IEA INTERNATIONAL ENERGY AGENCY

NEDO

# National Survey Report of PV Power Applications in JAPAN

## 2013

PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

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## Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Co-operation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme (IEA-PVPS) is one of the collaborative R & D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The 24 participating countries are Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), China (CHN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia (MYS), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Thailand (THA), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). The European Commission, the European Photovoltaic Industry Association, the US Solar Electric Power Association, the US Solar Energy Industries Association and the Copper Alliance are also members.

The overall programme is headed by an Executive Committee composed of one representative from each participating country or organization, while the management of individual Tasks (research projects / activity areas) is the responsibility of Operating Agents. Information about the active and completed tasks can be found on the IEA-PVPS website www.iea-pvps.org

## Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. An important deliverable of Task 1 is the annual "*Trends in photovoltaic applications*" report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the country National Survey Report for the year 2013. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

The PVPS website www.iea-pvps.org also plays an important role in disseminating information arising from the programme, including national information.

# 1 INSTALLATION DATA

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, **PV installations are included in the 2013 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2013, although commissioning may have taken place at a later date**.

## 1.1 Applications for Photovoltaics

Annual installed capacity of 2013 reached 6 968 MW (DC-base), about quadrupling increase from the previous year (2012: 1 718 MW). Almost all the PV systems were introduced under the Feed-in Tariff (FIT) program. Breakdown of the annual installed capacity of 2013 by application is; 0 MW for off-grid domestic, 14,1 MW for off-grid non-domestic, 6 953MW for grid-connected (grid connected distributed plus grid connected decentralized).

## 1.2 Total photovoltaic power installed

Cumulative PV installed capacity as of the end of 2013 reached 13 599 MW. Cumulative PV installed capacity by application is; 8,8 MW for off-grid domestic, 114,6 for off-grid non-domestic and 13.475,7 MW

Table 1: PV power installed during calendar year 2013

| | | | **MW installed in 2013 - AC value** | **MW installed in 2013 - DC value** |
|---|---|---|---|---|
| **Grid-connected** | BAPV | Residential (<10kW) | 1,366 | 1,366 |
| | | Commercial (<50 kW, icluding small-scale ground mounted) | 1,651 | 1,899 |
| | | Industrial (50 kW – 1 MW, cluding small-scale ground mounted) | 1,565 | 1,878 |
| | | *Total BAPV* | 4,582 | 5,143 |
| | BIPV | Residential | 40 | 40 |
| | | Commercial | | |
| | | Industrial | | |
| | | *Total BIPV* | | 40 |
| | Ground-mounted | cSi and TF | N.A. | 1,770 |
| | | CPV | N.A. | 1 |
| | | Total Ground-mounted | 1,406 | 1,771 |
| **Off-grid** | | Residential | 0 | 0 |
| | | Other | 14.1 | 14.1 |
| | | Hybrid systems | N.A. | N.A. |
| | | Total off-grid | 14.1 | 14.1 |
| | | **Total** | 6,042 | 6,968 |

**Table 2b: grid-connected PV power installed during calendar year 2013 (Unit: MW)**

| | Capacity (AC-based) | Capacity (DC-based) |
|---|---|---|
| < 10kW | 1,406 | 1,406 |
| 10kW - < 50kW | 1,651 | 1,899 |
| 50kW - < 1MW | 1,565 | 1,878 |
| 1MW - < 1MW | 1,151 | 1,439 |
| 2MW or more | 255 | 331 |
| Total | 6,028 | 6,953 |

Source：AC: The Ministry of Economy, Trade and Industry (METI),
DC: Estimated by RTS Corporation

**Table 2: Data collection process:**

| | |
|---|---|
| Are the installation data reported in AC or DC? | AC: The Ministry of Economy, Trade and Industry (METI)<br>DC: Estimated by RTS Corporation |
| Is the collection process done by an official body or a private company/Association? | The Ministry of Economy, Trade and Industry (METI) |
| Link to official statistics (if this exists) | http://www.enecho.meti.go.jp/category/saving_and_new/saiene/kaitori/index.html |
| | DC capacity was estimated in consideration of over-panelling |

**Table 3: PV power and the broader national energy market.**

| *MW-GW for capacities and GWh-TWh for energy* | 2013 numbers | 2012 numbers |
|---|---|---|
| Total power generation capacities (all technologies) | 246GW | 238GW |
| Total power generation capacities (renewables including hydropower) | 58.8GW | 51.8GW |
| Total electricity demand (= consumption) | 979TWh | 991TWh |
| New power generation capacities installed during the year (all technologies) | 7.4GW | 8.26GW |
| New power generation capacities installed during the year (renewables including hydropower) | 7GW | 2.19GW |
| Total PV electricity production in GWh-TWh | 13,599GWh | 6,632GWh |
| Total PV electricity production as a % of total electricity consumption | 1.4% | 0.67% |

**Table 4: Other informations**

<table>
<tr><th></th><th>2013 Numbers</th></tr>
<tr><td>Number of PV systems in operation in your country (a split per market segment is interesting)</td><td>Total No is N.A.<br>Number of residential PV system: 1510 000 (preliminary data as of the end of 2013)</td></tr>
<tr><td>Capacity of decommissioned PV systems during the year in MW</td><td>N.A.</td></tr>
<tr><td>Total capacity connected to the low voltage distribution grid in MW</td><td rowspan="2">13,239MW</td></tr>
<tr><td>Total capacity connected to the medium voltage distribution grid in MW</td></tr>
<tr><td>Total capacity connected to the high voltage transmission grid in MW</td><td>~360MW</td></tr>
</table>

**Table 5: The cumulative installed PV power in 4 sub-markets.**

| Sub-market | Stand-alone domestic | Stand-alone non-domestic | Grid-connected distributed | Grid-connected centralized | TOTAL |
|---|---|---|---|---|---|
| 1992 | 150 | 15,260 | 1,220 | 2,370 | 19,000 |
| 1993 | 200 | 19,170 | 2,300 | 2,600 | 24,270 |
| 1994 | 250 | 23,260 | 5,130 | 2,600 | 31,240 |
| 1995 | 300 | 29,360 | 10,820 | 2,900 | 43,380 |
| 1996 | 350 | 35,890 | 20,500 | 2,900 | 59,640 |
| 1997 | 400 | 44,900 | 43,100 | 2,900 | 91,300 |
| 1998 | 450 | 52,300 | 77,750 | 2,900 | 133,400 |
| 1999 | 500 | 56,200 | 149,000 | 2,900 | 208,600 |
| 2000 | 550 | 63,000 | 263,770 | 2,900 | 330,220 |
| 2001 | 600 | 66,227 | 383,086 | 2,900 | 452,813 |
| 2002 | 955 | 71,692 | 561,295 | 2,900 | 636,842 |
| 2003 | 1,101 | 77,792 | 777,830 | 2,900 | 859,623 |
| 2004 | 1,136 | 83,109 | 1,044,846 | 2,900 | 1,131,991 |
| 2005 | 1,148 | 85,909 | 1,331,951 | 2,900 | 1,421,908 |
| 2006 | 1,212 | 87,376 | 1,617,011 | 2,900 | 1,708,499 |
| 2007 | 1,884 | 88,266 | 1,823,244 | 5,500 | 1,918,894 |
| 2008 | 1,923 | 88,886 | 2,044,080 | 9,300 | 2,144,189 |
| 2009 | 2,635 | 91,998 | 2,521,792 | 10,740 | 2,627,165 |
| 2010 | 3,374 | 95,420 | 3,496,017 | 23,333 | 3,618,144 |
| 2011 | 5,546 | 97,728 | 4,741,464 | 69,210 | 4,913,948 |
| 2012 | 8,822 | 100,530 | 6,522,317 | | 6,631,669 |
| 2013 | 8,822 | 114,618 | 13,475,729 | | 13,599,169 |

# 2 POLICY FRAMEWORK

## 2.1 Direct support policies

**Table 6: PV support measures (summary table)**

| | On-going measures | Measures that commenced during 2013 |
|---|---|---|
| Feed-in tariffs (gross / net?) | - The Feed-in Tariff (FIT) program for renewable energy power generation facilities took effect in July 2012 based on the "Renewable Energy Law". For newly-installed PV systems with the capacity below 10 kW, the surplus electricity generated aside from the self-consumption is covered. For newly-installed PV systems with the capacity of 10 kW or more, the gross electricity generated is covered by the program | - |
| Capital subsidies for equipment or total cost | - Subsidy for measures to support introduction of residential PV systems (METI, Ministry of Economy, Trade and Industry)<br>- More than 1 000 local governments implement their own subsidy programs<br>- Subsidy to support restoration through promoting introduction of renewable energy power generation facilities, etc.<br>- Subsidy for measures for off-grid renewable energy power generation systems (Project to promote introduction of renewable energy power generation systems in communities)<br>- Project to support introduction of technologies by small-sized local public organizations (MOE, Ministry of the Environment)<br>- Subsidy for eco lease business promotion project for households and businesses (MOE) | - Subsidy program for residential PV systems was terminated in the end of FY 2013 (March 31, 2014)<br>- Project to promote introduction of renewable energy through citizens' interaction in Fukushima Prefecture |
| Green electricity schemes | - Utilities terminated the green electricity fund program in connection with the start of the FIT program<br>- Trading of green power certificates certified by the Green Energy Certification Center | - |
| PV-specific green electricity schemes | - "Green Trade", trading of green power certificates by a private company RAUL and an NPO PV-Net | - |
| Renewable portfolio standards (RPS) | - RPS was amended in connection with the start of the FIT program<br>- Both newly-installed and existing PV systems are eligible for selling electricity, but newly-installed PV systems are shifting to take advantage of FIT | - |
| PV requirement in RPS | - | - |
| Investment funds for | - Investment funds for large-scale PV power plants | - Investment funds for large- |

| | | |
|---|---|---|
| PV | by financial institutions | scale PV power plants by Tokyo and other local governments<br>- "Green Fund" project to establish a fund to promote investment in low-carbon in local communities (MOE/ local financial institutions, etc.) |
| Income tax credits | Residential PV systems<br>- Tax credit for the investment on renovation of energy conservation and barrier-free houses including PV systems: reduction of 10 % of cost from income tax is applicable for the maximum installation cost of 2 MJPY for home renovation to improve energy conservation without loans. In case of introducing PV systems, the applicable maximum installation cost is 3 MJPY<br>Non-residential PV systems<br>- Tax reduction for green investment (for PV and wind power generation systems): special depreciation available for maximum of 30 % of acquisition cost, 7 % tax credit (only for small- and medium-sized enterprises (SMEs)) and immediate amortization (write off of 100 % of acquisition cost)<br>- Special measure of the tax basis related to renewable energy power generation facilities (fixed asset tax): reduction of the tax basis to two-thirds of the cost of the tax basis for renewable energy power generation facilities (including storage batteries, transformation units and power transmission facilities) acquired under the approval of the FIT program (limited to the fixed asset tax of three years from the fiscal year when the fixed asset tax is charged) | - |
| Prosumers' incentives (self-consumption, net-metering, net-billing…) | - Subsidy for measures for off-grid renewable energy power generation systems<br>- Project to promote zero-energy houses (MLIT, Ministry of Land, Infrastructure, Transport and Tourism) | - Subsidy for project to support introduction of lithium ion storage batteries for stationary applications<br>- Project to promote enhancement of management by small- and medium-sized enterprises (SMEs), etc. through reduction of greenhouse gas emissions (MOE)<br>- Project to promote introduction of renewable energy power generation facilities at disaster-prevention centers (Osaka Prefecture) |

| | | |
|---|---|---|
| Commercial bank activities e.g. green mortgages promoting PV | - Low-interest loan programs<br>- Introduction of PV systems to their own buildings<br>- Syndicate loans for large-scale PV power plants<br>- Asset Based Lending (ABL) by putting up facilities of MW-scale PV power plants as collateral | - Mortgages with irradiation guarantee for single-family houses equipped with PV systems, which pays compensation in case of insufficient irradiation (Resona Bank) |
| Activities of electricity utility businesses | - Construction of large-scale PV power plants for in-house use<br>- Implementation of RPS | - Introduction of large-capacity storage batteries and development of control technology |
| Sustainable building requirements | - | - Energy conservation standards for houses and buildings were amended (self-consumption of PV systems is highly appreciated)<br>- The national government aims to achieve net zero energy house (ZEH) in standard newly-built houses by 2020 |

