IEA INTERNATIONAL ENERGY AGENCY

NEDO

National Survey Report of PV Power Applications in JAPAN
2015

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 member countries.

The IEA Photovoltaic Power Systems Technology Collaboration 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 participating countries and organisations can be found on the www.iea-pvps.org website.

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 2015. 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 2015 statistics if the PV modules were <u>installed and connected to the grid</u> between 1 January and 31 December 2015, although commissioning may have taken place at a later date**.

1.1 Applications for Photovoltaics

Annual installed capacity of 2015 reached 10 811 MW (DC), about 11 % increase from the previous year (2014: 9 740 MW (DC)). Almost all the PV systems were introduced under the Feed-in Tariff (FIT) program.

1.2 Total photovoltaic power installed

Cumulative PV installed capacity as of the end of 2015 reached 34 150 MW (DC). Cumulative PV installed capacity by application is; 8,8 MW for off-grid domestic, 118 MW for off-grid non-domestic and 34 023 MW for grid-connected.

Table 1a: PV power installed during calendar year 2015

			MW installed in 2015 - AC value	**MW installed in 2015 - DC value**
Grid-connected	BAPV	Residential (<10 kW)	803	803
		Commercial (<50 kW, icluding small-scale ground mounted)	3 356	3 624
		Industrial (50 kW – 1 MW, cluding small-scale ground mounted)	1 732	1 913
		Total of BAPV	5 891	6 340
	BIPV	Residential (< 10 kW)	60	60
		Commercial (10 - 250 kW)		
		Industrial (> 250 kW)		
		Total of BIPV	60	60
	Ground-mounted	cSi and TF (1 MW ~)	3 844	4 409
		CPV		
		Total of ground-mounted	3 844	4 409
Off-grid		Residential		
		Other	2,4	2,4
		Hybrid systems		
		Total of off-grid	2,4	2,4
		Total	9 797,4	10 811,4

Table 1b: Grid-connected PV power installed during calendar year 2015 (under FIT program) (Unit: MW)

	Capacity (AC-based)	Capacity (DC-based)
< 10kW	863	863
10 kW - < 50 kW	3 316	3 581
50 kW - < 500 kW	818	893
500 kW-< 1 MW	914	1 020
1 MW - < 2 MW	2 427	2 784
2 MW or more	1 417	1 625
Total	9 755	10 767

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

Table 2: Data collection process

Are the installation data reported in AC or DC?	AC: The Ministry of Economy, Trade and Industry (METI) DC: Estimated value
Is the collection process done by an official body or a private company/Association?	AC: The Ministry of Economy, Trade and Industry (METI)
Link to official statistics	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	2015 numbers	2014 numbers
Total power generation capacities (all technologies)	267 GW_{AC}	271 GW
Total power generation capacities (renewables including hydropower)	81 GW_{AC}	83 GW
Total electricity demand (= consumption)	953 TWh	965 TWh
New power generation capacities installed during the year (all technologies)	8,3 GW_{AC} [2]	16,8 GW
New power generation capacities installed during the year (renewables including hydropower)	10,7 GW_{AC}	10,4 GW
Total PV electricity production in GWh-TWh	34 150 GWh	23 339 GWh
Total PV electricity production as a % of total electricity consumption [1]	3,5 %	2,4 %

[1]: Total PV electricity production/ Total electricity demand x 100

[2]: Nuclear capacity decreased.

Table 4: Other information

	2015 Numbers
Number of PV systems in operation in Japan	**Residential PV system: 1 890 000 systems (newly installed system in 2015: 182 552 systems)**
Capacity of decommissioned PV systems during the year in MW	**N.A.**
Total capacity connected to the low voltage distribution grid in MW	**~ 31 211 MW**
Total capacity connected to the medium voltage distribution grid in MW	
Total capacity connected to the high voltage transmission grid in MW	**~ 2 812 MW**

Table 5: The cumulative installed PV power in 4 sub-markets (Unit: kW)

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
2014	8 822	115 996	23 214 264		23 339 082
2015	8 822	118 372	34 023 264		34 150 458

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Table 6 shows typical PV module prices for a number of years for residential applications. These are end-user prices. There is a large price gap between residential PV systems and MW-scale PV power plants.

Table 6: Typical module prices of residential applications 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
2014	197	130
2015	138	N.A.

2.2 System prices

Table 7 shows typical applications and prices of PV systems by category. Table 8 shows the trends in system prices. The standardization of grid-connected PV systems 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 7: **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)		348
Grid-connected 10 kW- < 1 MW		256
Grid-connected Ground-mounted ≥ 1 MW	Power generation business	240
Other category (hybrid diesel-PV, hybrid with battery…)		N.A.

Table 8: National trends in system prices for different applications (JPY/W)

	Residential PV systems (< 10 kW)	Commercial and industrial average (10 kW - 1 MW)	Ground-mounted average (≥ 1 MW)
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
2014	366	290	263
2015	348	256	240

2.3 Cost breakdown of PV installations

Cost breakdown of PV installations is the summarized results of hearing survey carried out during FY 2015. Hearing survey was conducted on major suppliers of PV system, installers, and EPCs.

2.3.1 Residential PV System < 10 kW

Table 9: Cost breakdown for a residential PV system

Cost category	Average (JPY/W)
Hardware	
Module	138
Inverter	42
Mounting structure	37
Measurement/ monitoring instrument, etc.	20
Other (electric equipment/ materials of electric equipment, etc.)	20
Soft costs	
Installation	65
Other (promotion/ administration cost, etc.)	26
Total	348

2.3.2 Utility-scale PV systems > 1 MW

Table 10: Cost breakdown for an utility-scale PV system

Cost category	Average (JPY/W)
Hardware	
Module	80
Inverter	24
Mounting structure	32
Measurement/ monitoring instrument, etc.	4
Other (electric equipment/ transformer/ materials of electric equipment, etc.)	21
Soft costs	
Installation	41
Site development	13
Contribution for grid connection	6
Designing/ development	6
Fund raising	1
Other (promotion/ administration cost, etc.)	13
Total	240

2.4 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. Since Japanese financial institutions tend to focus on collateral, it is difficult for PV projects to secure collateral finance since their value as collateral is low and the value of land as an asset cannot cover the loan. Therefore, financial institutions and developers are now seeking financing utilizing variety of measures. Below is the general financing measures in Japan.

- Corporate finance: Since financing is available at very low cost in case own credit line or collateral such as real estate, etc. can be prepared, many PV project owners use corporate finance. However, it requires holding assets directly for a long term and the available assets for holding can reach a limit in many occasions.
- 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. In reality, the credit capability of the sponsor is tend to be put much value.
- 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 at relatively low interest.
- Leasing (sale and leaseback): Leasing companies own the facilities and operating companies pay the lease fee. Sometimes, after transferring one's PV assets to leasing companies, etc., operating companies lease back the PV assets to carry out its business without owning large-scale assets. It is used by combining with other loans at times.
- Loan for individual: Consumer credit companies or banks finance individuals without collateral. Consumer credit companies are relatively positive even though the availability of financing depends on the reliability, etc. of the individuals.

Occasionally, small- and medium-sized enterprises (SMEs) as well as wealthy individuals with high income take advantage of the Green Investment Tax Break (terminated in FY 2014) in which immediate depreciation at the first fiscal year is available and result in tax savings or a tax system to promote investment in plant and equipment to improve productivity (100 % immediate depreciation up to FY 2015 and 50 % special depreciation up to FY 2016). In such cases, they tend to fund the full amount out of their own resources that are objects of taxation.

Table 11: PV financing scheme

Residential (solar loan/ sales on credit)	Long-term prime rate + approx. 50 - 200 bp (low-rate financing is available by combining home mortgage). Preferential interest rate is available depending on financial institute.
Small to medium size (corporate loan/ sales on credit/ lease)	Long-term prime rate + approx. 150 - 200 bp Guarantor or collateral are required in many cases. Even though the interest is high, loan without collateral is available in some cases using sales on credit. In case of the scheme of lease, the installation is owned by the leasing companies, etc.
Large-scale PV (project finance)	LIBOR or TIBOR + approx. 100 - 150 bp + up-front fee (approx. 1 % of the amount financed)
Specific scheme for PV: Asset-based lending (ABL)	ABL is a financing scheme in which loan is secured with collateral of movable assets such as PV power generation facilities, guarantee agreement, electric power selling agreement and insurance, etc. Financing is also available even without real-estate collateral.

2.5 Specific investments program

With the start of the Feed-in Tariff (FIT) program in Japan in July 2012, a wide variety of business models are considered by taking advantage of the revenues from selling electricity generated by PV systems fixed for the period of 20 years under the FIT program. Basic and typical business models for investment are loan and lease programs, which occupy the majority of financing. Other business models include the following:

Third Party Ownership (TPO) of PV systems: TPO is a business model under which an owner of a building leases the roof of his/ her building to a third party, who installs a PV system. The owner of the building receives the lease fee. There is a case of TPO where the roofs of a large number of houses or small- and medium-sized facilities are aggregated to coordinate financing. In reality, however, right of lease of the roof cannot be registered and requirement to duly assert against third parties is not established. Therefore, it is often the case that the project is judged to carry a high risk of long-term management. There are some cases where a public tender is conducted on the right of use for the roofs of public facilities. However, the use of public facilities for unintended use is allowed for up to one year in principle under the Local Autonomy Act and there are some cases where a lease contract is required to be recontracted every year. Power producers need to take a certain level of risk. Accordingly, the roof-lease model has not expanded very much.

