial activities and restore the environment.
Evaluation and risk management

New energy technologies and advanced materials must be properly evaluated, and managed to achieve a sustainable society. We are analyzing and evaluating scenarios for introducing new energy technologies, and evaluating CO₂ emission reduction activities. In addition, we are developing technologies to appropriately evaluate risks of chemicals and the environmental impact of substances produced by industrial activities.

“ADMER Ver. 2.5", software that computes the concentration of chemical substances in the atmosphere based on the emission amount and weather conditions

Risk assessment reports of nanomaterials
Technology research associations
—A new scheme for “promoting open innovation”—
Lithium Ion Battery Technology and Evaluation Center (LIBTEC)

Research on test protocols of materials for lithium ion battery in cooperation with members of the association.

Establishment: Apr. 2010
President: Akira YOSHINO
Members: 18 companies, 1 research organizations

Feed back to find guidelines for new materials research

Battery Industries

(Kansai)

Kansai Open Space Lab.

Characterization of battery

Materials for battery

Preparation of test cell
Photovoltaic Power Generation Technology Research Association (PVTEC)

R and D of advanced solar cell technology

Support for joint projects with international institutions

Establishment: Dec. 1990
President: Yukinori KUWANO
Members: 63 companies, 4 research organizations

High-performance thin-film Si PV prototype

Performance & reliability evaluation
Energy Savings in Petroleum Industry
Energy savings

Improving energy efficiency has the direct and immediate effect of reducing greenhouse gas emissions.

Energy consumption in chemical industry in Japan

- Industry: $6.01 \times 10^{18} \text{J}$
- Steel: 28%
- Chemical: 15%
- Ceramics: 8%
- Paper: 7%
- Others: 42%

(except naphtha for products)

Distillation columns are the major energy consumers (40%) in the chemical and petrochemical industries.
Development of Heat Integrated Distillation Column

In the HIDI C, a certain amount of heat is transferred from the rectifying section to the stripping section. It generates the reflux flow for the rectifying section and vapor flow for the stripping section. Thus the condenser or reboiler is, in principle, not needed and zero external reflux operation could thus be realized.

- Member of R&D Consortium supported by METI / NEDO (FY2002 – FY2005)
- National Institute of Advanced Industrial Science and Technology (AIST) http://www.aist.go.jp/
- Project Leader
- Kansai Chemical Engineering Co., Ltd. http://www.kce.co.jp/
- Kobe Steel Co., Ltd. http://www.kobelco.co.jp/index_e_wi.htm

The pilot plant in Chiba factory of Maruzen Petrochemical Co., Ltd. at Chiba, Japan.
Kimura Chem. Plants Co. Ltd.
AIST

Hannover Messe
22\textsuperscript{nd} April, 2008
## SUPERHIDIC® - Case Study / Summary -

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<tr>
<th>Service</th>
<th>O.P. Strip/Rect</th>
<th>Comp. Ratio</th>
<th>No. of Side Hex</th>
<th>Rebo. Duty @Conv.</th>
<th>Comp'or Power</th>
<th>E.S.I.</th>
<th>△OPEX [MM¥/Year]</th>
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<tr>
<td>Xylene Column (mixed Xy product)</td>
<td>250/409 [kPaA]</td>
<td>1.65 [-]</td>
<td>3 [-]</td>
<td>6.39 [MW]</td>
<td>0.92 [MW]</td>
<td>0.635 [MW]</td>
<td>58 [%]</td>
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<tr>
<td>Cumene Column</td>
<td>115/218 [kPaA]</td>
<td>1.91 [-]</td>
<td>3 [-]</td>
<td>3.42 [MW]</td>
<td>0.01 [MW]</td>
<td>0.317 [MW]</td>
<td>74 [%]</td>
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<td>DiEB Column</td>
<td>105/145 [kPaA]</td>
<td>1.93 [-]</td>
<td>5 [-]</td>
<td>0.870 [MW]</td>
<td>0.05 [MW]</td>
<td>0.063 [MW]</td>
<td>75 [%]</td>
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<tr>
<td>Stripper (Disprop. Unit)</td>
<td>191/921 [kPaA]</td>
<td>5.11 [-]</td>
<td>4 [-]</td>
<td>9.83 [MW]</td>
<td>4.11 [MW]</td>
<td>0.313 [MW]</td>
<td>50 [%]</td>
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* Energy Saving Index  
\[
\text{E.S.I.} = \frac{\text{Reboiler Duty @ConvDist} - \left(\text{Reboiler Duty @HIDiC} + \text{Comp'or Power} / 0.366\right)}{\text{Reboiler Duty @ConvDist}}
\]

### Operating Costs

<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium Press. Steam [JPY/tonne]</td>
<td>2,800</td>
<td>3,500</td>
<td>2,500</td>
</tr>
<tr>
<td>Low Press. Steam [JPY/tonne]</td>
<td>2,000</td>
<td>2,500</td>
<td>1,500</td>
</tr>
<tr>
<td>Electricity [JPY/kW]</td>
<td>7</td>
<td>10</td>
<td>9</td>
</tr>
</tbody>
</table>

Operating hour per year = 8000 hr
New Research Center in Fukushima
Renewable Energy Research Center in Fukushima

- Promotion of R&D of renewable energy which is open to the world
- Contribution to industrial clusters and reconstruction
- Utilization of renewable energy and energy-saving practices
- Development of human resources on renewable energy

**Private companies, METI, MEXT, universities, international research institutes**
Overview of the Renewable Energy Research Center

- Verification of Renewable Energy Network
- Advanced Technology for Wind-Power Generation
- Appropriate Technology Use for Geothermal
- Energy Storage / Utilization Technology
- Solar Module Mass Production Technology for Next-Generation
The National Renewable Energy Laboratory (NREL)  
Golden, Colorado

NREL is the U.S. Department of Energy’s primary national laboratory for renewable energy and energy efficiency research and development.
Renewable Energy
Energy Savings
Natural Resources
Energy Network System
Thank you for your attention!