## 2.2 Direct Support measures

### *2.2.1 Support measures exiting in 2013*

#### *2.2.1.1 Description of support measures excluding prosumers, BIPV, and rural electrification*

The subsidy program for residential PV systems continued in 2013. The feed-in tariff (FIT) program, which took effect in July 2012 was also continued in 2013. In 2013, approximately 6 GW of PV systems were installed and started operation under the FIT program. For industrial applications, some ministers and agencies implemented support programs for specific applications and regions. Local governments using the Green New Deal Fund are implementing projects to promote introduction of renewable energy in communities. Also, support through tax treatment was also continued.

#### *2.2.1.2 Prosumers' development measures (self-consumption)*

Under the FIT program, surplus electricity generated by PV systems with a capacity less than 10 kW is purchased at preferential rates. For these PV systems, if they are installed together with other power generators (gas cogeneration systems, etc.) or storage batteries, purchase prices are reduced. To promote self-consumption, METI implements "Subsidy for measures for off-grid renewable energy power generation systems" for the purpose of promoting introduction of renewable energy power generation systems, etc. for self-consumption. METI also implements projects to support introduction of storage batteries. As part of the "Demonstration projects of next-generation energy and social systems", designed to establish smart communities, demonstration tests on self-consumption of the entire electricity generated by PV systems using home energy management systems (HEMS) have been implemented. MOE supports introduction of low-carbon equipment (PV systems for self-consumption, etc.) by small- and medium-sized enterprises (SMEs), aiming to reduce greenhouse gas emissions. Local governments are increasingly interested in promoting self-consumption of electricity. In the Project to promote introduction of renewable energy power generation systems, Osaka Prefecture requires PV systems to be installed with storage batteries and the generated electricity to be used for self-consumption.

#### 2.2.1.3 *BIPV development measures*

While there is not measures to vitalize the building-integrated PV (BIPV) market, NEDO started “Demonstration project for diversifying PV applications” in FY 2013. For buildings under this project, development and demonstration for installation technology, design and materials have been underway, for walls, windows and balconies of buildings where it has been difficult to install PV systems for technical and cost reasons. NEDO is promoting development of exterior wall-integrated PV modules as part of R&D on commercialization of organic thin-film PV. Not limited to BIPV, but the national government aims to achieve net zero energy houses (ZEH) by 2020, targeting almost zero consumption of primary energy in standard newly-built houses. For promoting zero energy consumption in houses and buildings, subsidy programs to promote introduction of PV systems and other renewable energy systems as well demonstration tests have been implemented by MLIT and METI.

#### 2.2.1.4 *Rural electrification measures*

Since the entire nation is almost 100 % electrified in Japan, there are no rural electrification measures. However, there are measures to support introduction of renewable energy in islands in order to reduce carbon emissions in remote islands not having connection lines with electricity grids in mainland Japan. These islands depend on expensive fossil fuel-based energy such as diesel power generation. Thus, local economy is affected by increasing prices of fossil fuels. There is also an issue of large amount of $CO_2$ emissions. In 2013, MOE implemented “Project to accelerate renewable energy and energy saving in remote islands” with the FY 2013 supplementary budget, to support formulating plans to set up a project to create low-carbon communities and to support introduction of renewable energy and energy saving facilities. For continuously supporting similar projects in remote islands, budget has been secured for FY 2014.

#### 2.2.1.5 *Other measures including decentralized storage and demand response measures*

In 2013, ministries and agencies supported technology development on establishing smart grid and storage battery systems designed to stabilize electric grids at the time of large-scale introduction of energy, energy management systems, electricity demand and response and so on. Demonstration projects mainly on smart community were conducted both home and abroad. In FY 2013, METI secured the budget of 8,6 BJPY for the “Demonstration projects of next-generation energy and social systems”, a large-scale demonstration test in four regions in Japan and 2,2 BJPY for the “Next-generation energy technology demonstration project” in four regions. In other countries, demonstration projects for smart grid were conducted in the USA, France, Spain and China. “Urgent demonstration project for large-capacity storage systems”, a project for FY 2012 with the budget of 29,6 BJPY, was conducted in 2013. Development of control technology and demonstration for storage batteries addressing output fluctuations of PV systems were conducted mainly by electric companies. For renewable energy systems with a capacity of 1 MW and more, MOE conducted a model project for demonstration of control technology for storage batteries. Furthermore, NEDO conducts technology development on large-capacity storage systems and devices such as materials for storage batteries.

### *2.2.2 Support measures phased out in 2013*

The subsidy program for residential PV systems was terminated in the end of FY 2013 (March 31, 2014). The support program for residential PV systems was initiated in 1994 as a monitoring project and was terminated once in 2005. Then, it was resumed in 2009 as a subsidy program. From the beginning, the period of five years (from FY 2009 to FY 2013) was set for this subsidy program. Since another subsidy program established as a fund in FY 2011 was also terminated in FY 2013, there is no subsidy program for FY 2014. From FY 2014 onwards, dissemination of residential PV systems will be supported by the FIT program.

### *2.2.3 New support measures implemented in 2013*

METI started “Subsidy for project to promote introduction of renewable energy through citizens’ interaction in Fukushima Prefecture” in FY 2013, in order to support introduction of renewable energy in Fukushima Prefecture. This program supports projects in Fukushima to introduce renewable energy power generation facilities and ancillary storage batteries installed at public facilities by local public organizations, as well as projects to introduce renewable energy power generation facilities by private entities. For PV systems, the lower amount of either one-third of the eligible cost or 250 000 JPY/kW will be subsidized. Also in FY 2013, under the FIT program, 19,1 BJPY budget was secured as subsidy to compensate the losses incurred by reducing surcharge for industries consuming large amount of electricity. This subsidy program is expected to continue in FY 2014 with the budget to be largely increased from FY 2013. Meanwhile, MOE established the “Green Fund” for renewable energy power generation projects in 2013, in order to invest in low-carbon projects in communities and to make an investment via sub funds in collaboration with local financial institutions.

### *2.2.4 Measures currently discussed but not implemented yet*

As part of the FY 2014 budget, support measures related to introduction of renewable energy including PV are planned by ministries and agencies. METI will start “R&D project to develop technology to address output fluctuations of electric grids” and “Demonstration project to establish next-generation electric grids for distributed energy sources”, in order to accelerate technology development toward full-scale dissemination of renewable energy. Budget of 5 BJPY was newly allocated for the “Subsidy to support restoration through promoting introduction of renewable energy power generation facilities, etc.”, which provide subsidy for introduction of renewable energy in areas damaged by nuclear power plant failures in Fukushima Prefecture in 2011. This subsidy programs also supports introduction of PV systems in Iwate, Miyagi and Fukushima Prefectures. Through this program, METI aims to recover lost job opportunities and to cultivate related industries by drastically expanding dissemination of renewable energy in disaster-stricken areas. Meanwhile, MOE, aiming to promote low-carbon communities focusing on distributed energy, will start new activities in FY 2014 to establish independent and distributed energy systems in remote islands and other areas including the following: support for formulating plans to set up a project to create low-carbon communities; project to support introduction of renewable energy and energy saving facilities; and demonstration project for hybrid-type storage systems.

## 2.3 Indirect policy issues

### *2.3.1 International policies affecting the use of PV Power Systems*

Regarding the target of reducing greenhouse gas emissions by 6 % from the 1990 levels in the first commitment period of the Kyoto Protocol, the Japanese government continued promoting efforts based on the Kyoto Protocol Target Achievement Plan (Cabinet approval in April 2005), and estimates that the reduction target can be achieved. The government decided not to participate in the second commitment period of the Kyoto Protocol. In FY 2013 onwards, based on the Cancun Agreements under the United Nations Framework Convention on Climate Change (UNFCCC), the government announced that it is determined to continue actively conducting measures against global warming through setting a reduction target by 2020 and via global reporting and verification of progress to achieve the target. At the nineteenth session of the Conference of the Parties (COP 19) to the UNFCCC held in November 2013 in Warsaw, Poland, Minister of the Environment reported that Japan expects to achieve reduction of greenhouse gas emissions by 8,2 % in the first commitment period of the Kyoto Protocol, achieving its target of 6 % reduction. The minister also announced a new reduction target of 3,8 % by 2020 from the 2005 levels. The previous reduction target of greenhouse gas emissions toward 2020 was “25 % from the 1990 levels”. However, consumption of fossil fuels significantly increased to cover the lack of nuclear power since the

Great East Japan Earthquake in March 2011 which led to stop of operation of nuclear power plants. Accordingly, the target was revised with the assumption that no nuclear power plants go into operation. At the COP 19, Prime Minister Shinzo Abe expressed Japan's commitment on "ACE: Actions for Cool Earth". ACE will cover technology innovation, international expansion of Japan's low-carbon technology and support for developing countries (1.6 TJPY over three years between 2013 and 2015).

### 2.3.2 *The introduction of any favourable environmental regulations*

After the Great East Japan Earthquake, not only nuclear power plants but also several thermal power plants were forced to stop operation as they were damaged by the earthquake and tsunami, which led to tight electricity supply and demand situation. In particular, in the summer of 2011, a number of nuclear power plants were not able to restart operation. Therefore, a binding "order to restrict electricity use" was invoked, requiring electricity users to curb their electricity use. After these experiences, a law on energy conservation was amended in Japan, to make it possible for the national government to curb the energy usage on a long-term basis. The largest point of amendment is that energy management with the time concept is included such as measures for peak electricity (reduction in kW), in addition to improving efficiency of energy usage (reduction in kWh) which have been conducted earlier. In the amended Act on the Rational Use of Energy (Energy Conservation Act) published on May 31, 2013, promotion of levelling electricity demand and expansion to building materials, etc. under the Top Runner program were stated. Also, the government's plan to enhance energy conservation standards for buildings step by step was also presented.