As for crowd funding, etc. for the investment in PV power generation, there are some citizens' funds similar to crowd funding. However, at present, PV projects can be surely financed with loan and lease programs at sufficiently low interest rates, so that advantages of crowd funding, which is not certain to secure, have not been recognized. In particular, in case dividends are provided, it is necessary to establish a strict framework to manage funds in compliance with laws and regulations including the Financial Instruments and Exchange Act. This might rather increase the financing cost. In order to avoid the regulations of the Financial Instruments and Exchange Act, there are some cases where regional specialty products are offered in place of dividends.

10 to < 50 kW PV systems account for approximately 40 % of annual PV installed capacity in 2015. This capacity range has the largest number of PV projects in Japan. The current growth of this market can be attributed to the fact that tax-saving schemes are available. This capacity range can be connected to the low-voltage electric grid and entry hurdles are low. Also, small- and medium-sized enterprises (SMEs) as well as wealthy individuals can take advantage of the Green Investment Tax Break (100 % immediate depreciation, which was terminated in FY 2014) and a tax system to promote investment in plant and equipment to improve productivity (100 % immediate depreciation up to FY 2015 and 50 % special depreciation up to FY 2016). With the depreciation, they can defer the tax payment through depreciation of profit and income. Although a scheme of some 4 to 7 % tax break is available, many opt for a scheme of accelerated depreciation. Since this scheme is easy for SMEs to take, installations of small-capacity PV systems with a capacity of 10 to < 50 kW PV systems are significantly growing.

Table 12 Other financing schemes

Third Party Ownership (TPO) (without initial investment)	"Roof lease model" is available, which leases only the right of use of roofs. However, this business model has not expanded very much due to legal restrictions.
Renting	There are some cases where land is rented.
Leasing	It is easier for leasing to secure credit line than bank loans and the procedures are easier. It is not necessary to own excessive asset for a long time. The leasing model has been actively used for these reasons.
Financing through utilities	There are cases where electric utilities themselves or their subsidiaries conduct the PV power generation business, but there have been no cases of financing by electric utilities for third parties. Under the Japanese laws and regulations, PV systems owned by the electric utilities themselves are not eligible for the FIT program.
Investment in PV power plants	At present, the majority of investment takes advantage of the FIT program. Investment by making the use of electricity generated from PV systems is limited.
Crowd funding (investment in PV power generation)	There are some citizens' funds. However, at present, PV projects can be surely financed at sufficiently low interest rates even via financial institutions, so that advantages of crowd funding, which is not certain to secure, have not been recognized.
Other	In many cases, financial products are handled as tax-saving products taking advantage of accelerated depreciation, etc.

2.6 Additional Country information

Table 13: Country information

Retail Electricity Prices for an household (Low voltage 100 V or 200 V) (TEPCO Energy Partner)	Base rate: 280,80 JPY/10 A (1 kVA) Charge for the volume of usage: <120 kWh/month 19,43 JPY/kWh, 120 - 300 kWh/month 25,91 JPY/kWh, >300 kWh/month 29,93 JPY/kWh (TEPCO Energy Partner, type B, typical ampere for general household: 10 - 60 A, three-phase pricing system with prices varying depending on the volume of usage) *1: "Surcharge to promote renewable energy power generation (1,58 JPY/kWh (April 2016), 2,25 JPY/kWh (May 2016 - April 2017))" will be added on top of the above-mentioned charge, depending on the electricity usage. *2: Fuel regulatory costs will be added or reduced depending on the import prices of crude oil, LNG , and coal and currency exchange (fuel regulatory cost of low-voltage supply in Kanto Area as of June 2016: -3,88 JPY/kWh). *3: There are various price plans depending on hours and seasons. *4: Electric companies announced various price plans of their own following the full deregulation of electric power including retail electricity prices for household from April 1, 2016. (Source: TEPCO Energy Partner's website)
Retail Electricity Prices for a commercial company (High voltage: ≤ 6,6 kV)(TEPCO Energy Partner)	Base rate: 1 684,80 JPY x (185 - power factor)/ 100 per kW Charge for the volume of usage: 17,22 JPY/kWh (summer), 16,08 JPY/kWh (other seasons)(TEPCO Energy Partner, commercial use, from June 1, 2016) *1: Contract demand will be fixed according to annual maximum electricity demand. *2: Surcharge to promote renewable energy power generation and fuel regulatory costs will be added or reduced in the same way as prices for household. *3: There are various price plans depending on hours and seasons as well as demand control contracts. (Source: TEPCO Energy Partner's website)
Retail Electricity Prices for an industrial company (High voltage: ≤ 6,6 kV) (TEPCO Energy Partner)	Base rate: 1 782 JPY x (185 - power factor)/ 100 per kW Charge for the volume of usage: 15,87 JPY/kWh (summer), 14,87 JPY/kWh (other seasons) (TEPCO Energy Partner, high voltage electricity (≥ 500 kW), from June 1, 2016) Base rate: 1 269 JPY/kW Charge for the volume of usage: 17,05 JPY/kWh (summer), 15,94 JPY/kWh (other seasons)(TEPCO Energy Partner, high voltage electricity A (< 500 kW), from June 1, 2016) *1: Contract demand will be fixed according to annual maximum electricity demand. *2: Surcharge to promote renewable energy power generation and fuel regulatory costs will be added or reduced in the same way as prices for household. *3: There are various price plans depending on hours and seasons as well as demand control contracts. (Source: TEPCO Energy Partner's website)
Population at the end of 2015 (or latest known)	127,11 million (Statistics Bureau, Ministry of Internal Affairs and Communications (MIC), finalized in November 2014)
Country size (km^2)	377 972km^2 (Statistics Bureau, MIC)
Average PV yield in kWh/kWp	1 000 – 1 100 kWh/kW/yr
Name and market share of major electric companies (share by sales)	1 TEPCO 32,3 % 2 Kansai Electric 16,2 % 3 Chubu Electric 13,8 % 4 Tohoku Electric 9,9 % 5 Kyushu Electric 8,7 % 6 Chugoku Electric 6,1 % 7 J-POWER 3,4 % 8 Shikoku Electric 3,1 % 9 Hokkaido Electric 3,1 % 10 Hokuriku Electric 2,5 % 11 Okinawa Electric 0,9 % (Source: Industry trends)
Name and market share of electric utilities (based on electricity demand of 2015)	1 General Electricity Utilities (10 electric companies from Hokkaido to Okinawa) 95,2 % 2 Power Producer and Suppliers (PPS) 4,7 % 3 Specially Designated Power Supply Business 0,1 % (Source: Survey of Electric Power Statistics, METI

3 POLICY FRAMEWORK

3.1 Direct support policies for PV installations

3.1.1 New, existing or phased out measures in 2015

3.1.1.1 Description of support measures excluding BIPV and rural electrification

Support measures excluding BIPV and rural electrification are described in Table 14.

3.1.1.2 BIPV development measures

As for the building-integrated PV (BIPV), the New Energy and Industrial Technology Development Organization (NEDO) implements “Demonstration project for diversifying PV applications” from FY 2013 to FY 2016. This demonstration program is divided into three subprojects; 1) “project for demonstration of diversifying PV applications” facilitates installations of PV system on locations where yet to advance such as building walls, agricultural sites, slopes and water surface, 2) “project of feasibility studies for diversifying PV applications” carries out researches on the market size and issues, etc. of new fields, and 3) “technology development project to make high value addition to PV” cultivates functions and applications excluding electricity generation in PV. As a result of the demonstration program, lightweight and low-cost PV module which decreases reflection of lights even installed on the wall, lightweight electricity-generating system which can be used even under harsh environment like animal housings and a system which does not reduce agricultural productivity even installed on plastic greenhouses, etc. were successfully developed so far. In addition to that, NEDO started a study project named “study on BIPV” from FY 2016 to collect information and identify issues for commercialization of BIPV.

METI also started a project on “International standardization of BIPV modules” in FY 2015, which is scheduled to last for three years to FY 2017.

3.1.1.3 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 to islands in order to reduce carbon emissions in remote islands not having grid connection with the mainland. These islands depend on expensive fossil fuel-based energy such as diesel power generation, therefore, they are susceptible to fossil fuel prices and have an issue of large amount of CO_2 emissions. Given this situation, METI and the Ministry of the Environment (MOE) have carried out dissemination measures for renewable energy such as PV and installation of storage batteries at remote islands to reduce fossil fuel usage. Recently, since the feed-in tariff (FIT) program was introduced, installation of PV has increased even in the remote islands with idle lands. However, problems such as suspension of responses to applications for grid connection contracts and output curtailment became obvious because of the limit of adjusting power which was caused by limited demand. Projects to install storage batteries are also increasing, however, they are limited to the introduction taking advantage of subsidies since the cost is still expensive.

3.1.1.4 Support for electricity storage and demand response measures

“Demonstration of Next-generation Energy and Social Systems”, which was initiated from FY 2010 in four regions in Japan (Yokohama City, Toyota City, Kyoto Prefecture (Keihanna Science City) and Kitakyushu City), terminated in FY 2014 as a government-led project, delivering various results with injection of subsidies amounting to approximately 30 BJPY. These results were put into a report in FY 2015 and shifted its technologies to the phase of utilization in different areas. As an extension of these projects, “Demonstration Tests of Next-generation Energy Technologies” was initiated from FY 2014 and various demonstration projects including “trading Negawatts” are being carried out in Osaka City (Osaka Business Park), Onagawa Town, Toyota City, Kazuno City and Kashiwa City.

