Outline of “Photovoltaic Power Systems Development Strategy ~ NEDO PV Challenges ~”

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Outline

1. NEDO PV Challenges
2. Target of Levelized Cost of Energy
3. Technology development project of NEDO
4. Summary
Role of NEDO

NEDO plays an important part in Japan’s economic and industrial policies as one of the largest public research and development management organizations.

We support research and development under the government policies.
It has two basic missions: addressing energy and global environmental problems, and enhancing industrial technology.
### Situation of Photovoltaics Installations

**Installations of Renewable Energy by Feed-in Tariff System** *(Unit: GW)*

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>PV</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.6</td>
<td>33.9 (+28.3)</td>
<td>79.5</td>
</tr>
<tr>
<td></td>
<td><strong>House</strong> 4.7 <strong>Non-house</strong> 0.9</td>
<td><strong>House</strong> 8.7 (+ 4.0) <strong>Non-house</strong> 25.2 (+ 24.3)</td>
<td></td>
</tr>
<tr>
<td>Wind Power</td>
<td>2.6</td>
<td>3.1 (+0.5)</td>
<td>2.8</td>
</tr>
<tr>
<td>Medium and Small Hydro</td>
<td>9.6</td>
<td>9.8 (+0.2)</td>
<td>0.8</td>
</tr>
<tr>
<td>Biomass</td>
<td>2.3</td>
<td>2.8 (+0.5)</td>
<td>3.7</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.5</td>
<td>0.51 (+0.01)</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20.6</td>
<td>50.1 (+29.5)</td>
<td>86.9</td>
</tr>
</tbody>
</table>

Cumulative basis. ( ) shows increment. *(Source: Prepared by NEDO based on METI data)*
[Background] Purpose of Photovoltaic (PV) Strategy

• Five years have passed after the formulation of the photovoltaic (PV) road map (PV2030+) in 2009. Meanwhile, the environment around Photovoltaics (PV) has changed drastically.

• Domestically, the actualization of the society introducing PV on a large scale is imminent due to the effect of Feed-in tariff system. Hence, instead of the conventional “strategy for popularization”, “strategy for support to the society after high penetration” should be considered.

• Internationally, price competition of “solar cells” becomes more serious and the related industry structure is changing.
NEDO PV Challenges (Established 2014)

5 issues for Photovoltaics (PV)

Increase of the national burden
- LCOE Reduction

Request of long-term stable power generation secured
- Enhanced Reliability

Manifestation of the location constraints
- Cancellation of Siting Restriction

Correspondence of the waste mass generation
- Establishment of Recycling System

Intensification of global competition
- Creation of High Added Value
1. **PV should become a popular energy source capable of propagating by itself without relying on public support by 2030.**

(1) In 2020, PV should support energy consumption by realizing levelized cost of energy allowing its power to be selected for the business sector and captive use in the industrial sector with greater potential as an alternative power to the grid power supply (thereby the grid load will be reduced).

LCOE of PV comparative to business electricity price, namely, **14 yen/kWh** will be targeted. (Grid parity)

(2) Until 2030, Levelized cost of energy allowing its power to be selected for power generation business or private power generation will be realized to support energy supply.

LCOE of PV comparative to conventional thermal power, namely, **7 yen/kWh.** (Generation parity)

(3)”Reliability” realizing these objectives should be also assured.
2. Popularization in the society
A new energy system will be created by cancelling siting restrictions through diversification of introduced configuration and by avoiding grid restrictions through the features of a distributed power source. Foundation to utilize Photovoltaics (PV) will be expanded. By establishing a recycling system a society introducing Photovoltaics (PV) on a large scale and in a sustainable manner will be realized.

3. Leading the world by creating the new values
Electric power business will be diversified in the areas including aggregation business. In addition, a development of new utilization methods will allow any values other than “power generation” of Photovoltaics (PV) to be proposed. The activities will lead to the creation of new businesses and new industries.
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## Target of Levelized Cost of Energy
[Non-residential Sector]

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Price [Yen/W]</td>
<td>251</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>Module Efficiency [%]</td>
<td>16</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>Operation Period [Year]</td>
<td>20</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Capacity Factor [%]</td>
<td>14</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Total Cost</td>
<td>18.59</td>
<td>12.00</td>
<td>6.26</td>
</tr>
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</table>

Base of Procurement price calculation method at FY2016
The significance of “7 yen/kWh”

- “Module prices” and “system technology” capable of realizing a system price of 100 yen / W in Japan
- “High-performance” of the module efficiency of 25%
- “Reliability” of operation period of 30 years

Japan’s solar power industry that can win in the world!
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NEDO R&D projects for PV

Development of cells and Modules

R&D for Innovative Solar Cells

Development of Next Generation High Performance Technology for PV Systems

R&D for Commercial viability of Dye-sensitized and Organic Solar Cells

Development of high performance and reliable PV modules to reduce levelized cost of energy

PV System and elsewhere

High performance system and low maintenance cost

Low-cost recycling technology

Low-cost installing technology in untapped field

High-value PV system technology

Total system efficiency
BOS cost
Maintenance cost

Cell, Module efficiency
Production cost
Reliability

FY 2008 09 10 11 12 13 14 15 16 17 18 19 2020 2030

14 Yen/kWh

7 Yen/kWh

Yen/kWh
# Goals of “Development of high performance and reliable PV modules to reduce levelized cost of energy”