- Promotion of levelling electricity demand

In addition to conventional energy conservation, when electricity users utilize storage batteries and energy management systems (HEMS and BEMS), or power generation facilities for self-consumption and contribute to addressing peak electricity, the contribution is counted as part of target achievement. Factories and transportation industries are obliged to set their non-binding targets and report their efforts. The calculation method to achieve the target was revised. It is possible that PV systems for self-consumption which are not eligible for the FIT program contribute to addressing peak shifting.

- Enhancement of energy conservation standards in buildings

So far, energy conservation standards were either reporting obligations or non-binding obligations depending on the floor spaces of buildings. From 2016 onwards, they will be changed to conformity obligations. By around 2020, houses covering the area of below 300 $m^2$ will also fall under conformity obligations. Housing and construction sector is forced to review their construction methods. In the standards to be reviewed, reduction of energy consumption by using PV systems and HEMS will also be evaluated. Thus, installation of these systems may be facilitated. As of FY 2013, subsidy is provided for promoting introduction of innovative energy-saving technology such as net zero energy buildings and houses (ZEB/ZEH). This subsidy is continued in FY 2014.

### 2.3.3 *Policies relating to externalities of conventional energy*

Nuclear power plants which stopped operation after the Great East Japan Earthquake have not restarted operation since October 2013. Electricity shortage is covered mostly by thermal power generation. Power generation volume by LNG, oil and coal-fired power generation increased. Dependence on fossil fuels as power source rapidly increased from 60 % before the earthquake to 90 %. Also, energy-based $CO_2$ emissions in FY 2012 also increased by around 7,5 % from that of FY 2010. In particular, electricity-based $CO_2$ emissions increased significantly. Along with these trends, trade balance went into red in 2011, for the first time in 31 years due to imports of fossil fuels. In 2013, Japan registered a record trade deficit of 11.5 TJPY. Since imported fossil fuels are influenced by situations in politically-unstable countries or areas, there are rising concerns from the perspective of energy security. Under such circumstances, securing domestically-produced energy sources is recognized as one of the important issues in the “Basic Energy Plan” which was approved by the Cabinet in April 2014. In this energy plan, renewable energy is positioned as one of the important low-carbon domestically-produced energy sources which is promising and versatile, and can contribute to energy security.

- PV’s contribution

After the Great East Japan Earthquake, electricity supply and demand status has become tight in Japan. Accordingly, the national government, with METI’s initiative, evaluates the actual performances and makes a forecast on electricity supply and demand from the viewpoint whether electricity can surely be supplied to cover the demand in peak hours in the summer and in the winter. The governments’ evaluation includes PV power generation whose installed capacity has been sharply increasing in recent years.

**Table A: Power supply capabilities of PV systems in the summer of 2014 by electric company in Japan (MW)**

| Electric company | | Hokkaido | Tohoku | Tokyo | Chubu | Kansai | Hokuriku | Chugoku | Shikoku | Kyushu | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Summer of 2013 (Actual) | **Actual installed capacity** | **170** | **520** | **2 380** | **1 570** | **1 190** | **150** | **750** | **430** | **1 600** | **8 760** |
| | **Actual supply capability** | **30** | **90** | **560** | **510** | **440** | **70** | **180** | **120** | **200** | **2 200** |
| | Peak demand date | Aug.7 | Aug.19 | Aug.9 | Aug.22 | Aug.22 | Aug.19 | Aug.22 | Aug.22 | Aug.20 | |
| Summer of 2014 (Forecast) | Purchase of surplus PV power | 120 | 750 | 2 080 | 1 330 | 1 030 | 110 | 670 | 330 | 1 230 | 7 650 |
| | Purchase of PV power (100 % from facility) | 410 | 150 | 1 710 | 1 310 | 1 310 | 110 | 690 | 350 | 2 040 | 8 080 |
| | Utility’s own PV facilities | 1 | 4 | 30 | 9 | 10 | 4 | 3 | 2 | 3 | 66 |
| | **Total estimated installed capacity** | 530 | 900 | 3 820 | 2 650 | 2 350 | 220 | 1 370 | 680 | 3 270 | 15 780 |
| | **Estimated supply capability** | **0** | **80** | **600** | **610** | **540** | **40** | **310** | **170** | **330** | **2 680** |

Source: Electricity Supply-Demand Verification Subcommittee under METI (October 2013 and April 2014)

*1: “Supply capability” of PV power generation is the installed capacity which PV systems supply power at the peak demand by electric company. This represents the capacity which PV contributed in the summer peak hours. As for estimated supply capability, each electric company is responsible for evaluating the supply capability which is surely expected to be secured in the peak demand hours. Irradiation of three days of each year with the largest electricity demand over the past twenty years is collected, and the average figure of five days with the lowest demand is evaluated as the stable supply capability.

*2: Generated power used for self-consumption is evaluated as energy conservation. Only the surplus electricity connected to electric grids is evaluated here.

As shown in Table A, in the summer of 2013, actual installed capacity was large because the installed PV capacity was more than expected. Also, as an increasing number of PV power plants started operation thanks to the FIT program, it is estimated that the installed capacity in 2014 will nearly double that of 2013 to 15,78 GW. In service areas of some electric companies such as Kyushu Electric, peak hours comes in the late afternoon (around 17:30) due to increasing awareness of energy and electricity conservation. In these areas, PV's supply capability or contribution is low.

### *2.3.4 Taxes on pollution (e.g. carbon tax)*

In Japan, "Tax for Climate Change Mitigation (Carbon Tax)" has been imposed since October 2012. This tax is imposed on top of the Petroleum and Coal Tax, in proportion to the usage of fossil fuels. Tax rate has been increased step by step over three and half years. From April 2016, 289 JPY/t-$CO_2$ will be imposed.

For the period bewteen October 2012 and March 2014, in combination with the conventional Petroleum and Coal Tax, the tax rates were 2 290 JPY/kl for crude oil and oil products, 1 340 JPY/t for hydrocarbon gas and 1 340 JPY/t for coal. From April 2014, as part of the phased tax rate increase, the rates are 2 540 JPY/kl, 1 600 JPY/t and 1 140 JPY/t, respectively. Revenue from the Carbon Tax is approximately 262,3 BJPY, which is used for promoting introduction of renewable energy, drastic enhancement of energy-saving measures and so on. Measures to curb energy-based $CO_2$ emissions will be reinforced.

### *2.3.5 National policies and programmes to promote the use of PV in foreign non-IEA countries*

Japan has been promoting activities for international cooperation to disseminate PV power generation so that it can play an active role in disseminating PV power generation particularly in Asia, in order to address global warming issues, to improve living standards in developing countries, to reduce energy consumption in other countries, and to contribute to energy security. Although Japan is not paticipating in the second commitment period of the Kyoto Protocol, it has promoted projects overseas through clean development mechanism (CDM) and joint implementation (JI), based on the Kyoto Mechanism in the first commitment period of the Kyoto Protocol. As of the end of 2012, there are 766 CDM projects and 55 JI projects approved by the Japanese government. Regarding PV power generation, there are 11 projects totalling over 100 MW are underway in the Philippines, China (IEA PVPS member country) and South Korea (IEA PVPS member country). As to Joint Crediting Mechanism (JCM), Japan signed bilateral documents in 2013 with Mongolia, Bangladesh, Ethiopia, Kenya, Maldives, Vietnam, Laos and Indonesia.

As for technology development through international cooperation, projects are conducted by the New Energy and Industrial Technology Development Organization (NEDO). Among major PV-related projects in non-IEA PVPS countries, there are two projects as follows: Smart Community Demonstration Project in an Industrial Complex in Java Island, Indonesia (FY 2012 - 2015) and a technology demonstration project using large-scale PV systems in India (FY 2012 - 2014).

Besides, Japan International Cooperation Agency (JICA) and Japan Bank for International Cooperation (JBIC) also implement activities overseas related to PV power generation.

- JICA implements inter-governmental cooperation, through grant aid or loan assistance, as well as technological cooperation projects based on requests from developing countries. It supports developing master plans mainly for rural electrification using PV power generation through the study of development for rural electrification. In recent years, JICA has enhanced its activities in the areas of replacement for diesel power generation in island nations, introduction of large-scale PV projects through loan assistance, as well as development and improvement of human resources.

- JBIC actively provides financing supports to environmental protection projects as part of its GREEN (Global action for Reconciling Economic growth and ENvironmental preservation) activities. It also plays a central role in the acquisition of emissions rights based on the Kyoto Protocol.

# 3 HIGHLIGHTS OF R&D

## 3.1 Highlights of R&D

New Energy and Industrial Technology Development Organization (NEDO) continued R&D Projects named "R&D for High Performance PV Generation System for the Future", "R&D on Innovative Solar Cells" and "Development of Organic Photovoltaics toward a Low-Carbon Society" under FIRST Program (Funding Program for World leading Innovative R&D on Science and Technology) in 2013.

Under the "R&D for High Performance PV Generation System for the Future", research projects on crystalline silicon solar cells, thin film silicon solar cells, CIS solar cells and organic thin-film solar cells are continued. Following the the results of interim evaluation of the program conducted in 2012, a project on silicon feedstock manufacturing was finished and new projects including development of CZTS solar cell were started in 2013.

Under the "R&D on Innovative Solar Cells" that will be finished in March 2015, 4 research projects were continued in 2013: i) post-silicon solar cells for ultra-high efficiencies (multi-junction solar cells); ii) novel thin film multi-junction solar cells with a highly-ordered structure; and iii) thin-film full spectrum solar cells with low concentration ratios and iv) high-efficiency concentrating solar cells, a joint research of European Union (EU) and Japan.

As for organic PV (OPV) technology, the project named "Development of Organic Photovoltaics toward a Low-Carbon Society (FIRST Program)" led by the University of Tokyo has been continued.

Most of research programs will be finished in the end of FY 2014 (March 2015) and NEDO started planning of R&D programs for the next phase starting in FY 2015.

Meanwhile, the following two fundamental R&D programs by Japan Science and Technology Agency (JST) under the Ministry of Education, Culture, Sports, Science and Technology (MEXT) have been continued: i) Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells and ii) Creative Research for Clean Energy Generation Using Solar Energy.

In addition to these projects, as a part of efforts under "Advanced Low Carbon Technology Research and Development Program (ALCA Program)", fundamental research projects aiming at developing solar cells that can contribute to achieving 7 JPY/kWh were conducted mainly by universities. n the area of "Solar Cell and Solar Energy Systems", total 18 projects including new 5 projects started in 2013 are underway.