From FY 2015, urgent demonstration projects to install storage batteries, etc. were started in various locations in order to cope with sharply-increasing PV systems, etc. “Demonstration Project for Improving the Balance of Power Supply and Demand with a Large-Capacity Storage Battery System” in which large-capacity storage batteries are installed at substations, etc. of electric companies, “Project to support introduction of storage battery systems for renewable energy power producers”, which supports introduction of storage batteries by renewable energy power producers, and “Project to support infrastructure development for introduction of renewable energy power generation systems, etc.”, which supports installation of storage batteries, etc. for stricken areas by the Great East Japan Earthquake, were initiated.

For the use of lithium ion storage batteries, the national support program called “Subsidy project to support introduction of lithium ion storage batteries for stationary applications” have been implemented as a continuation from previous year. Sustainable open Innovation Initiative (SII) is the contact window for this program. In 2015, the total amount of 13 BJPY was injected as the subsidy program to carry out installation mainly in newly-built houses. There is also a subsidy program for industrial application called “Subsidy for measures for off-grid renewable energy power generation systems”, carried out by New Energy Promotion Council (NEPC) to serve as a contact window for this program. In FY 2015, 282 PV projects were selected with 65 projects (equivalent of 3,3 MW) equipped with storage batteries. The storage batteries introduced under these projects have function of emergency measure rather than grid adjustment. Demonstrative projects to verify the measures to frequency fluctuation and expansion of possible hosting capacity by installing large-capacity power storage facilities in electric grids have continued and demonstrative experiments have been implemented by Hokkaido Electric using redox flow storage batteries and by Tohoku Electric using sodium sulfur (NaS) batteries. Besides, demonstrative projects to verify increase of possible hosting capacity of renewable energy by improving demand and supply balance were newly initiated and carried out by Tohoku Electric using lithium ion batteries and by Kyushu Electric using Nas batteries. Demonstrative projects are also implemented overseas. Hitachi participates in the project in the USA, and Toshiba participates in the project in Spain. As for hydrogen, which is expected to be a future energy storage system, infrastructure development was initiated mainly for automobile usage. Introduction of fuel cells for domestic use is also increasing, therefore, if hydrogen can be generated, procured and transported at low cost, they could contribute to further dissemination of renewable energy.

Electric companies offer rate system to raise electricity prices at time of high demand such as price plans depending on hours and seasons and contracts with demand and supply adjustment. ENNET, a specified-scale electricity utility, offers point refund system in case of energy saving by notifying the peak hour on the day before. Thanks to the increased number of installation of smart meters in the past one or two years partly influenced by liberalization of electricity retail, it is available to set more precise price plans, etc. For general customer’s option, more price plans become available although they are still developing. In addition, some electric companies introduced plans to discount rates by installing “demand control systems” for companies.

Table 14: PV support measures (summary table)

	On-going measures residential	Measures that commenced during 2015 - residential	On-going measures Commercial + industrial	Measures that commenced during 2015 – commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2015 – ground mounted
Feed-in tariffs	Yes (purchase of surplus electricity)	Cut in purchase price	Yes	Cut in purchase price	Yes	Cut in purchase price
Feed-in premium (above market price)	No	No	No	No	No	No
Capital subsidies	No	No	There are subsidies for non-FIT applicant		There are subsidies for non-FIT applicant	
Green certificates	Yes		Yes		Yes (rarely used since FIT is more profitable	
Renewable portfolio standards (RPS) with/without PV requirements	No	No	Transitional measures of the past programs are still valid	No	Transitional measures of the past programs are still valid	No
Income tax credits	A tax system to promote investment in plant and equipment to improve productivity - Intended for companies and individuals who file an income tax return on the blue form - Two options : immediate depreciation (100 %) or 5 % tax credit (by the end of March 2016) - Two options: special depreciation (50 %) or 4 % tax credit (from April 1, 2016, by the end of March 2017)					
Self-consumption	No	No	There are subsidies intended for PV for self-consumption purpose		No	No
Net-metering	No	No	No	No	No	No
Net-billing	No	No	No	No	No	No
Commercial bank activities e.g. green mortgages promoting PV	There are various financing options as an extension of mortgage and home improvement loan. The interest rate as of May 2016 is approx. 1,7 - 3 %.		Many financial institutions offer financing options for PV system with a capacity of 10 kW or more taking advantage of FIT. The case of corporate finance is not very different from usual business loan, however, there could be conditions such as maximum period of 20 years, no warranty and unnecessity of consigner. There is a case to keep the electricity for selling as collateral. The interest rate as of May 2016 is approx. 2 - 4 %.			
Activities of electricity utility businesses	No	Obligation to equip devices to address output curtailment	- Obligation to equip devices to address output curtailment started in 2015 - There are cases that electric companies or subsidiary companies carry out PV business - Multiple cases of storage batteries for adjustment are installed at substations or sites of thermal power plant of remote islands or the areas where capacity of electrical distribution is saturated			
Sustainable building requirements	"Next generation energy conservation standards", reviewed in 2013, becomes effective in stages and it is subject to all buildings including residences from April 2015. For buildings with gross floor area of 2 000 m^2 or more, previous reporting obligations was changed to conformity obligations from FY 2016 onwards and for buildings with gross floor area of < 300 m^2, it was changed to conformity obligations from FY 2020 onwards (previously non-binding obligations). In case of conformity obligations, a building which primary energy consumption falls below standard as a result of assessment in a specific manner cannot be constructed. It is expected that installation of PV on buildings will increase through conformity obligations because PV is assessed as a device to reduce energy consumption.					
BIPV incentives	No	No	No	No	No	No
Other						

Dissemination of residential storage batteries for stationary applications is promoted thanks to subsidy program intended for residential storage batteries. However, many of them are for emergency use at the time of electric outage, etc. or operated in the mode to storage electricity in the middle of the night and discharge in the daytime and rarely used to mitigate the impacts for electrical grid caused by natural variable electricity.

3.2 Self-consumption measures

Table 15: Self-consumption measures

PV self-consumption	1	Right to self-consume	Transfer of environmental value is available through green power certificates, etc. In other cases, the right to self-consume attributes to the consumer.
	2	Revenues from self-consumed PV	Self-consumed electricity is not subject to taxation.
	3	Charges to finance Transmission & Distribution grids	The fee will not be charged in case of self-consumption.
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Set by FIT for surplus electricity.
	5	Maximum timeframe for compensation of fluxes	Measured by installing two meters (selling/ purchase) and bill separately on a monthly basis. Therefore, there is no compensation.
	6	Geographical compensation	There is no compensation.
Other characteristics	7	Regulatory scheme duration	10 years under FIT program.
	8	Third party ownership accepted	Available for roof-lease business models. However it should be used with FIT and there are no third party ownership business models combined with electricity retailing.
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Except for respecting the regulations set at the time of grid connection and paying the amount required by electric companies, there are no charges intended for renewable energy such as fees arise out of imbalance, etc.
	10	Regulations on enablers of self-consumption (storage, DSM…)	Installation of storage batteries for houses is increasing. However, they are not operated in the mode to facilitate self consumption of PV electricity (since it is more profitable to sell electricity)
	11	PV system size limitations	< 10 kW for purchase of surplus electricity. For 10 kW or more, there is no size limitations as far as electric companies permit.
	12	Electricity system limitations	There are no limitations as far as output curtailment without limit and compensation is accepted.
	13	Additional features	Promotion and support measures for self-consumption are expected to be strengthened.

3.3 Tenders, auctions & similar schemes

There are two types of tenders: tender for the capacity of power transmission and distribution lines and tender under the FIT program restriction.

- Tender for the capacity of power transmission and distribution lines

The tender for the capacity of power transmission and distribution lines is conducted in areas where PV projects are concentrated into specific power transmission and distribution lines. This has an aim of sharing the financial burden to strengthen upper electric grids or substations by several power producers. Electric utilities are entitled to conduct the tender. The tender shall be conducted based on the guideline released by METI in November 2015. Each electric utility presents the capacity for the tender by area and conducts the tender. Renewable energy power producers make a bid for the planned capacity of a PV power plant and unit price of sharing cost per kW. The minimum price is set and the priority ranking shall be determined from the highest bidding prices. When the product of bidden unit sharing cost and capacity exceeds the total construction cost planned by the electric utility, the tender is closed. The amount of actual sharing cost shall be calculated by proportionally dividing the total construction cost planned by the electric utility depending on the capacity of the systems by renewable energy power producers within the range of capacity for the tender.

- Tender under the FIT program restriction

Although the tender under the FIT program restriction is included in the revision of the Renewable Energy Act which was enacted in May 25, 2016, details of the tender process are scheduled to be discussed later. At present, specifications of locations and facilities of renewable energy power generation systems as well as securing of grid connection capacity are required at the time of bidding. Expiration date is set and deposit is required. Ceiling price shall also be set. The tender under the FIT program is expected to start from the one for large-scale projects.

3.4 Direct Support measures

- Subsidy for measures for off-grid renewable energy power generation systems

This program distributes subsidy to PV systems, etc. for self-consumption. The Feed-in Tariff (FIT) program is not applied under the subsidy.