<table>
<thead>
<tr>
<th>Development item</th>
<th>Goals</th>
<th>Main Target</th>
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<tbody>
<tr>
<td>c-Si/CIS</td>
<td>• Steadily realize the power generation cost reduction</td>
<td>7 yen/kWh in 2030</td>
</tr>
<tr>
<td></td>
<td>• Ensure the competitiveness by the performance of 7 yen / kWh.</td>
<td>14 yen/kWh in 2020</td>
</tr>
<tr>
<td></td>
<td>• Pursuing high performance and low cost in c-Si/CIS solar cells</td>
<td></td>
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<tr>
<td>High Efficiency</td>
<td>• Achieve a 7 yen / kWh with a different approach than c-Si/CIS</td>
<td>7 yen/kWh in 2030</td>
</tr>
<tr>
<td></td>
<td>• Differentiation in the difference of the overwhelming characteristic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Create a new market by taking advantage of the characteristics.</td>
<td></td>
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<tr>
<td></td>
<td>• To lower the cost of III–V solar cells of over 30% Efficiency</td>
<td></td>
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<tr>
<td></td>
<td>• Development of low cost perovskite solar cells</td>
<td></td>
</tr>
<tr>
<td>Low cost</td>
<td>• Elucidation of degradation mechanism</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Development of new accelerated test method</td>
<td></td>
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<tr>
<td>High Reliability</td>
<td>• Improve the reliability of solar power generation and realize that solar power is generalized in the society</td>
<td></td>
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<tr>
<td></td>
<td>• Develop a technology to evaluate the long-term reliability of the solar module</td>
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The definite contents of development about high reliability

• Development of output measurement technology
  To develop a measurement technology to correctly evaluate the output of the solar cell which standardization is not progressing.

• Development of characterization methods of output yield
  About solar radiation database, update data, and high accuracy promoting the expansion, improve the user experience improvement.

• Development of characterization methods of reliability and lifetime
  Get the power generation data from the solar power generation system, to analyze and evaluate, to extract the degradation factor of the solar power generation system, to elucidate the degradation mechanism, and to develop a degradation prevention technology.
  To development characterization method to evaluate the long-term reliability in consideration of the environment in which the photovoltaic module is installed.
Development of output measurement technology

Development of precise PV performance characterization technologies
（AIST, Miyazaki Uni., Gifu Uni., Ritsumeikan Uni., TUS, JET）

Development outline:
- Performance characterization technology for novel PV devices
- Precise outdoor characterization technology
- Precise measurement technologies of PV module temperature
- The quantitative analysis of the solar irradiance fluctuations
- the high speed measurement method of the index of solar spectral irradiance distribution, i.e. average photon energy (APE)
- System performance analysis method by using PV module sensor
- Demonstration of measurement technology
Development of precise characterization methods of output yield for photovoltaic systems (AIST, CRIEPI, JWA, Saga Uni.)

Development outline:
- Characterization methods of output yield for various photovoltaic modules with outdoor degradation
- Construction of solar radiation database
- Interpolation algorithm of photovoltaic power and solar irradiance data
- Analysis software of photovoltaic power and solar irradiance data
Development of characterization methods of reliability and lifetime

Development of accelerated testing method for evaluating the long term reliability of ZEB adaptive photovoltaic module (KANEKA Co.)

Development outline:
- Long-term reliability testing method for ZEB
- Long-term durability characterization and long-term output yield characterization
- Durability characterization of low-cost high reliability solar module
- Standardization of testing method developed

![Graph showing Pmax and cycle number relationship with ATC and TC labels.]

The thermo-image of partial shadow.
Development of characterization methods of reliability and lifetime

Development of inspection for predictable life time for PV module using laser technology
（NISSHINBO Mechatronics inc., NAIST）

Development outline:
- Elucidation and modeling of the degradation mechanism. (e.g. PID)
- Testing method in consideration of the environment in which the solar cell module is installed
- Technology to predict whether the power generation for 30 years
- Standardization of prediction technology

Current Mapping

Carrier lifetime
Development of characterization methods of reliability and lifetime

Prediction of lifetime and development of test methods for photovoltaic modules
(AIST, DuPont, Toray Inc., Industrial Research Institute of Ishikawa, Gifu Univ., TUAT, JAST, TUS)

Development outline:
- Degradation phenomenon survey by photovoltaic module installed outdoor
- Degradation phenomenon survey by indoor acceleration examination
- Elucidation of the PID mechanism
- Study of accelerated testing method about physical or mechanical degradation, Chemical corrosion degradation, PID
In recent years...

- Solar modules of solar power generation system that a design and construction are insufficient is blown by strong winds.
- Electric shock risk of the solar module is concerned when the solar module has been submerged by flood.

Attention has been focused on the safety of the solar power generation system.

2015 Wind induced disaster (Gunma)  2015 Typhoon damage (Kyushu)  2015 Flood damage (Ibaraki Kinugawa)

(Source: METI Power Safety Commission 12th)
Immediate response are required for safety of the solar power system structure.

So, We carry out verification tests about the wind pressure performance of the frame and the bering capacith of the pile.

And we compile design guidelines and the safe manual of various fields affecting photovoltaic power generation.

Image of the bearing capacity performance test of the pile

Image of wind pressure resistance performance test of the frame
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In NEDO PV Challenges, There are 5 issues and solution for the society introducing PV on a large scale.

LCOE of 14 yen /kWh by 2020, LCOE of 7 yen /kWh by 2030 was established as goal.

NEDO started the project, “Development of high performance and reliable PV modules to reduce levelized cost of energy” from 2015.

NEDO drive forward the project for high reliability.

NEDO started the new project about safety in the solar power generation system.