Tokyo Institute of Technology (TIT) has been leading "FUTURE-PV Innovation Projects" since 2012 through JST aiming at highly efficient silicon nano-wire solar cells as one of the efforts under the "program to establish an innovative energy research center" by MEXT. Research activities under the projects were transferred to Fukushima Renewable Energy Institute (described below) from April 2014.

While most demonstration activities on practical application of PV power generation are conducted in several demonstration projects aiming at realizing smart communities, NEDO is implementing 2 demonstration projects on practical application of developed technologies and application technologies of PV systems.

Under "Leading technological development for commercialization of organic PV" started in FY 2012, NEDO selected 6 projects in FY 2012 and 3 projects in FY 2013 for pilot production and demonstration of DSCs and OPVs in order to demonstrate those solar cells in the real environment and identify issues.

In FY 2013, NEDO started a new 3-year demonstration project, "Demonstration project for diversifying PV application" in order to extend application area of PV systems. 12 projects were selected to demonstrate installation technologies for agricultural lands, tilted slopes, water surface and power generation efficiencies and BIPV technologies in November 2013. In addition to these, METI implemented “Demonstration project on developing power output forecasting technology of PV power generation” as one of the measures to enhance power system infrastructure for the use of PV power generation.

In October 2013, the National Institute of Advanced Industrial Science and Technology (AIST) established a new research center, “Fukushima Renewable Energy Institute” that AIST made efforts for its preparation in Koriyama City, Fukushima Prefecture. In the institute, projects of research and development of renewable energy technologies and their applications such as PV power generation and hydrogen energy are conducted. In the area of PV power generation, technological development of high-efficiency crystalline silicon solar cells and FUTURE-PV Innovation Projects are conducted in the new institute. In the area of PV system, demonstration projects will be conducted in the link with wind and geo-thermal power generation. In April 2014, transfer of human resources and equipment from Tsukuba were finished and full-fledged research activities were started.

## 3.2 Public budgets for market stimulation, demonstration / field test programmes and R&D

The FY 2013 budgets for PV system-related R&D, demonstration programs and market incentives are mainly based on national budgets as shown in Table 7.

The budget for R&D is the sum of “R&D on Innovative Solar Cells”, “R&D for High Performance PV Generation System for the Future”, “Leading technological development for commercialization of organic PV” and financed by The Ministry of Economy, Trade and Industry. The R&D budget for renewable energy and the budget from The Ministry of Education, Culture, Sports, Science and Technology (MEXT) are not included. The budget for the demonstration is allocated for the first year spending of “Demonstration project for diversifying PV application” started from FY 2013.

The budget for market incentives is based on “Subsidy for introducing residential PV systems as restoration measures” and “Projects for establishing a fund for high penetration of residential PV systems as restoration measures”, formulated as multi-fiscal year funding within the FY 2011 3rd supplementary budget. These programs were finished in the end of FY 2013.

The budgets of local governments played an important role in the market incentives. As of 14th November 2013, 1 267 municipalities among total 1,740 municipalities all over Japan implemented subsidy programs for residential PV systems. The amount of subsidy for PV system varies by municipality and the total amount is unknown. Majority of municipalities provide the subsidy ranging from 20 000 JPY/kW to 50 000 JPY/kW (average subsidy is 38 000 JPY/kW).

**Table 7: Public budgets for R&D, demonstration/field test programmes and market incentives.**

| | FY 2011 | | | FY 2012 | | | FY 2013 | | |
|---|---|---|---|---|---|---|---|---|---|
| | R&D | Demo/ Field Test | Market Stimulation | R&D | Demo/ Field Test | Market Stimulation | R&D | Demo/ Field Test | Market Stimulation |
| National (BJPY) | 5,98 | 2,38 | 55,13 | 10,4 | 0,04 | 119,38[1] | 8,76 | 0,5 | 119,38[1] |
| Regional [2] (BJPY) | - | - | - | - | - | - | - | - | - |

[1]: Market incentives: Budget for more than a fiscal year.

[2]: More than 1 000 municipalities such as prefectures, cities, towns, and villages are implementing their own subsidy programs for residential PV systems in 2013; the budget amount is unknown.

# 4 INDUSTRY

## 4.1 Production of feedstocks, ingots and wafers (crystalline silicon industry)

**Table 8: Production information for the year for silicon feedstock, ingot and wafer producers in 2013**

| Manufacturers (or total national production) | Process & technology [1] | Total Production | Product destination (if known) | Price (if known) |
|---|---|---|---|---|
| Tokuyama | Polysilicon (Siemens process) | 1 000 tonnes [2] | | |
| M.SETEK | Polysilicon | tonnes | | |
| | sc-Si ingot | | | |
| Mitsubishi Materials | Polysilicon (for semiconductor, Siemens process) | Undisclosed | | |
| OSAKA Titanium technologies | Polysilicon (for semiconductor, Siemens process) | Very little [3] | | |
| Ferrotec | | | | |
| Shin-Etsu Chemical | Si wafers | | | |
| Panasonic (SANYO Electric) | n-type sc-Si wafers for HIT (a-Si on c-Si) (125 mm x 125 mm) | Undisclosed | Internal use | |
| Kyocera | mc-Si wafers (p-type, 156 mm x 156 mm) | c.a. 1 200 MW | Internal use | |
| Choshu Industry | | | | |
| Silicon Plus (Spower) | Ingot | 5 tonnes | Domestic/ overseas | |
| | Si wafers | (Production capacity: 20 mil. wafers/yr) | Domestic | |
| Kasatani | n-type sc-Si wafers | 60 MW [4] | Domestic | |

| | | | | |
|---|---|---|---|---|
| TKX [4] | Si wafer processing | | | |

[1]: c-Si: crystalline silicon, sc-Si: single crystalline silicon, mc-Si: multicrystalline silicon, a-Si: amorphous silicon

[2]: Excluding the production for semiconductor

[3]: Off-grade products only (derivatives of polysilicon for semiconductor only)

[4]: Silicon wafer processing with ingots from third parties

Source: answers from each company for the questionnaire by NEDO

Among overseas activities by Japanese manufacturers of silicon feedstock for solar cells, ingots and wafers, Tokuyama constructed a large-scale polysilicon production plant in Sarawak, Malaysia. The first-phase plant started production in November 2013. Tokuyama is currently confirming the optimal production conditions in terms of facilities and quality, in order to acquire certification for semiconductor-grade polysilicon. The second-phase plant is scheduled to start production and sales of solar-grade polysilicon in the middle of 2014. Panasonic produces wafers for its own HIT solar cells. They purchase silicon feedstock and process n-type sc-Si ingots by CZ process in Oregon, USA, then slice them into 125 mm x 125 mm wafers in a production plant in Malaysia. Mitsubishi Materials owns its wholly-owned polysilicon production subsidiary (production capacity: 1 500 t/yr) in Alabama, USA, almost 100 % of whose production is semiconductor-grade polysilicon.

## 4.2 Production of photovoltaic cells and modules (including TF and CPV)

So far, Japanese crystalline silicon PV manufacturers have used internally-produced solar cells. However, in order to respond to the rapidly-growing PV market in Japan thanks to the FIT program which started in July 2012, some companies purchase solar cells from overseas, mainly from China and Taiwan to cover the shortage. On the other hand, some companies, mainly major electric appliances manufacturers, purchase PV modules from overseas manufacturers as components of PV systems. For general-purpose products, they purchase mainly from China for cost merits, whereas they purchase high efficiency products from SunPower (USA) and others to secure high performance products for residential PV applications.

According to statistics by the Japan Photovoltaic Energy Association (JPEA), total shipment of PV modules in 2013 was 7 677 MW, 2,5 times that of 2012, exceeding the previous record figure by a large margin. Domestic production volume was 3 607 MW. In the domestic market, production for domestic market was 3 436 MW and that for import was 4 069 MW. The share of production for domestic market to the total domestic shipment volume decreased from 68,6 % to 45,8 % between 2012 and 2013. This is the first time that the ratio did not reach 50 %. Meanwhile, export largely decreased to 171 MW as suppliers put priority in shipment for the domestic market. The largest export destinations of PV modules were non-European/ US countries with 129 MW, accounting for 75 % of the total export. Export of solar cells was 111 MW, of which 73 MW was for Europe, accounting for 66 %.

Among the products which are specially designed for Japan, there are supporting structures and installation methods enhanced or suitably designed for weather conditions in Japan. These products on the market include PV modules with higher withstand load suitable for heavy snow areas, PV modules with measures against salt damage in coastal areas, dust-proof and water-proof inverters. As for residential PV systems, housing manufacturers one after another have announced houses equipped with ≥ 10 kW PV systems which are eligible for the gross purchase of electricity under the FIT program.

PV manufacturers developed and launched various products in 2013. PV modules with different technologies were announced, including those with improved efficiency in PV cells and modules and PV modules with higher efficiency and output. For single-family houses, PV modules in various shapes (triangle, small-area, etc.) were launched, designed to fit unique shapes of roofs of the houses in Japan and to increase installed capacity. For residential PV systems, there are products equipped with HEMS and storage systems, applicable for smart houses. For thin-film PV products, Solar Frontier developed and launched a light-weight (ca. 8 kg/module) CIS PV module. Sharp launched a new see-through PV module which can be used as glass building material.

PV manufacturers have been expanding their sales activities and power generation business overseas, mainly in the USA and Asian countries. Sharp provides services for large-scale PV power plants including O&M and monitoring. Meanwhile, overseas production of these manufacturers was affected by the changes in market trends, including closure of factories in 2013. Panasonic stopped wafer production at its factory in Oregon, USA to focus on manufacturing of ingots. In Hungary, they decided to stop PV module production and to close the factory. They will shift to an integrated production framework in their factory in Malaysia covering wafer slicing and production of PV cells and modules. They started a full-scale mass production in 2013, reorganizing their global production framework. Sharp, affected by the shrinking European market, stopped PV module production in the UK.

Meanwhile, in Japan, two thin-film PV manufacturers announced withdrawal from the PV production between 2013 and early 2014. Honda Soltec stopped production of CIGS PV modules in March 2014. Fuji Electric announced that they would transfer their a-Si solar cell business to FWAVE, a wholly-owned Japanese subsidiary of ZinniaTek (New Zealand), effective at the end of March 2014. Both companies faced difficulties in continuing their PV business due to the price gaps between c-Si PV products and thin-film PV products as well as their lack of competitiveness in product performance.