- Subsidy for projects to implement the Feed-in Tariff (FIT) program for renewable energy

For energy-intensive industries, reduction of surcharge payment is eligible. The amount of reduced surcharge is compensated with the government budget.

- Urgent reaction to address electric companies’ suspension of responses to applications for grid connection of renewable energy

Following the rapid increase of PV installation, some electric companies suspended responses to applications for grid connection of PV. This is an urgent budgetary measure to mitigate such situation. The action is implemented in three categories.

  - Establishment of the technology to enables remote output curtailment

    Technical demonstration to control renewable energy output remotely from electric company’s load dispatching center

  - Utilization of storage batteries

    Installation of large-capacity storage batteries at electric company’s bulk power system in order for adjustment of PV output

  - Support for renewable energy infrastructure development for quake-stricken areas such as Fukushima Prefecture

    Support for introduction of renewable energy power generation systems and electric feeder lines, etc. at stricken areas by the Great East Japan Earthquake

- Project to support introduction of lithium ion batteries for stationary installation

This subsidy program supports a part of introduction cost of residential storage batteries for stationary applications

- Subsidy for projects to promote wide use of renewable energy for local production and local consumption

  This subsidy program supports efforts to development of energy system with local-production-and-local-consumption model.

3.5 Financing and cost of support measures

Under the FIT program, the largest incentive for PV dissemination, which took effect in July 2012, all the electricity users share the cost which electric companies paid for purchasing the electricity generated by renewable energy power generation systems, in the form of surcharge in proportion to the amount of electricity they consume. The surcharge is added to the electricity bill. In order to remove regional discrepancies in surcharge collected by electric companies, “Organization to adjust cost burden” (consigned by the Green Investment Promotion Organization) collects the surcharge once and distribute the grant to electric companies in proportion to their records of purchasing renewable energy-based electricity. Under this scheme, however, high-volume electricity users such as manufacturers are entitled to reduce the surcharge. METI covers the expenses required to compensate the losses generated from the surcharge reduction and incurred by the Organization to adjust cost burden in the form of subsidy through government budget. The budget amount is; 19,1 BJPY in FY 2013, 29,0 BJPY in FY 2014, 45,6 BJPY in FY 2015, and 48,3 BJPY in FY 2016. Amount of purchased electricity generated by PV systems under the FIT program is around 56,4 TWh as of the end of January 2016, exceeding 2,3 TJPY in total.

3.6 Indirect policy issues

3.6.1 International policies affecting the use of PV Power Systems

Following the formulation of “Proposed outline of Long-term Energy Supply-demand Outlook” by METI in July 2015, the Global Warming Prevention Headquarters at the Prime Minister's Office approved Intended Nationally Determined Contributions (INDC) which includes an emissions reduction target of 26% below FY 2013 emission levels by FY 2030, equivalent to 25,4% below FY 2005 levels by FY 2030 (at 1 042 million tonnes of CO_2e) toward the twenty-first session of the Conference of the Parties (COP 21) in July 27, 2015 and submitted to the United Nations Framework Convention on Climate Change (UNFCCC). In the INDC, it is targeted that an energy-related CO_2 emissions to be reduced by 21,9 % below FY 2013 emission levels. In order to achieve these target, the cabinet decided the “Plan for Global Warming Countermeasures”, in which medium-term plan for global warming prevention by Japan is indicated, in a cabinet meeting in May 13, 2016. This plan specifies the actions to be addressed by the government, local governments, business operators and general public and government measures and draws a bath for achieving targeted reduction, as well as establishing a goal to reduce the CO_2 emissions by 80 % by 2050 as a long-term target. In this plan, it is mentioned that renewable energy should be “introduced to the maximum extent possible”.

3.6.2 The introduction of any favourable environmental regulations

Following shutdown of the majority of nuclear power plants due to the Great East Japan Earthquake, electricity supply and demand gap was created, which brought about the circumstances that might have shaken Japan’s energy security. Consequently, 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, including both supply side and demand side. In the newly-amended Act on the Rational Use of Energy (Energy Conservation Act), promotion of levelling electricity demand and expansion of the Top Runner program to cover building materials, etc. were specifically initiated. 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, 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 but 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 to contribute to addressing peak shifting.

- Enhancement of energy conservation standards in buildings

  Before 2016, accomplishment of 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, step by step. By around 2020, all buildings including houses covering the floor space of below 300 m^2 will also fall under conformity obligations. Thus, 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, which may offer a significant incentive for the installation of these systems. As of FY 2014, 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 2016.

3.6.3 Policies relating to externalities of conventional energy

Since October 2013, as for nuclear power plants which stopped operation after the Great East Japan Earthquake, a total of four nuclear power plants resumed operation, but two of them are shutdown following the approval of provisional ruling application for shutdown. Electricity shortage is covered mostly by thermal power generation. With the increase of power generation volume by fossil fuel-based power generation, dependence on fossil fuels as power source sharply increased from some 60 % before the earthquake to 90 %. Total greenhouse gas emissions in FY 2014 also increased by around 7,3 % from that of FY 1990. Although CO_2 emissions are decreasing by 2,4 % from that of FY 2005 following reduction of electricity consumption and increase of renewable energy, electricity-based CO_2 emissions continue to be high. Since imported fossil fuels are influenced by situations in politically-unstable countries or regions, there are rising concerns from the perspective of energy security. Under such circumstances, securement of domestically-produced energy sources is recognized as one of the important issues in the "Proposed outline of Long-term Energy Supply-demand Outlook" which was announced in 2015. In this outline, 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, METI 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. Evaluation of METI covers actual power supply records of PV systems.

Table 16: Power supply capabilities of PV systems in the summer by electric company in Japan

(MW)

Electric company		Hokkaido	Tohoku	Tokyo	Chubu	Kansai	Hokuriku	Chugoku	Shikoku	Kyushu	Total
Summer of 2015 (Actual)	**Actual PV installed capacity**	**745**	**1 843**	**6 741**	**4 266**	**3 147**	**442**	**2 128**	**1 393**	**5 325**	**26 030**
	Actual supply records on a day and an hour of peak demand	**407**	**761**	**3 779**	**2 047**	**628**	**308**	**1 080**	**399**	**1 523**	**10 932**
	Peak demand date and hour	Wed, Aug. 5 11 - 12:00 a.m.	Thu, Aug 6 2 - 3:00 p.m.	Fri, Aug 7 1 - 2:00 p.m.	Mon, Aug 3 2 - 3:00 p.m.	Tue, Aug 4 4 - 5:00 p.m.	Fri, Aug 7 11 - 12:00 a.m.	Thu, Aug 6 2 - 3:00 p.m.	Fri, Aug 7 4 - 5:00 p.m.	Thu, Aug 6 4 - 5:00 p.m.	-
	(Peak electricity demand)	4 470	13 930	49 570	24 890	25 560	5 260	10 750	5 110	15 000	154 540
	PV ratio to peak demand	9,1 %	5,5 %	7,6 %	8,2 %	2,5 %	5,9 %	10,0 %	7,8 %	10,2 %	7,1 %
Summer of 2016 (Forecast)	Purchase of surplus PV power	146	636	2 693	1 632	1 199	137	834	377	1 465	9 119
	Purchase of PV power (100 % from facility)	964	2 241	6 013	4 411	2 974	490	1 952	1 523	5 429	25 997
	Utility' owned PV facilities	1	5	30	15	11	4	6	2	3	77
	Total estimated installed capacity	111	2 882	8 736	6 058	4 184	631	2 792	1 902	6 897	35 193
	Estimated supply capability	**0**	**469**	**1 468**	**1 623**	**1 071**	**139**	**769**	**553**	**1 274**	**7 366**

Source: Electricity Supply-Demand Verification Subcommittee under METI (October 2015 and May 2016)

*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 16, in the summer of 2015, electricity supply capability in the peak hours of electric companies was 10,932 GW in total against the installed capacity of 26,03 GW. It is estimated that the installed capacity in 2016 will be 35,193 GW, a large increase from 2014. In the service areas of some electric companies, peak hours come in the late afternoon (16:00 to 17:00) due to increasing awareness of energy and electricity conservation. In these areas, PV's supply capability or contribution is low.

3.6.4 Taxes on pollution (e.g. carbon tax)

In Japan, "Tax for Climate Change Mitigation (Carbon Tax)" has been imposed since October 2012, which requires the public to widely and fairly share the burden for the usage of all the folssil fuels including petrolium, natural gas and coal, in proportion to their enviromental load (CO_2 emissions). This tax is imposed on top of the conventional Petroleum and Coal Tax, in proportion to the usage amount of fossil fuels. Tax rate has been increased step by step over three and half years. It has been decided that 289 JPY/t-CO_2 will be imposed from April 2016. For the period between 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 to March 2016, 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. From April 2016 (FY 2016) onwards, when the phased tax rate increase is completed, the definitive tax rate will be applied and the rate will be 2 800 JPY/kl for crude oil and oil products, 1 860 JPY/t for hydrocarbon gas and 1 370 JPY/t for coal.