**Table 9: Production and production capacity information for 2013**

| Cell/Module manufacturer (or total national production) | Technology [1] (sc-Si, mc-Si, a-Si, CdTe) | Total Production (MW) | | Maximum production capacity (MW/yr) | |
|---|---|---|---|---|---|
| | | Cell | Module | Cell | Module |
| *Wafer-based PV manufacturers* | | | | | |
| **1 Sharp** | c-Si | Undisclosed | (Shipment: 1 758 MW) | Undisclosed | 1 355 |
| **2 Kyocera** | mc-Si | Undisclosed | ca. 1 200 | Undisclosed | 1 200 |
| **3 Panasonic (SANYO Electric)** | HIT (a-Si on c-Si) | Undisclosed | Undisclosed | Undisclosed | Undisclosed |
| **4 Mitsubishi Electric** | sc-Si | 280 | 500 | 300 | 650 |
| **5 Fujipream** | sc-Si | 0 | 24,7 | 0 | 50 |
| | mc-Si | 0 | 14,6 | 0 | 50 |
| | sc-Si (BIPV) | 0 | 0 | 0 | 6 |
| | mc-Si (BIPV) | 0 | 0 | 0 | 6 |
| **6 Choshu Industry** | sc-Si | | | | |
| | mc-Si | | | | |
| **7 Suntech Power Japan** | sc-Si | - | 0,25 | - | 99 |
| | BIPV | - | 0,17 | - | 1 |
| **8 Itogumi Motech** | sc-Si | - | 2,3 | - | 10 |
| | mc-Si | - | 57,3 | - | 70 |
| **9 Towada Solar** | sc-Si | - | 2,72 | - | 3,0 |
| | mc-Si | - | 6,07 | - | 7,0 |

| | | | | | |
|---|---|---|---|---|---|
| **10 GMG** | sc-Si | 0 | 0 | 0 | 0 |
| | mc-Si | 0 | 0 | 0 | 0 |
| **11 Noritz** | mc-Si | | | | |
| **12 Japan Solar Factory** | sc-Si | - | 2,0 | - | 30 |
| | mc-Si | - | 0,5 | - | 30 |
| **13 Spower** | c-Si | | | | |
| **14 PVG Solutions** | sc-Si | 7 | - | 35 | - |
| Total | | *1 921* [4] | *2 597* [4] | *2 180* [3] | *2 947* [3] |
| *Thin film manufacturers* | | | | | |
| **1 Solar Frontier** | CIS | 929 | 929 | 980 | 980 |
| **2 Kaneka** | a-Si, a-Si/poly-Si hybrid | 52 | 52 (incl. 27 MW of BIPV) | 120 | 120 (incl. 45 MW of BIPV) |
| **3 Sharp** | a-Si/μc-Si | Undisclosed | (Shipment: 107 MW) | Undisclosed | 320 |
| **4 Honda Soltec** [2] | CIGS | 14,5 | 14,5 | 30 | 30 |
| **5 Fuji Electric** [2] | a-Si | | | | |
| **6 Mitsubishi Chemical** | a-Si, OPV | Undisclosed | Undisclosed | Undisclosed | Undisclosed |
| *Cells for concentration* | | | | | |
| **1 Daido Steel** | CPV | | <1 | | <1 |
| **2 Sumitomo Electric Industries** | CPV | | | | |
| **TOTALS** | | **2 922** [4] | **3 608** [4] | **3 499** [3] | **4 266** [3] |

[1]: c-Si:crystalline silicon ,sc-Si: single crystalline silicon, mc-Si: multicrystalline silicon, a-Si: amorphous silicon, μc-Si: microcrystalline silicon, poly-Si: multi-crystalline Si thin-film, OPV: organic thin-film PV

[2]: Withdrew from PV business

[3]: Studied by RTS Corporation

[4]: Shipment statistics by the Japan Photovoltaic Energy Association (JPEA)

## 4.3 Manufacturers and suppliers of other components

- Inverters

With regards to inverters for residential applications, Japanese manufacturers such as Omron, Tabuchi Electric, Panasonic, Mitsubishi Electric and Yaskawa Electric are dominating the market, with some overseas manufacturers including SMA Solar Technology. Residential applications are shifting towards multiple-unit grid-connection type inverters, with manufacturers including Omron, Yaskawa Electric, Panasonic, Kyocera and Sharp already having their products certified for multiple-unit grid-connection type inverters.

For 10 kW to <50 kW inverters for low-voltage grid connection, major inverters on the market include a 9,9-kW inverter by Tabuchi Electric; a 5,5-kW inverter by Omron; and 10-kW inverters by Shindengen Electric Manufacturing, Yaskawa Electric, GS Yuasa and Sanyo Denki. Overseas manufactures such as SMA have also entered this area.

In systems with a capacity over 50 kW, which are connected to high-voltage grids, more than two inverters are often installed in order to increase the total capacity as well as the system reliability. Unit capacities of inverters include 10 kW, 20 kW, 25 kW, 100 kW, 250 kW, 500 kW, 600-kW level and 1 000 kW.

With regard to inverters with a capacity of 100 kW and more, the market has been led by heavy electric manufacturers including TMEIC, Daihen, Nissin Electric, Meidensha, Fuji Electric and Hitachi, with recent entries of manufacturers such as GS Yuasa, Sanyo Denki, Yaskawa Electric and Hitachi Industrial Equipment Systems. Overseas manufacturers such as SMA, ABB and KACO have also joined the market.

For ≤10 kW inverters, a certification scheme by the Japan Electrical Safety & Environment Technology Laboratories (JET) has been introduced. For >10 kW inverters, approval is given by electric companies individually.

JET certification is categorized into three types of inverters: 1) conventional type; 2) multiple-unit grid-connection type and 3) FRT-support type. Multiple-unit grid-connection type is designed for inverters that employ an islanding operation detection method by frequency feedback method with step reactive power injection (JEM-1498) and an FRT (Fault Ride Though) function.

Table B shows average prices of grid-connected PV inverters.

**Table B: Average prices of grid-connected PV inverters** **(JPY/kW)**

| INVERTER SIZE | FY 2011 | FY 2012 | FY 2013 |
|---|---|---|---|
| 10-100 kVA | 82 000 | 66 000 | 60 000 |
| > 100 kVA | 68 000 | 52 000 | 48 000 |

- Storage batteries

Storage batteries are used in zero energy house (ZEH) in combination with PV systems, as measures to address peak cut and peak shift as well as to stabilize electric grids. In particular, lithium ion storage batteries are used to achieve zero energy in houses. For the use of lithium ion storage batteries, the national support program called “Project to support introduction of lithium ion storage batteries for stationary applications” is available. Sustainable open Innovation Initiative (SII) is the contact window for this program. In 2013, 10 000-level systems were installed, mainly in newly-built houses. A demonstrative research to ease fluctuations of power flow on a short- to mid-term basis was conducted by installing large-capacity power storage facilities in electric grids. As a result, redox flow storage batteries and lithium ion storage batteries were installed in electric grids of Hokkaido Electric, Tohoku Electric and Kyushu Electric and so on.

- Battery charge controllers

Battery charge controllers are used for small-scale off-grid power source systems for rural electrification, etc. There is no such product in Japan on a commercial level.

- DC switch gears

Also called junction boxes, they are manufactured by such manufacturers as Nitto Denko and Kawamura Electric. Some products have string monitors embedded. Overseas manufacturers in this area include Weidmueller and ABB.

- Supporting structures

For supporting structures, hot-dip steel plate with high corrosion resistance, molten hot-dip galvanizing steel plate and single-tube pipes, aluminum and stainless steel are used. Among them, those made of hot-dip steel plate with high corrosion resistance is the most popular. They are manufactured by such manufacturers as Neguros Denko and Okuji Kensan.

## 5 COMPETITIVENESS OF PV ELECTRICITY

### 5.1 Module prices

Table 10 shows typical PV module prices for a number of years for residential applications. These are end-user prices. The price in 2013 decreased by 10 % from 2012.

Typical prices of PV modules in 2013 by capacity range were 252 JPY/W (61 % of the system cost) for residential PV systems with a capacity below 10kW, 190 JPY/W (50 %) for those with a capacity between 10 KW and below 50 kW, 145 JPY/W (44 %) for those with a capacity between 50 kW and below 1 MW and 112 JYP/W (41 %) for those with a capacity of 1 MW or more. These prices widely vary depending on the system size and there is a large price gap between residential PV systems and MW-scale PV power plants.

**Table 10: Typical module prices for a number of years**

| Year | Average price (JPY/W) | Best price (JPY/W) |
|---|---|---|
| 1992 | 996 | |
| 1993 | 950 | |
| 1994 | 927 | |
| 1995 | 764 | |
| 1996 | 646 | |
| 1997 | 652 | |
| 1998 | 674 | |
| 1999 | 598 | |
| 2000 | 542 | |
| 2001 | 481 | |
| 2002 | 462 | |
| 2003 | 451 | |
| 2004 | 441 | |
| 2005 | 428 | |
| 2006 | 433 | |
| 2007 | 436 | |
| 2008 | 447 | 386 |
| 2009 | 393 | 347 |
| 2010 | 366 | 343 |
| 2011 | 327 | 306 |
| 2012 | 280 | 269 |
| 2013 | 252 | 242 |

## 5.2 System prices

Table 11 shows typical applications and prices of PV systems by category. Table 12 shows the trends in system prices. The standardization of grid-connected PV systems (mainly the residential PV market) has progressed with the growth of the PV market in Japan, and the prices have been decreasing. On the other hand, off-grid system prices are determined case by case because there are various types of applications and the size of each market is small.

**Table 11**: **Turnkey Prices of Typical Applications**

| Category/Size | Typical applications and brief details | Current prices per W (JPY/W) |
|---|---|---|
| OFF-GRID <1 kW | Telecommunications, lighting, traffic and road signs, ventilating fans, pumps, remote monitoring, navigation signs, clock towers, etc. | N.A. |
| OFF-GRID ≥1 kW | Agricultural facilities, communication facilities, disaster prevention facilities, mountain cottages, park facilities, housing in remote areas, lighthouses, etc. | N.A. |
| Grid-connected Rooftop <10 kW (residential) | | 413 |
| Grid-connected Rooftop 10 - <50 kW (commercial) | | 369 |
| Grid-connected Rooftop < 50 - <1MW | | 342 |
| Grid-connected Ground-mounted ≥1 MW | Power generation business | 275 |
| Other category (hybrid diesel-PV, hybrid with battery…) | | N.A. |

**Table 12: National trends in system prices (current) for different applications**

(JPY/W)

| | Residential PV systems (< 10 kW) | Commercial and industrial average (50 -1MW) | Ground-mounted average (≥1MW) |
|---|---|---|---|
| 1994 | 1 920 | | |
| 1995 | 1 510 | | |
| 1996 | 1 090 | | |
| 1997 | 1 062 | | |
| 1998 | 1 074 | | |
| 1999 | 939 | | |
| 2000 | 844 | | |
| 2001 | 758 | | |
| 2002 | 710 | | |
| 2003 | 690 | | |
| 2004 | 675 | | |
| 2005 | 661 | | |
| 2006 | 683 | | |
| 2007 | 696 | | |
| 2008 | 723 | | |
| 2009 | 605 | | |
| 2010 | 559 | | |
| 2011 | 513 | | |
| 2012 | 451 | 372 | 280 |
| 2013 | 413 | 342 | 275 |

## 5.3 Financial Parameters and programs (leasing…)

Since the FIT program started, a number of commercial PV power plants have been constructed one after another. With this trend, financing schemes have become more diversified. However, financing entities do not have enough understanding or experiences in the PV industry and they are still looking for the best ways. Since Japanese financial institutions, in particular, tend to focus on collateral, it is difficult for PV projects to secure finance since their value as collateral is low and the value of land as an asset cannot cover the loan. Financing PV projects in Japan is in the process of developing financing schemes best-suited for PV projects, through combination of equity and debt finance as well as mezzanine finance.

- Project finance: All the assets and rights of the project are set as collateral to finance the sponsor with non-recourse or limited recourse loans.

- Asset-based lending (ABL): Facilities are set as collateral for assignment of collective movable assets and power sales are set as collateral for assignment of power sales claims to execute loans.

- Institutional loans by local governments and municipalities (start-up loan): Local governments and municipalities, credit guarantee associations and financial institutions share the risk for the loans by financial institutions.

- Leasing: Leasing companies own the facilities and operators pay the lease fee. Initial investment is not required.

In order to increase bankruptcy remoteness, some projects adopt a trust scheme. In the first business year, they take advantage of the Green Investment Tax Credit with which one-time depreciation is available. There are quite a few cases where PV systems are used as part of tax saving.

**Table 13: PV financing scheme  (described in the text above)**

## 5.4 Additional Country information

**Table 14: Country information**

| | |
|---|---|
| Retail Electricity Prices for an household (Low voltage 100 V or 200 V)(TEPCO, Tokyo Electric Power Company) | Base rate: 273,00 JPY/10 A (1 kVA)<br>Charge for the volume of usage: <120 kWh/month 18,89 JPY/kWh, 120 - 300 kWh/month 25,19 JPY/kWh, >300 kWh/month 29,10 JPY/kWh (TEPCO, type B, typical ampere for general household: 10 - 60 A, three-phase pricing system with prices varying depending on the volume of usage)<br>*1: “Surcharge to promote renewable energy power generation (0,35 JPY/kWh)” and “surcharge to promote PV power generation (0,05 JPY/kWh)” will be added on top of the above-mentioned charge, depending on the electricity usage.<br>*2: There are various price plans depending on hours and seasons.<br>(Source: TEPCO’s website, March 1, 2014) |
| Retail Electricity Prices for a commercial company (High voltage: ≤6,6 V, extra high voltage: >22 kV)(TEPCO) | Base rate: 1 638 JPY/kW<br>Charge for the volume of usage: 16,65 JPY/kWh (summer), 15,55 JPY/kWh (other seasons)(TEPCO, high voltage electricity for commercial use)<br>*1: same as above<br>(Source: TEPCO’s website, April 1, 2014) |
| Retail Electricity Prices for an industrial company (High voltage: ≤6,6 V, extra high voltage: >22 kV) (TEPCO) | Base rate: 1 732,50 JPY/kW<br>Charge for the volume of usage: 15,34 JPY/kWh (summer), 14,37 JPY/kWh (other seasons)TEPCO, high voltage electricity (≥500 kW))<br>Base rate: 1 233,75 JPY/kW<br>Charge for the volume of usage: 16,49 JPY/kWh (summer), 15,41 JPY/kWh (other seasons)(TEPCO, high voltage electricity A (<500 kW))<br>*1: same as above<br>(Source: TEPCO’s website, March 1, 2014) |
| Population at the end of 2013 (or latest known) | 127,12 million (Statistics Bureau, Ministry of Internal Affairs and Communications (MIC), finalized in October |

| | |
|---|---|
| | 2013) |
| Country size ($km^2$) | 377 960km$^2$ (Statistics Bureau, MIC) |
| Average PV yield in kWh/kWp | 1 000 – 1 100 kWh/kW/yr |
| Name and market share of major electric utilities (share by sales) | 1 TEPCO 33,5 %<br>2 Kansai Electric 16,0 %<br>3 Chubu Electric 14,9 %<br>4 Tohoku Electric 10,1 %<br>5 Kyushu Electric 8,7 %<br>6 Chugoku Electric 6,7 %<br>7 Hokkaido Electric 3,3 %<br>8 Shikoku Electric 3,2 %<br>9 Hokuriku Electric 2,8 %<br>10 Okinawa Electric 0,9 %<br>Source: Industry trends |

# 6 PV IN THE ECONOMY

## 6.1 LABOUR PLACES

**Table 15: Estimated PV-related labour places in 2013**

| | 2012 | 2013 |
|---|---|---|
| Research and development (not including companies) | 1 000 | 1 000 |
| Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D | 46 000 | 100 300 |
| Distributors of PV products | | |
| System and installation companies | | |
| Electricity utility businesses and government | | |
| Other | | |
| **Total** | 47 000 | 101 300 |

## 6.2 Business value

**Table 16: Value of PV business**

| Sub-market | Capacity installed in 2013 (MW) | Price (JPY/W) | Value (MJPY) | Totals (MJPY) |
|---|---|---|---|---|
| **Off-grid <1 kW** | | | | |
| **Off-grid ≥1kW** | | | | |
| **Grid-connected roof-top < 10 kW (for residential)** | 1 406 | 413 | 580 519 | |
| **Grid-connected for commercial** | 1 878 | 369 | 700 673 | |
| **Grid-connected for industrial** | 1 439 | 342 | 642 314 | |
| **Grid-connected ≥ 1MW** | 1 771 | 275 | 486 982 | |
| **Total** | 6 953 | | | 2 410 488 |
| **Export of PV products** | | | | 11 700 |
| **Change in stocks held** | | | | |
| **Import of PV products** | | | | 304 108 |
| ***Value of PV business*** | | | | 2 106 380 |

Value of PV business has been significantly growing thank to a strong demand. Import value of PV products is on the increase. Although some overseas manufacturers started exporting their inverters to Japan, their export value is low and is not included in this table. Import value described in Table 16 is an estimated value of import of PV modules.

# 7 INTEREST FROM ELECTRICITY STAKEHOLDERS

## 7.1 Structure of the electricity system

In Japan, 10 general electricity utilities are in operation in each region, providing all of power generation, transmission, distribution and retail services. In their service areas where they have permissions from the national government, they owe duty of power supply to customers who are not supplied power from others. The general electricity utilities are allowed to regionally monopolize the power service in a vertically integrated manner, and investment return by fully distributed cost method is assured.

Customers for 50 kW or over in extra-high voltage and high voltage electricity are institutionally deregulated, with approximately 62 % of electricity is in the scope of deregulation. However, the market structure of a virtual monopoly by the general electricity utilities basically remains unchanged, and the present market is not competitive enough. Market share of new entrants in the retail market is only 3,6 % in FY 2011. On top of that, the Great East Japan Earthquake revealed structural problems of the current electricity system. Flexible and stable supply was difficult when nuclear power plants suspended operation due to the Earthquake and power supply and demand got stringent. They were not able to provide power through power interchange in wide areas or accommodate power from non-utility power generation. It became apparent that the current electricity system, established after World War II to support post-war high-growth period, is outdated in today's huge paradigm shift over power supply. Therefore, the government plans to promote deregulation of the electricity business in three phases as shown in Table C to establish revitalized market and a smarter and more robust electricity system.

## 7.2 Interest from electricity utility businesses

- Introduction of large-scale PV power plants by electricity utilities

Federation of Electric Power Companies (FEPC) of which the 10 general electricity utilities are members announced in October 2008 that the 10 utilities will construct large-scale PV power plants with a total capacity of 140 MW. As of the end of 2013, all the installation is not completed. PV power plants owned by electricity utilities, however, are not eligible for the Feed-in Tariff (FIT) system.

- Development of technology to forecast power generation volume

To operate power grids stably when PV systems are introduced in large scale, electricity utilities take initiative in technology development and demonstrative researches for forecasting PV power generation volume in short cycles as a subsidized project by METI. In addition to the 10 electricity utilities, the University of Tokyo, the Japan Weather Association and electrical manufacturers participate in the project. The 10 electricity utilities monitor pyranometers installed in

321 locations nationwide. The project focuses on two key objectives as follows:

1) Understanding of PV power generation output data

Utilizing pyranometers and voltage/ power flow sensors installed in power distribution grids, the project will develop technology to understand output status of PV systems in a macro perspective. The project aims to accurately understand PV capacity on a regional basis to forecast power flow and get the picture of the levelling effect.

2) Development of PV output forecast technology in short cycles

Applying weather forecast technology, the projects will forecast PV output on a daily basis and by every three to five minutes to apply the results for daily supply-demand control and grid management including frequency adjustment. It aims to understand algorithm of output power forecast and to formulate it as a system.

- Development of power storage technology utilizing large-scale storage batteries

The project reviews the use of large-scale storage batteries to store power and coordinate fluctuations which cannot be adjusted by grid management in case of large-scale introduction of renewable energy. Currently, Hokkaido Electric conducts a demonstrative experiment to study the effect through 60 MWh of redox flow batteries at its substations using subsidy from METI. Tohoku Electric also conducts the same experiment with 20 MWh of lithium ion batteries.

- Enhancement of inter-area grid connection lines

There are two frequencies in Japan: 50 hertz in eastern Japan and 60 hertz in western Japan, and the capacity of the frequency conversion station connecting eastern and western Japan is only 1 GW. Furthermore, it is also pointed out that inter-regional grid connection lines to transport power from areas with vast land and sufficient renewable energy resources to points of demand are weak. To solve these issues, enhancement of inter-regional grid connection lines is needed, and how much grid capacity has to be reinforced and how to share the cost burden are being reviewed by the national government level in conjunction with electricity system reform. Specific measures are about to begin as such enhancement of inter-regional grid connection lines will not only help increase the receiving capacity of renewable energy but also lead to the enhancement of stable supply.

## 7.3 Interest from municipalities and local governments

In addition to the national support measures, PV support programs implemented by local governments and municipalities play an important role for the dissemination support of PV systems. As of November 14, 2013, 1 267 of approximately 1 740 local governments and municipalities nationwide have implemented subsidy programs to support installation of residential PV systems. Majority of them provide the subsidy ranging from 10 000 JPY/kW to 50 000 JPY/kW. To award subsidy or low-interest loans, some of them require that HEMS should be installed with residential PV systems at the same time. Tokyo Metropolitan Government (TMG) terminated the subsidy program for residential PV systems on March 31, 2013 and started so-called the “Power of the Roof” solar project from April 2013 for residential PV systems. This project helps provide reliable residential PV systems at a price lower than the market price through low-interest loan programs in partnership with financial institutions as well as package installation plans including after-sales service by designated distributors. Kanagawa Prefecture also offers “Kanagawa Solar Bank System”, a similar program as Tokyo’s “Power of the Roof” solar project, for PV systems for residential and industrial applications.