Revenue from the Carbon Tax is expected to be 262,3 BJPY from FY 2016 onwards, which will be used for implemention of various measures to curb energy-based CO_2 emissions including energy-saving measures, dissemination of renewable energy, and cleaning and streamlining of fossil fuels. For instance, Revenue from the Carbon Tax will be utilized as financial resources of many measures such as promotion of domestically-located innovative low-carbon technology-intensive industries such as lithium ion batteries, promotion of introduction of energy-saving systems by small- and medium-sized enterprises (SMEs), etc., and promotion of introduction of renewable energy systems in consideration of geographical characteristics taking advantage of Green New Deal Funds, etc.

3.6.5 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 (terminated in November 2015) of the Kyoto Protocol. Regarding PV power generation, there are 17 projects totalling over 100 MW are underway in the Philippines, Bangladesh, Vietnam and so on. As to Joint Crediting Mechanism (JCM), Japan signed bilateral documents with 16 countries namely Mongolia, Bangladesh, Ethiopia, Kenya, Maldives, Vietnam, Laos, Indonesia, Costa Rica, Palau, Cambodia, Mexico, Saudi Arabia, Chile, Myanmar and Thailand. In these countries where JCM is implemented, a total of over 40 PV-related projects are carried out by Japanese companies as of January 2016. Out of these 40 projects, METI and NEDO carry out 16 PV-related projects such as feasibility studies and introduction demonstration projects. Besides, MOE supports a total of 15 projects as installation subsidiary projects utilizing JCM financing such as introduction of PV systems to local schools and commercial facilities and electricity supply through MW-scale PV power plants. In addittion to that, as for JCM project planning studies (PS) and feasibility studies, MOE selected 12 PV-related projects.

NEDO conducts the Project to demonstrate technology and system for improving efficiency of international energy consumption. 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 - 2017) and a technology demonstration project using large-scale PV systems in India (FY 2012 - 2015).

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 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 systems through loan assistance, as well as development and improvement of human resources. In 2015, in addition to the commencement of the operation of the PV power plant with the output capacity of 1 MW in Tonga through grant aid of 1,5 BJPY, JICA selected a business operator for the feasibility study of the canal-top PV power plant project with the output capacity of 10 MW in India. Besides, JICA signed an agreement for equity participation in "the Asia Climate Partners LP (ACP)", one of the largest private equity funds in Asia that undertakes investment for companies which operate renewable energy business, etc., with contribution of up to 94,3 MUSD to the fund.

- JBIC actively provides financing support to environmental protection projects such as development of PV systems and energy-efficient power generation facilities and introduction of energy-saving facilities in developing countries as part of its GREEN (Global action for Reconciling Economic growth and ENvironmental preservation) activities which was initiated from 2010. By the end of March 2016, JBIC approved 28 projects with a main focus on renewable energy business planned in India, Turkey and Latin America. It also plays a central role in the acquisition of emissions rights based on the Kyoto Protocol.

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

In Japan, NEDO has been leading to conduct research and development of PV power generation and the Japan Science and Technology Agency (JST) conducts some of the fundamental research projects. The most of research projects for technology development conducted by NEDO terminated in FY 2014. Based on the "NEDO PV Challenges", a new guidance for technology development formulated in 2014, new technology development projects were initiated on a full scale in FY 2015. Under the new framework of technological research, NEDO significantly shifted its direction from "strategies to promote dissemination of PV power generation" to "strategies to support the society after penetration of PV power". In addition to "Technological development for improvement of system performance and operation and maintenance (O&M)" and "Development of PV recycling technologies", initiated in 2014 in advance of others, "Development of high performance and reliable PV modules to reduce levelized cost of energy (FY 2015 to FY 2019)" which deals with the manufacturing technology of PV cells and modules. The development projects initiated with publicly advertising and selecting subjects. As a result, under the NEDO's development program, three technology development projects, one demonstrative research project as well as smart community demonstrative researches as a part of demonstrative researches such as "Demonstration Project of Technology/System for International Energy Consumption Efficiency etc." are carried out in 2015.

With "Development of high performance and reliable PV modules to reduce levelized cost of energy", it is aimed to improve performance and reduce cost of PV cells and modules in succession to the projects such as "R&D for High Performance PV Generation System for the Future" and "R&D on Innovative Solar Cells" which ended in 2014. The following technology development topics were selected to carry out technology development by setting the development target to achieve power generation cost of 14 JPY/kWh by 2020 and 7 JPY/kWh by 2030 in a mass production level. As for high-efficiency and low-cost technology of practical PV cells, efficiency improvement of crystalline silicon PV modules and its mass production process development are conducted as industry-university projects on two development topics of "Development of crystal silicon PV modules using advanced multiple technologies and high performance CIS modules" and "Development of common components for solar cells and modules". As for R&D for high performance CIS modules, high-efficiency and low-cost process development of CIS PV modules is conducted as an industry-university project. Regarding technology development of new PV cells, two industry-university consortium-led research projects on "Research and Development of ultra-high efficiency and low-cost III-V compound semiconductor solar cell modules" and "Development of innovative low production cost solar cells based on perovskite-type materials" are promoted as a project of "Research and development of innovative new structure solar cells" to carry out component technology development aiming for practical application of these PV cells. Besides, regarding reliability assessment, etc. of PV systems, under "Development of Common Fundamental Technologies (Reliability evaluation technology of PV systems)", technology development on measurement of output, etc., output evaluation of PV power generation, and assessment of reliability and lifecycle, etc. of PV, are carried out as well as conducting researches on development trend of the above mentioned technologies under the topic of "trend survey". In 2017, mid-term evaluations on these technology developments will be provided.

Regarding two technology development projects which started in 2014 in advance to others, full-scale technology developments are underway concerning on the following topics. Under the "Project for development of PV recycling technologies (FY 2014 to FY 2018, 116 MJPY)", technology developments are conducted with the purpose of developing low-cost treatment technology of used PV modules as well as verifying its feasibility and effectiveness in four topics; 1) "technological survey on removal, recycling and separation of the end-of-life PV systems at lower cost", 2) "feasibility study (FS) (development) of low-cost decomposition technologies", 3) “demonstration of low-cost decomposition technologies”, and 4) “PV recycling trends survey”. Under the “Development for improving conversion efficiency and maintenance technology of PV systems (FY 2015 to FY 2018, 428 MJPY)”, with the purpose of developing technology regarding BOS filed aiming at PV cost reduction, as well as conducting the fact-finding investigation on domestic/ overseas conditions towards significant reduction of BOS cost, two technology development projects are carried out; 1) “technology development to improve PV system efficiency” with an aim to reduce BOS cost and 2) “development of maintenance technology of PV systems” with an aim to effectively maintain PV systems.

As for R&D conducted by MEXT, MEXT promotes “FUTURE-PV Innovation Projects” which Japan Science and Technology Agency (JST) has implemented in association with reconstruction from the Great East Japan Earthquake. Researchers moved its development site to Fukushima Renewable Energy Institute of the National Institute of Advanced Industrial Science and Technology (AIST-FREA) to conduct R&D activities with a central focus on the fundamental technology. These projects will be terminated in FY 2016. MEXT also conducts two basic R&D programs through Japan Science and Technology Agency (JST): “Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells” and “Creative Research for Clean Energy Generation using Solar Energy”. Most of the research projects under both programs were terminated as scheduled, however, a technological field named “PV cells and solar energy utilization system” was established as one technological field under the “Advanced Low Carbon Technology Research and Development Program (ALCA)” of JST. In this field, fundamental researches regarding 15 research topics are underway with the central focus on exploratory researches on new principles of power generation and new materials with potential to become innovative technologies such as much higher energy conversion efficiency compared to conventional PV cells.

As for demonstration research of PV system, technology developments and demonstrations on verification of installation technology and power generating performance in various environment such as building walls, agricultural sites, slopes and water surface and adding of high value through addition of functions such as hybrid application of solar thermal/ solar light and new application are conducted under “Demonstration project for diversifying PV applications (FY 2013 to FY 2016)” aiming at expanding application of PV. Until now, demonstration researches are conducted on topics such as decrease of reflected lights from PV modules on building walls, coexistence with farming, light-weight installation technology, simplified installation technology on slopes, utilization technology of water surface and simplified tracking technology.

Regarding utilization technologies of PV systems, METI and NEDO conduct various technological development programs under demonstrative projects aiming at realization of smart communities. A number of demonstrative projects on smart communities are conducted home and abroad and a large number of PV systems are introduced under such projects. These projects are aiming at global market development by localization of technologies to meet the needs of different countries and regions. The followings are major demonstrative projects conducted in FY 2015.

- Demonstration Tests of Next-generation Energy Technologies (Project selected in FY 2014): Demonstration of power control system in Kashiwanoha Campus and surrounded areas, Kashiwa City, Chiba Prefecture (finished in March 2015), Technology demonstration on electricity supply system utilizing EVs and PHVs in Osaka Business Park, Osaka City, Osaka Prefecture, Demonstration of energy management for integrated fish processing site in Onagawa Town, Miyagi Prefecture, Technology demonstration aiming at establishing local sharing system for thermal energy and electricity in an industrial park, Toyota City, Aichi Prefecture and Demand side PPS demonstration project for local production and consumption, Kazuno City, Akita Prefecture
- Smart Community Demonstration Project: Lyon, France (FY 2011 to FY 2015), Gongqing City, Jiangxi Province, China (FY 2011 to FY 2015), Malaga, Spain (FY 2011 to FY 2015), Java Industrial

Park, Indonesia (FY 2012 to FY 2017), Manchester, UK (FY 2014 to FY 2016), Speyer, Germany, (FY 2015 to FY 2017), Maui Island, Hawaii, USA (FY 2011 to FY 2016), Neemrana industrial park, India (FY 2012 to FY 2015), Oshawa, Ontario, Canada (FY 2015 to FY 2016)

Furthermore, demonstration projects on large-capacity storage systems were started by electric utilities as part of support programs by METI and MoE, aiming to expand possible grid connection capacity of renewable energy and control the grid. In FREA, which was newly-established in Koriyama City, Fukushima Prefecture in 2014, its research structure was organized. As for PV-related technology, development of comprehensive evaluation technology of PV systems and performance test of large-capacity inverters, etc. are carried out as part of renewable energy network technology, and industry-university technology development projects on crystalline silicon PV cells using thinner wafer, etc. are carried out as PV cell/ module technology.