On top of the subsidy for residential PV systems, some local governments and municipalities offer subsidy programs for industrial installation and programs for low-interest loan or loan facilitation. Furthermore, the “roof-lease project” in which roofs of the public facilities including schools and apartments as well as public land are leased for the PV installation sites for profit and cases of the investment for the construction and operation of large-scale PV power plants by local governments and municipalities are emerging. In addition to the installation of large-scale PV power plants in Tokyo, TMG established private-public fund, planning to invest in total approximately 10 MW of large-scale PV power plants in six locations nationwide. Kanagawa Prefecture is compiling

“Kanagawa Smart Energy Plan” to disseminate PV power generation, including investment in large-scale PV power plants and “roof-lease project”.

# 8 STANDARDS AND CODES

## 8.1 Standards

As for the standards regarding PV power generation, industrial associations for electric appliances, The Japan Electrical Manufacturers' Association (JEMA) and the Optoelectronics Industry and Technology Development Association (OITDA) are taking a major role in mapping out draft standards. The Japanese Standards Association (JSA) compiles the draft standards and proposes them to the Japanese Industrial Standards Committee (JISC) for deliberation based upon the Industrial Standardization Act. After these procedures, the Japanese Industrial Standards (JIS) standards are formulated. Currently, a large number of standards are formulated according to the standardization framework listed in Table D. Although the standards basically comply with the IEC standards by the International Electrotechnical Commission (IEC), some of them reflect unique circumstances of Japan. Recently, vigorous efforts have been made to establish standards for reliability of PV modules, balance of systems (BOS) and the entire PV system.

In FY 2013, JIS standards for crystalline silicon and thin-film PV modules (JIS C 8918 and JIS C 8939) were revised to harmonize testing method globally. This revision is expected to help reduce the burden of operators as well as to encourage entry to the global market.

## 8.2 Certification

Japan Electrical Safety & Environment Technology Laboratories (JET) started a certification program for PV modules, “JETPVm certification” in October 2003. This is equivalent to the TÜV certification which is conducted mainly in Europe covering non-concentrator type crystalline silicon and thin-film PV modules for terrestrial installation for sale.

Model certification of PV modules and annual inspection of factories are conducted and labels will be issued for the PV modules which satisfy the standards. Performance tests are conducted in compliance with IEC61215 Ed.2 (JIS C 8990) for crystalline silicon PV modules and IEC61646 Ed.2 (JIS C 8991) for thin-film PV modules. Furthermore, the following safety standards were added in 2006:

- IEC61730-1 Ed.1 (JIS C 8992-1): Certification of safety conformity of PV modules - Part 1: Structure requirements

- IEC61730-2 Ed.1 (JIS C 8992-2): Certification of safety conformity of PV modules - Part 2: Testing requirements

As the JETPVm certification system has been certified by the CB-FCS (Full Certification Scheme) of the IECEE (IEC System for Conformity Testing and Certification of Electrotechnical Equipment and Components), mutual certification procedures can be simplified with certificates of conformity and other documents. As of the end of March 2014, 11 043 models of PV modules from 95 manufacturers have been certified and registered. Certification system for PV module components is also in operation, and certification system for backsheets started in 2010. In 2012, certification systems for terminal boxes, connectors and cables also started. Certification system for direct current cables for PV systems started in June 2012 as well.

Reliability certification based on standard “JIS Q 8901” setting the requirements of PV modules for terrestrial installation - reliability assurance system (designing, manufacture and performance) was established with the start of the FIT program in July 2012. Four organizations, namely JET, TÜV Rheinland Japan, UL Japan and VDE offer the certification service. As of the end of March 2014, 1 103 models by eight manufacturers are registered in the JET certification program.

JET conducts a certification program for “Grid-connected Protective Equipment etc. for Small Distributed Generation Systems” to certify inverters with a capacity of below 20 kW for small-sized distributed PV systems to connect to low-voltage power distribution lines. This certification program aims at smooth “preliminary technological discussions” at the time of connection to electricity grids of utilities. Similar to certification of PV modules, product models are certified, factories are inspected and certification labels are issued for the products which satisfy the standards. Certification standards are based on the “Individual Test Method of Grid-connected Protective Equipment etc. for Grid-connected PV Power Generating Systems (for PV Power Generating Systems) stipulated by JET. The standards are based on “Electricity Utilities Industry Law”, as well as METI’s “Ordinance to set technological standards on electrical facilities”, “Official Interpretation of Technical Requirement of Electric Facilities under the Electricity Utilities Industry Law”, “Grid-interconnection Technical Requirement Guidelines on Quality of Electricity” and so on.

JET started a new certification program for inverters for multiple grid-interconnection for PV systems in 2011. An inverter manufactured by Omron using ”AICOT ®” technology was certified. “AICOT” is a technology to prevent islanding operation in case of installations of grid connection of multiple number of inverters for PV systems. So far, inverters from Kyocera, SANYO Electric, YASKAWA Electric, Panasonic, Delta Electronics, Sanyo Denki, Diamond Electric Manufacturing, Sharp, Tabuchi Electric, Hitachi Appliances, IDEC and Noritz were certified and registered. “JEM1498: frequency feedback system with step reactive power injection (system to detect standard active islanding operation of PV inverters)” was formulated in August 2012 as a related standard. In December 2013, test for instantaneous voltage drop and test for frequency fluctuations were added to the certification tests as tests for fault ride through (FRT) requirements.

### 8.3 Standards and codes for PV systems

In FY 2013, reverse power flow in a power distribution system (bank) in grid-connection is allowed due to the revision of the technical standards of electrical facilities, gaining expectations for increased grid-connection capacity. Codes for cables for 1 000 Vdc system has also been established, allowing system cost reduction.

The 2013 addendum of “Technical Standards for Grid-interconnection JEAC-9701-2012 (Green Book)”, concretely describing technical requirements for grid connection was published, clarifying FRT requirements in Japan.

The licensed electrical engineer system for maintenance and management of PV systems was revised to expand areas of management and to improve frequency of inspection.

In order to improve installation skills for residential PV system, “PV installer qualification test” has been regularly conducted since 2013 by the Japan Photovoltaic Energy Association (JPEA). Around 3 000 installers took the exam and approximately 2 400 of them passed.

**Table D: Standardization Framework for PV Systems**

| Category | | | JIS No. | Title | Remark |
|---|---|---|---|---|---|
| Terms and symbols | | | C 0617 | Graphical symbols for diagrams | Revised in 2011 |
| | | | C 8960; 2004 | Glossary of terms for photovoltaic power generation (incl. solar cells) | Revised in 2012 |
| System | | | C 8905; 1993 | General rules for stand-alone photovoltaic power generating system | |
| | | | C 8906; 2000 | Measuring procedure of photovoltaic system performance | |
| | | | C 8981; 2006 | Standards for safety design of electrical circuit in photovoltaic power generating systems for residential use | |
| | | | C 8907; 2005 | Estimation method of generating electric energy by PV power system | |
| | | | TS C 0055 | Electromagnetic compatibility testing and measuring procedure of power conditioner for photovoltaic systems | Formulated in 2011 |
| | | | JEM-TR 228 | Guideline for maintenance and review of small output PV power systems | Revised in 2012 |
| | | | - | Electromagnetic compatibility standard of PV power systems | Under discussion |
| | | | - | Guideline for field test of PV power systems | Under discussion |
| Solar Cell | Crystalline Solar Cell | Reference | C 8910; 2005 | Primary reference solar cells | |
| | | | C 8904-2 | Requirements for reference solar devices | Formulated in 2011 |
| | | | C 8904-3 | Measurement principles for photovoltaic (PV) solar devices with reference spectral irradiance data | Formulated in 2011 |
| | | Solar simulator | C 8912; 2011 | Solar simulators for crystalline silicon solar cells and modules | Revised in 2011 |
| | | Crystalline silicon solar cells | C 8913; 2005 | Measuring method of output power for crystalline silicon solar cells | |
| | | | C 8915; 2005 | Measuring method of spectral response for crystalline silicon solar cells and modules | |
| | | | C 8920; 2005 | Measuring method of equivalent cell temperature for crystalline silicon solar cells by the open-circuit voltage | |
| | | Crystalline silicon PV modules | C 8918; 2013 | Crystalline silicon solar PV modules | Revised in 2013 |
| | | | C 8916; 2005 | Temperature coefficient measuring methods of output voltage and output current for crystalline silicon solar cells and modules | |
| | | | C 8914; 2005 | Measuring method of output power for crystalline silicon PV modules | |
| | | | C 8917; 2005 | Environmental and endurance test methods for crystalline silicon PV modules | |
| | | | C 8919; 2005 | Outdoor measuring method of output power for crystalline silicon solar cells and modules | |
| | | | C8990; | Crystalline silicon terrestrial photovoltaic (PV) modules - | |

| | | | | | |
|---|---|---|---|---|---|
| | | | 2009 | - Design qualification and type approval | |
| | Amorphous Solar Cell | Reference cell/ module | C 8904-2 | Requirements for reference solar devices | Formulated in 2011 |
| | | | C 8904-3 | Measurement principles for photovoltaic (PV) solar devices with reference spectral irradiance data | Formulated in 2011 |
| | | Solar simulator | C 8933; 2011 | Solar simulators for amorphous silicon solar cells and modules | Revised in 2011 |
| | | Amorphous silicon solar cell | C 8934; 2005 | Measuring method of output power for amorphous silicon solar cells | |
| | | | C 8936; 2005 | Measuring methods of spectral response for amorphous silicon solar cells and modules | |
| | | Amorphous silicon PV modules (thin-film PV modules) | C 8939; 2013 | Amorphous silicon PV modules | Revised in 2013 |
| | | | C 8937; 2005 | Temperature coefficient measuring methods of output voltage and output current for amorphous silicon solar cells and modules | |
| | | | C 8935; 2005 | Measuring method of output power for amorphous silicon PV modules | |
| | | | C 8938; 2005 | Environmental and endurance test methods for amorphous silicon PV modules | |
| | | | C 8940; 2005 | Outdoor measuring method of output power for amorphous silicon solar cells and modules | |
| | | | C8991; 2011 | Thin-film terrestrial photovoltaic (PV) modules -- Design qualification and type approval | Revised in 2011 |

**Table D: Standardization Framework for PV Systems (2/2)**

| Category | | JIS No. | Title | Remark |
|---|---|---|---|---|
| Solar Cell | Other types of solar cells | C 8904-7 | Computation of the spectral mismatch correction for measurements of photovoltaic devices | Formulated in 2011 |
| | | C 8944; 2009 | Measuring methods of spectral response for multi-junction solar cells | |
| | | C 8942; 2009 | Solar simulator for multi-junction solar cells and modules | |
| | | C 8943; 2009 | Indoor measuring method of output power for multi-junction solar cells and modules (Component reference cell method) | |
| | | C 8945; 2009 | Temperature coefficient measuring methods of output voltage and output current for multi-junction solar cells and modules | |
| | | C 8946; 2009 | Outdoor measuring method of output power for multi-junction solar cells and modules | |
| | | TS C 0052 | Measuring methods of spectral response for CIS solar cells | Published in 2010 |
| | | TS C 0049 | Secondary reference CIS solar cells | Published in 2010 |
| | | TS C 0051 | Measuring method of output power for CIS solar cells and modules | Published in 2010 |
| | | TS C 0053 | Temperature coefficient measuring methods of output voltage and output current for CIS solar cells | Published in 2010 |
| | | TS C 0050 | Solar simulator for CIS solar cells | Published in 2010 |
| | | OITDA PV01 | Evaluation method of performance for dye-sensitized solar devices | Formulated in 2009 |
| | Modules | JIS C 8992-1; 2010 | Confirmation of safety eligibility of PV modules - No. 1: Requirements for structure | Formulated in 2010 |
| | | JIS C 8992-2; 2010 | Confirmation of safety eligibility of PV modules - No. 2: Requirements for testing | Formulated in 2010 |
| | | - | Standards for compatibility of PV modules and arrays | Under discussion |
| | | JIS Q 8901 | Requirements of PV modules for terrestrial installation - reliability assurance system (designing, manufacture and performance) | Formulated in 2012 |
| | Other | - | Method to establish traceability of reference cells | Under discussion |
| Components | Array | C 8951; 2011 | General rules for photovoltaic array | Revised in 2011 |
| | | C 8952; 2011 | Indication of photovoltaic array performance | Revised in 2011 |
| | | C 8953; 2006 | On-site measurements of crystalline photovoltaic array I-V characteristics | |
| | | C 8954; 2006 | Design guide on electrical circuits for photovoltaic arrays | |

| | | | | |
|---|---|---|---|---|
| | | C 8955; 2011 | Design guide on structures for photovoltaic array | Revised in 2011 |
| | | C 8956; 2011 | Structural design and installation for residential photovoltaic array (roof mount type) | Revised in 2011 |
| | Inverter | C 8980; 2009 | Power conditioner for small photovoltaic power generating system | Revision under discussion |
| | | C 8961; 2008 | Measuring procedure of power conditioner efficiency for photovoltaic systems | |
| | | C 8962; 2008 | Testing procedure of power conditioner for small photovoltaic generating systems | To be integrated with C 8980 |
| | | JEM 1498 | JEM1498: frequency feedback system with step reactive power injection (system to detect standard active islanding operation of PV inverters) | Formulate d in 2012 |
| | | C 8963; 2011 | Test procedure of islanding detection measures for utility-interconnected photovoltaic inverters | Formulate d in 2011 |
| | | - | Safety standards of inverters | Under discussion |
| | | - | Environment-friendly design of inverters for small-scale PV Systems | Under discussion |
| | Terminal box | JEM 1493 | Terminal box and junction box for PV systems | Revised in 2013 |
| | | JEM | Relay terminal box for PV systems | Under discussion |
| Lead acid battery for PV | | C 8971; 1993 | Measuring procedure of residual capacity for lead acid battery in photovoltaic system | |
| | | C 8972; 1997 | Testing procedure of long discharge rate lead-acid batteries for photovoltaic systems | |

* TS: Technical Specifications (standard specification sheet)

* TR: Technical Report (standard information)

Source: The Japan Electrical Manufacturers' Association (JEMA)

# 9 HIGHLIGHTS AND PROSPECTS

## 9.1 Highlights

Since the start of the Feed-in Tariff (FIT) program in July 2012 under the Renewable Energy Law, total capacity of approved PV systems under the FIT program was 28,4 GW equivalent to 774 146 systems as of December 31, 2013. Of them, total 6,85 GW (AC) equivalent to 534 293 systems started operation. The impact of the FIT program was beyond expectation and triggered exponential installation of PV systems, opening a new stage of development toward full-scale introduction of PV systems in Japan. The framework for PV dissemination in Japan shifted significantly from the one under the initiative of supply side to the one under the initiative of user side. The Japanese PV industry is expanding to the downstream sector with the entries of system integrators, EPC businesses and PV utilization industries one after another. Over the past years, the Japanese PV market had been dominated by residential applications. Now, with the emergence of the PV market segments for public, industrial, commercial and utility-scale (PV power plants) applications, the Japanese PV market has become more well-balanced market with several core segments. These market segments cultivated diversification of installation sites including roofs and walls of various facilities, idle and unused land, former industrial sites and the like, agricultural land and golf courses in addition to roofs of houses. Financial institutions such as major banks, local banks, investment funds, leasing businesses and insurance companies started financial support for PV projects, recognizing the PV business as a growing sector. Furthermore, the rapid growth of the Japanese PV market drew attention of overseas manufacturers. Not only PV manufacturers but also players from PV inverter, supporting structure, system integration and EPC businesses entered the Japanese market one after another.

## 9.2 Prospects

In the Japanese PV market, FY 2014 is the third and final fiscal year of the three-year promotional period under the FIT program. It is expected that the annual installed capacity will stay at not less than 6 to 7 GW as approved PV systems will be constructed and start operation one after another as we saw in 2013. The tariffs under the FIT program from April 2014 were reduced as follows: 1) from 38 JPY/kWh to 37 JPY/kWh for PV systems with a capacity below 10 kW and 2) from 36 JPY/kWh to 32 JPY/kWh for PV systems with a capacity of 10 kW or more. Although the tariffs were reduced, installation cost of PV systems will also decreased, therefore it is expected that momentum for PV installation in each market segment from residential to utility-scale applications will be continued.

The Japanese government authorized the new “Basic Energy Plan” at the cabinet meeting on April 11, 2014 with a view to formulating an energy supply-demand structure for the next two decades or so. The new Basic Energy Plan categorizes renewable energy as “important low-carbon and Japan-made source of energy” and clearly demonstrates that “the Japanese government will accelerate introduction of renewable energy to the maximum for around three years from 2013 and continue promotion aggressively” as a governmental policy. To this end, the government established “Council of ministers for renewable energy” to enhance its function as playmaker and promote partnerships among related ministries and agencies, aiming to achieve unprecedented level of introduction of renewable energy.

In this manner, dissemination of PV systems will gain further momentum with the continued FIT program, promotion of price reduction of PV systems, enhancement of the PV industry structure, regulations and electricity system reform under the new framework of renewable energy introduction supported by the whole government.

## Definitions, Symbols and Abbreviations

For the purposes of this and all IEA PVPS National Survey Reports, the following definitions apply:

PV power system market: The market for all nationally installed (terrestrial) PV applications with a PV power capacity of 40 W or more.

Installed PV power: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m$^2$, cell junction temperature of 25$^o$C, AM 1,5 solar spectrum – (also see 'Rated power').

Rated power: Amount of power produced by a PV module or array under STC, written as W.

PV system: Set of interconnected elements such as PV modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a PV power capacity of 40 W or more.

CPV: Concentrating PV

Hybrid system: A system combining PV generation with another generation source, such as diesel, hydro, wind.

Module manufacturer: An organisation carrying out the encapsulation in the process of the production of PV modules.

Off-grid domestic PV power system: System installed to provide power mainly to a household or village not connected to the (main) utility grid(s). Often a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'. Can also provide power to domestic and community users (plus some other applications) via a 'mini-grid', often as a hybrid with another source of power.

Off-grid non-domestic PV power system: System used for a variety of industrial and agricultural applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc. that are not connected to the utility grid. Usually a means to store electricity is used. Also referred to as 'stand-alone PV power system'.

Grid-connected distributed PV power system: System installed to provide power to a grid-connected customer or directly to the electricity grid (specifically where that part of the electricity grid is configured to supply power to a number of customers rather than to provide a bulk transport function). Such systems may be on or integrated into the customer's premises often on the demand side of the electricity meter, on public and commercial buildings, or simply in the built environment on motorway sound barriers etc. They may be specifically designed for support of the utility distribution grid. Size is not a determining feature – while a 1 MW PV system on a rooftop may be large by PV standards, this is not the case for other forms of distributed generation.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station. The power supplied by such a system is not associated with a particular electricity customer, and the system is not located to specifically perform functions on the electricity grid other than the supply of bulk power. Typically ground mounted and functioning independently of any nearby development.

Turnkey price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid PV system, the prices associated with storage battery maintenance/replacement are excluded. If additional costs are incurred for reasons not directly related to the PV system, these should be excluded. (E.g. If extra costs are incurred fitting PV modules to a factory roof because special precautions are required to avoid disrupting production, these extra costs should not be included. Equally the additional transport costs of installing a telecommunication system in a remote area are excluded).

Field Test Programme: A programme to test the performance of PV systems/components in real conditions.

Demonstration Programme: A programme to demonstrate the operation of PV systems and their application to potential users/owners.

Market deployment initiative: Initiatives to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives etc. These may be implemented by government, the finance industry, electricity utility businesses etc.

Final annual yield: Total PV energy delivered to the load during the year per kW of power installed.

Performance ratio: Ratio of the final annual (monthly, daily) yield to the reference annual (monthly, daily) yield, where the reference annual (monthly, daily) yield is the theoretical annual (monthly, daily) available energy per kW of installed PV power.

Currency: The currency unit used throughout this report is Japanese Yen.

PV support measures:

| | |
|---|---|
| Feed-in tariff | an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh that may be higher or lower than the retail electricity rates being paid by the customer |
| Capital subsidies | direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed PV system cost |
| Green electricity schemes | allows customers to purchase green electricity based on renewable energy from the electricity utility business, usually at a premium price |
| PV-specific green electricity schemes | allows customers to purchase green electricity based on PV electricity from the electricity utility business, usually at a premium price |
| Renewable portfolio standards (RPS) | a mandated requirement that the electricity utility business (often the electricity retailer) source a portion of their electricity supplies from renewable energies |
| PV requirement in RPS | a mandated requirement that a portion of the RPS be met by PV electricity supplies (often called a set-aside) |
| Investment funds for PV | share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends |
| Income tax credits | allows some or all expenses associated with PV installation to be deducted from taxable income streams |
| Compensation schemes (self-consumption, net-metering, net-billing…) | These schemes allow consumers to reduce their electricity bill thanks to PV production valuation. The schemes must be detailed in order to better understand if we are facing self-consumption schemes (electricity consumed in real-time is |

| | |
|---|---|
| | not accounted and not invoiced) or net-billing schemes (the electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity account is reconciled over a billing cycle). The compensation for both the electricity self-consumed and injected into the grid should be detailed. Net-metering schemes are specific since they allows PV customers to incur a zero charge when their electricity consumption is exactly balanced by their PV generation, while being charged the applicable retail tariff when their consumption exceeds generation and receiving some remuneration for excess electricity exported to the grid |
| Commercial bank activities | includes activities such as preferential home mortgage terms for houses including PV systems and preferential green loans for the installation of PV systems |
| Activities of electricity utility businesses | includes 'green power' schemes allowing customers to purchase green electricity, operation of large-scale (utility-scale) PV plants, various PV ownership and financing options with select customers and PV electricity power purchase models |
| Sustainable building requirements | includes requirements on new building developments (residential and commercial) and also in some cases on properties for sale, where the PV may be included as one option for reducing the building's energy foot print or may be specifically mandated as an inclusion in the building development |