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

The FY 2015 PV system-related budgets are mainly based on national budgets as shown in Table 17. The budget for R&D is the sum of “Development of high performance and reliable PV modules to reduce levelized cost of energy”, “Development of PV recycling technologies” and “Development for improving conversion efficiency and maintenance technology of PV systems” financed by METI. The R&D budget including grid connection technology and other renewable energies and the budget from MEXT are not included. The budget for the demonstration is FY 2015 spending for “Demonstration project for diversifying PV applications” started from FY 2013. As for the budget for market incentives, the national government did not allocate incentives specific to PV power generation in the form of subsidy, etc., other incentives for renewable energy dissemination such as “Subsidy for introducing renewable energy power generation systems as part of restoration measures” are used for introduction of PV systems.

Table 17: Public budgets for R&D, demonstration/field test programmes and market incentives

	FY 2013			FY 2014			FY 2015		
	R&D	Demo/ Field Test	Market Stimulation	R&D	Demo/ Field Test	Market Stimulation	R&D	Demo/ Field Test	Market Stimulation
National (BJPY)	8,76	0,5	119,38[1]	10,3	0,8		4,894	0,608	
Regional (BJPY)	-	-	-	-	-	-	-	-	-

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

While the PV dissemination programs by local governments played an important role in supporting PV dissemination, some local governments terminated subsidy programs after the national government terminated the subsidy program for residential PV systems. The level of subsidy according to the output capacity (per kW) for PV systems varies by municipality.

5 INDUSTRY

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

Table 18: Production information for the year for silicon feedstock, ingot and wafer producers in 2015

Manufacturers (or total national production)	Process & technology [1]	Total Production	Product destination	Price
Tokuyama	Polysilicon (Siemens process)	Undisclosed		
Mitsubishi Materials	Polysilicon (for semiconductor, Siemens process)	Undisclosed		
Osaka Titanium technologies 3	Polysilicon (for semiconductor, Siemens process)	Very small amount [2]		
Ferrotec	Ingot			
	Si wafers			
Shin-Etsu Chemical	Si wafers			
Panasonic	n-type sc-Si wafers for HIT (a-Si on c-Si) (125 mm x 125 mm)	Undisclosed		
Kyocera	mc-Si wafers	Undisclosed		
Silicon Plus (Spower)	Ingot			
	Si wafers			

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

[2]: Only off-grade production. Polysilicon production is specialized for semiconductor. No production for PV

Source: answers from each company for the questionnaire by NEDO

Among activities in 2015 of Japanese manufacturers of silicon feedstock for solar cells, ingots and wafers, one the remarkable characteristics was Tokuyama's restructuring of its polysilicon business in relation to its management reconstruction. Tokuyama officially started operation of a large-scale polysilicon production facility in Malaysia in September 2014. However, later, it became clear that the handling of semiconductor-grade polysilicon production was difficult and Tokuyama reported an extraordinary loss for it. As for solar-grade polysilicon (production capacity of 13 800 t/year), production and full-scale sales have been started. In the fall of 2015, it established a production framework for operation at full capacity and shipped 5 000 t. Tokuyama plans to start production at full capacity by the end of FY 2016 ending March 2017. At a semiconductor-grade polysilicon factory in Shunan City of Yamaguchi Prefecture, Tokuyama plans to restart one of the production lines and increase the production capacity by 40 % by the end of 2016 to establish a full-scale production framework. Regarding a polysilicon factory of M. SETEK, its parent company AU Optronics (AUO) of Taiwan announced the booking of impairment loss of the factory in the report on financial results in the fourth quarter of 2015. OSAKA Titanium technologies, a supplier of polysilicon mainly for semiconductors faced a production trouble in some semiconductor-grade products between October and December 2015, which resulted in shipment delay. As for wafers, there is no Japanese manufacturer exclusively engaged in producing wafers for solar cells. In many cases, PV module manufacturers procure either wafers or solar cells from third parties, procure ingots from overseas or produce them on their own, and consign slicing of wafers to third parties in Japan.

5.2 Production of photovoltaic cells and modules (including TF and CPV)

Shipment volumes by most of PV cell/ module manufacturers remained flat or decreased year on year, influenced by such factors as the revision of the FIT program. After the sluggish sales in the first half of FY 2015 (April to September 2015), recovery of sales was expected in the second half of the fiscal year (October 2015 to March 2016). Despite such expectation, the market situation remains tough as the average prices are on the declining trend. Among Chinse manufacturers, some achieved year-on-year increase in shipment volume in Japan. A couple of them shipped over 800 MW, approaching the shipment of top-ranked Japanese manufacturers. Under such circumstances, some Japanese manufacturers adjusted production due to the shrinking demand. Forecasting that the MW-scale PV market in Japan will shrink, they are shifting their target PV markets by returning to the residential PV market and moving to the PV market for building application. They are trying to differentiate themselves from others by launching high efficiency and high output products, enhancing product line-ups of HEMS and storage batteries and extending the period of output and component warranty. Furthermore, the business of ground-mounted PV systems in small- and medium-scale open spaces as well as O&M services both home and abroad have been enhanced.

Among crystalline silicon (c-Si) PV manufacturers, efforts to reduce cost and create added values have continued, including launches of higher output single crystalline and multicrystalline silicon PV modules, development of novel PV cells and modules with PERT, hetero junction and bifacial PV technologies. There were some new entries to PV manufacturing. Denka Shinki and INFINI (Japan Solar) started operation of new PV module factories. Sharp attracted a strong attention to its efforts in business restructuring. Sharp has continued the PV business. It made investment in plant and equipment and launched new models of “Black Solar” PV modules with higher output for residential PV applications. Meanwhile, the company sold its US subsidiary and EPC company Recurrent Energy to Canadian Solar of Canada.

Solar Frontier started operation of its Tohoku Factory in Japan, while supplying PV modules and selling PV projects it developed in the US, European and emerging markets.

In the area of technology development, several companies reported improvement of solar cell conversion efficiency. In particular, Solar Frontier achieved 22,3 % on CIS thin-film solar cell, which is the world’s highest conversion efficiency for thin-film CIS solar cells. Panasonic set a world record PV module efficiency of 22,5 % on a HIT solar cell. Panasonic then renewed its world record by achieving 23,8 % in March 2016. From FY 2015, a 5-year large-scale project on PV technology development started with the initiative of NEDO. It is anticipated that technology development by the companies engaged in this project will be accelerated.

According to PV shipment statistics by the Japan Photovoltaic Energy Association (JPEA), PV shipments by domestic production in 2015 were approximately 2,8 GW of solar cells and approximately 3,1 GW of PV modules, both almost remained flat on a year to year level.

Table 19: Production and production capacity information for 2015

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	sc-Si	Undisclosed	Undisclosed	Undisclosed	Undisclosed
2 Kyocera	sc-Si	Undisclosed	180	Undisclosed	180
	mc-Si	Undisclosed	1 070	Undisclosed	1 070
3 Panasonic	HIT (a-Si on c-Si)	Undisclosed	Undisclosed	Undisclosed	Undisclosed
4 Mitsubishi Electric	sc-Si	Undisclosed	400	Undisclosed	530
5 Fujipream	sc-Si		20		60
	mc-Si		6.4		60
6 Choshu Industry	sc-Si				
	mc-Si				
7 Suntech Power Japan	sc-Si (BIPV)	-	0,0135	-	0,6
	mc-Si (BIPV) (residential, < 10 kW)	-	0,0135	-	0,6
8 Towada Solar	sc-Si	-	1,8	-	3
	mc-Si	-	16,7	-	20
9 Spower	c-Si				
10 PVG Solutions	sc-Si (bifacial)	70		70	
11 Clean Venture 21	sc-Si				
12 Sphelar Power	Spherical Si				
Thin film manufacturers					
1 Solar Frontier	CIS	860	860	1 110	1 110
2 Kaneka	a-Si, a-Si/poly-Si hybrid	16	16	120	120
	a-Si, a-Si/poly-Si hybrid (BIPV) (residential, < 10 kW)	12	12		
3 FWAVE	a-Si	3		24	
4 Mitsubishi Chemical	a-Si, OPV				
Cells for concentration					
1 Sumitomo Electric Industries	CPV		0,02		5
TOTALS		**2 787 [2]**	**3 103 [2]**	**3 745 [3]**	**4 640 [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]: Shipment statistics by the Japan Photovoltaic Energy Association (JPEA)

[3]: Studied by RTS Corporation

Source: answers from each company for the questionnaire by NEDO

5.3 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 of Germany and Delta Electronics of Taiwan. Residential applications shifted towards multiple-unit grid-connection type inverters, with manufacturers including Omron, Tabuchi Electric, Yaskawa Electric, Panasonic, Kyocera, Sharp, Mitsubishi Electric, SMA Solar Technology and Delta Electronics 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 and a 25-kW inverter by Tabuchi Electric; a 5,5-kW inverter by Omron; and 10-kW inverters by Yaskawa Electric, GS Yuasa and Sanyo Denki. As the market for low-voltage grid connection has been steadily growing, some companies strengthened their products for industrial applications, including Omron's launch of a new 10-kW inverter. Overseas manufactures such as SMA Solar Technology and Huawei Technologies of China have also entered this market.

For the systems with a capacity over 50 kW, which are connected to high-voltage grids, two or more 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 machinery manufacturers including Toshiba Mitsubishi-Electric Industrial Systems Corporation (TMEIC), Hitachi, Ltd., Fuji Electric, Daihen, Nissin Electric and Meidensha. Other manufacturers such as GS Yuasa, Sanyo Denki, Yaskawa Electric and Hitachi Industrial Equipment Systems also produce the inverters in this capacity range. Overseas manufacturers such as SMA Solar Technology, ABB of Switzerland and Schneider Electric of France also comprise this market. General Electric (GE) of the USA, Sungrow of China and others newly entered this market. As more distributed inverters are installed for MW-scale PV power plants in Japan, the competition between large-capacity central inverters and distributed inverters has intensified. Reflecting an increasing demand for overseas markets, Japanese manufacturers have expanded their overseas businesses. TMEIC and Hitachi, Ltd. are strengthening production facilities and expanding overseas manufacturing sites. Tabuchi Electric started operation of a new factory in Thailand and increased its production capacity, while focusing on expanding sales of hybrid inverters equipped with storage batteries in North America.

For ≤ 10 kW inverters, a certification scheme by the Japan Electrical Safety & Environment Technology Laboratories (JET) has been introduced. JET certification is categorized into three types of inverters: 1) conventional type; 2) multiple-unit grid-connection type and 3) FRT-support type. Certification of multiple-unit grid-connection type inverters is designed for inverters that employ the Standard active islanding detection scheme for single-phase utility-interactive power conditioners (inverters) of distributed power sources (A frequency feedback method with step injection of reactive power) (JEM 1498) and an FRT (Fault Ride Though) function. Following the revision of the Ministerial Ordinance in January 2015, management of the FIT program was reviewed, which requires inverters to respond to remote-controlled output curtailment. For JET-certified products, it was announced that partial changes shall satisfy the requirement. Individual test method for grid protection devices has been revised and measures following the addition of complementary information to JEM 1498 have been promoted. For > 10 kW inverters, approval is given by electric companies individually.

- 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 mainly for residential applications and major manufacturers launched new products one after another with long life time, large capacity and high reliability. Panasonic and Eliiy Power are major storage battery manufacturers in Japan. They are also expanding the storage battery business in overseas markets via partnership with foreign companies. Some companies from abroad entered the Japanese market. PV manufacturers Hanwha Q CELLS Japan and others are selling storage batteries for residential applications.

- Battery charge controllers

Battery charge controllers are used for small-scale off-grid power source systems for rural electrification, etc. The number of products for installation in Japan is very small.

- DC switch gears

Also called junction boxes, DC switch gears are manufactured by such manufacturers as Nitto Denko and Kawamura Electric, who are exclusively engaged in DC switch gear manufacturing. Some products, mainly for MW-scale PV power plants have string monitors embedded. They are used for operation and maintenance (O&M) of PV power plants. Overseas manufacturers in this area include Weidmueller of Germany 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 are the most popular. They are manufactured by such manufacturers as Neguros Denko and Okuji Kensan, who are exclusively engaged in this field. As the demand for industrial PV systems has increased rapidly, POWERWAY of China and HILTI of Europe (Lichtenstein) have entered the Japanese market, in addition to domestic manufacturers. Along with the expansion of PV installed capacity, installation locations are getting more diverse. Accordingly, development has advanced on new products which can be easily installed on slopes, new installation methods which can reduce the installation period, as well as automated installation systems. Regarding brackets for supporting structures, development of lighter-weight products using aluminium is underway, in order to meet the demand for rooftop installation for industrial applications.

6 PV IN THE ECONOMY

6.1 Labour places

Table 20: Estimated PV-related labour places in 2015

	2014	2014
Research and development (not including companies)	1 000	900
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	125 000	128 000
Distributors of PV products		
System and installation companies		
Electricity utility businesses and government		
Other		
Total	**126 000**	**128 900**

6.2 Business value

Table 21: Value of PV business

Sub-market	Capacity installed in 2015 (MW)	Price (JPY/W)	Value (MJPY)	Totals (MJPY)
Off-grid < 1 kW				
Off-grid ≥ 1kW				
Grid-connected roof-top < 10 kW (for residential)	863	348	*300 324*	
Grid-connected for commercial	3 624	256	*927 744*	
Grid-connected for industrial	1 913	256	*489 728*	
Grid-connected ≥ 1 MW	4 409	240	1 058 160	
Total	10 809			*2 775 956*
Export of PV products				32 174
Change in stocks held				
Import of PV products				309 762
Value of PV business				2 498 369

Import value described in Table 19 is an estimated value of import of PV modules. Although some overseas manufacturers started exporting their inverters to Japan, the total amount of their shipping volume is not included since it is unknown.

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

In Japan, 10 general electricity companies 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 electric companies are allowed to regionally monopolize the electricity service under a vertically integrated framework, and recovery of investment by fully distributed cost method has been assured. Customers for 50 kW or larger systems in the category of extra-high voltage and high voltage electricity have already been 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 companies basically remains unchanged, and the present market is not competitive enough for cost reduction. The market share of new entrants (PPS) in the retail market is only 8,9 % as of January 2016. On top of that, the Great East Japan Earthquake revealed structural problems of the current electricity system. Flexible and stable power supply was difficult when nuclear power plants suspended operation due to the earthquake and power supply and demand got stringent. Cross-regional power transmission of power from non-utility power generators or IPPs was not possible. It became clear 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 national government is promoting deregulation of the electricity business in three phases as shown in Table 22 to establish a revitalized market and a smarter and more robust electricity system. Effective from April 2016, Japan’s electricity retailing has been fully revitalized. From now on, power transmission and distribution services by major electric companies are expected to be separated step by step.

Table 22 Schedule of Electricity System Reform

Phase	Year	Summary	Content
First phase	2015	Establishment of a body for cross-regional coordination of transmission operators (Organization for Cross-regional Coordination of Transmission Operators, Japan (OCCTO))	- Development of nation-wide plan of supply/ demand and grid - Cross-regional operation across the service areas of ordinary times - Instructions to supply electricity regardless of the demand control and service areas at the time of disaster - Acceptance of interconnection of new power sources and disclosure of grid information
Second phase	2016	Deregulation to enter into the retail market including the residential sector	- Consumers have the freedom to choose electric companies and prices - Institutional revision of regional monopoly by major electric companies
Third phase	2018 - 2020	Separation of power generation from power distribution and transmission, removal of price regulation	- Separation of power distribution and transmission from electric companies - Removal of retail price regulation in order to decrease the electricity price based on the competition principle

7.2 Interest from electricity utility businesses

- Introduction of large-scale PV power plants by electric companies

Federation of Electric Power Companies (FEPC) of which the 10 general electric companies are members announced in October 2008 that the 10 electric companies will construct large-scale PV power plants with a total capacity of 140 MW. Construction has been almost completed. PV power plants developed by electric companies themselves, however, are not eligible for the FIT program.

- Development of technology to forecast power generation amount

To assure stable operation of electric grids when PV systems are installed in large scale, electric companies take initiative in technology development and demonstrative researches for forecasting PV power generation amount as a project subsidized by METI, which contributes to controlling the balance between electricity supply and demand. They made the following accomplishments. In addition to the 10 electric companies, the University of Tokyo, the Japan Weather Association and manufacturers of electric appliances participated in this project. Based on these accomplishments, the 10 electric companies are developing technology to forecast power generation amount, which reflects regional characteristics.

1) Accurate understanding of amount of insolation

Estimated accuracy: estimated annual error of 15 W/m^2 against the standard insolation intensity of 1,000 W/m^2

2) Technology to forecast amount of insolation

Forecast of tomorrow

Estimated accuracy: estimated annual error of 100 - 160 W/m^2 against the standard insolation intensity of 1,000 W/m^2

Forecast of today

Estimated accuracy: estimated annual error of 80 - 150 W/m^2 against the standard insolation intensity of 1,000 W/m^2

3) Technology to estimate output of PV power generation

Accuracy: estimated annual error of up to 5 %, with some issues for forecasting in snowy regions

- Development of electricity storage technology using large-capacity storage batteries

For the purpose of adjusting short-cycle variation and balancing supply and demand following the large-scale introduction of renewable energy, projects to introduce large-capacity storage batteries in substations, etc. are under way as part of METI projects. The following demonstrative researches have started so far:

- Minami Hayakita Substation (Abira Town, Hokkaido Prefecture): redox flow batteries (15 MW, 60 MWh)
- Nishi Sendai Substation (Miyagi Prefecture): Lithium ion batteries (40 MW, 20 MWh)
- Minamisoma Substation (Minamisoma City, Fukushima Prefecture): Lithium ion batteries (40 MW, 40 MWh)
- Buzen Power Plant (Buzen City, Fukuoka Prefecture): NAS batteries (50 MW, 300 MWh)

- Enhancement of inter-regional grid lines

There are two frequencies for the electric grids in Japan: 50 Hz for the eastern part of Japan and 60 Hz for the western part of Japan. The frequency conversion station connecting the two frequency regions has the capacity of only 1.2 GW. It has also been pointed out that inter-regional grid connection lines to transport electricity from the areas with abundant land and renewable energy resources to the areas of demand for electricity are fragile. In order to solve these issues, inter-regional grid connection lines need to be reinforced. In connection with the electricity system reform, the government-level discussions are underway regarding the capacity of grid connection lines which need to be reinforced and how the cost should be borne. As for the frequency conversion station, preparations for starting construction to increase 900 MW have started. The route for the increase of another 900 MW is also under discussion. Construction of 300 MW increase of grid connection lines between Hokkaido and Tokyo has also started.

- Responses to accept grid connection

Along with the growth of PV installed capacity, some electric companies announced that they would suspend replies to new applications for grid connection in 2014. After that, they announced “30-day, etc. output curtailment capacity”, which sets the limit of output curtailment to 30 days or 360 hours. In case the capacity applied for grid connection exceeds the “30-day, etc. output curtailment capacity”, output curtailment will have “no limit without compensation”. In parallel with these restrictions, various information including open capacity of distribution lines has been released by electric companies.

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 of PV systems. While the subsidy program for installation of residential PV systems by the national government was terminated, a large number of local governments and municipalities have implemented subsidy programs to support installation of residential PV systems. In most cases, the amount of subsidy ranges from 10 000 JPY/kW to 50 000 JPY/kW. To award the subsidy, some of them present several requirements including installation of HEMS with residential PV systems at the same time. There are also support programs for industrial PV systems, although the number of programs is smaller than that for residential PV systems. The support programs for industrial PV systems include subsidy for installation, loan support and preferential tax treatment. Some programs require installation of PV systems and storage batteries, etc. at the same time, or installation of PV systems in facilities which are used as evacuation or disaster prevention centers. Support programs widely vary among municipalities. For instance, Kanagawa Prefecture conducted a public tender for the subsidy exclusive for the projects using thin-film PV modules. Kyoto City of Kyoto Prefecture started a subsidy program for shopping streets and condominium associations.

Moreover, local governments and municipalities also implement support programs other than direct subsidy. Some of them solicit power producers for installation of PV systems on the roofs of public facilities and public land. Also, some municipalities join hands to install PV systems in public facilities in order to secure power sources for evacuation centers in case of disaster. Some municipalities invest in construction and management of MW-scale PV power plants. Tokyo Metropolitan Government (TMG) became the first municipality to invest in a renewable energy fund through public-private partnership (PPP).

In 2015, a series of natural disasters occurred. Local heavy rainfalls and gust of wind damaged PV modules. Following these damages, some prefectures set up regulations on the installation of PV systems. In order to prevent outflow of soil from construction sites, Oita Prefecture requires project developers to agree with local residents on the development of forest covering a certain scale of land. Nagano Prefecture enhanced measures for MW-scale PV power plants against rainfalls. Some municipalities regulate installation of PV systems via ordinances to protect the landscape. Fujinomiya City of Shizuoka Prefecture located at the foot of Mt. Fuji, passed an ordinance to regulate new installation of MW-scale PV power plants to preserve the landscape, whereas Hokkaido Prefecture formulated a guideline to consider the landscape.

In preparation for full liberalization of electricity retailing in April 2016, municipalities established PPS one after another, expanding efforts for local production and consumption of energy. Partnerships between municipalities and private companies have advanced as well. Tottori City of Tottori Prefecture allies with Tottori Gas to supply electricity generated from local MW-scale PV power plants to the city hall and other public facilities, local enterprises and households.

Some municipalities proactively supporting introduction of PV and other renewable energy sources are setting installation targets and formulating action plans to achieve the targets. TMG set a new policy target to become the world's most advanced environment-friendly city. TMG aims to increase the utilization ratio of renewable energy to total electricity consumption to around 30 % by 2030. Fukushima Prefecture formulated an action plan to increase the ratio of renewable energy to the prefecture's electricity demand to some 30 % in FY 2018. The prefecture also presented a reduction target of greenhouse gas emissions. Motivated by COP21, local governments and municipalities are formulating their own anti-global warming measures.

8 HIGHLIGHTS AND PROSPECTS

8.1 Highlights

The Japanese government formulated the “Long-term Energy Supply and Demand Outlook” in July 2015 based on the “Fourth Strategic Energy Plan” formulated in 2014. Estimating that total power generation amount as of FY 2030 would be approximately 1 065 TWh, the government set the Energy Mix with the target shares by energy source as follows: 22 to 24 % by renewable energy; 20 to 22 % by nuclear power; 26 % by coal; 27 % by LNG and 3 % by oil. As the value of renewable energy as a power source has been evaluated, the target ratio of renewable energy in the Energy Mix was set larger than that of nuclear power. The ratios of renewable energy sources are 7,0 % by PV, 1,7 % by wind, 8,8 to 9,2 % by hydro, 1,0 to 1,1 % by geothermal, 3,7 to 4,6 % by biomass. The amount of power generation and power generation capacity by PV as of FY 2030 are expected to be 74,9 TWh and 64 GW, respectively. Aside from hydro, PV is positioned at the highest among renewable energy sources.

METI compiled a proposal for the revision of the Feed-in Tariff (FIT) program, focusing on the following issues: 1) measures to address projects which have not started operation; 2) promotion of long-term stable power generation; 3) cost-efficient introduction of PV power generation; 4) accelerated introduction of renewable power sources with longer lead time and 5) expanded introduction of renewable energy taking advantage of the electricity system reform. Based on this proposal, drastic revision of the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities (Renewable Energy Act) was discussed at the Ordinary Session of the Diet which started in January 2016 (and enacted in May 25, 2016). Toward realizing the Energy Mix in FY 2030, the national government aims to establish a sustainable market for renewable energy via this revision of the Renewable Energy Act. From this time forward, the details of the tender process are scheduled to be discusses.

In the fourth year of the FIT program for renewable energy which took effect in July 2012, PV installed capacity has stayed at a high level. Approved capacity of PV systems under the FIT program as of the end of December 2015 reached 79,3 GW (AC-based), approaching 80 GW. Meanwhile, annual PV installed capacity in 2015 increased to 9,8 GW (AC-based), renewing the annual record for the fourth consecutive year. As a result, cumulative PV installed capacity under the FIT program since July 2012 reached 25,2 GW (AC-based). On a DC basis, Japan’s annual PV installed capacity in 2015 was 10,8 GW, achieving the cumulative installed capacity of 34,2 GW.

21 years have passed since the Japanese government formulated the “Basic Guidelines for New Energy Introduction” in 1994 and started efforts to expand dissemination of renewable energy as a nation. Over the 21 years, Japan’s cumulative PV installed capacity reached 30 GW level. In 2015, however, annual PV approved capacity under the FIT program significantly decreased to 8,5 GW (AC), due to FIT reduction for PV systems, implementation of new rules for output curtailment, revision of the rules for the FIT program and so on.

10,8 GW (DC-based) of annual PV installed capacity in 2015 in Japan consists of three segments: < 10 kW PV systems (863MW, DC-based) mainly for residential applications; 10 to <1,000 kW PV systems mainly for public, industrial and commercial applications (5,5 GW, DC-based) and 1,000 kW and larger PV systems (“megasolar” market) mainly for the power generation business (4,4 GW, DC-based). As such, the growth of the Japanese PV market has been driven by non-residential applications.

In the PV industry in Japan, in addition to manufacturing of PV cells and modules as well as main PV system components such as inverters, the market segment of manufacturing other BOS devices such as supporting structures, storage batteries and energy management system (EMS) is established. Furthermore, a new non-residential market segment of EPC and service businesses such as PV power generation service, PV business support business and O&M business has been expanding largely. The size of the PV industry has grown to the scale of 3 trillion JPY.

In the area of technology development, the “New 5-year plan for PV power generation” has started. This plan, based on the “NEDO PV Challenges”, a principle of technology development formulated by NEDO in 2014, is designed to reduce the cost of PV power generation. Under this plan, “Development of high performance and reliable PV modules to reduce levelized cost of energy” such as crystalline silicon, CIS thin-film, III-V compound, Perovskite and other PV technologies has started.

8.2 Prospects

As of the end of December 2015, including the initial three-year preferential period of the FIT program to accelerate the introduction of renewable energy power generation systems, cumulative PV approved capacity reached 79,3 GW (AC-based), of which 25,2 GW (AC-based) has been installed. This means that the remaining 54,1 GW (AC-based) of PV projects have been approved but not installed yet. From now on, it is assumed that the 54,1 GW will not be installed in full, but installations of newly-approved PV projects will be added to the annual installed capacity. Accordingly, it is expected that the annual PV installed capacity will stay at a steady level. Since the annual PV approved capacity in 2015 onwards has largely slowed down, it is assumed that annual PV installed capacity in Japan will gradually decrease to the range of 3 to 5 GW. Also, the revision of the Renewable Energy Act was enacted through deliberation at the Diet in May 2016. From April 2017, the amendments will take effect including measures to address projects which have not started operation, establishment of a new scheme for project approval as well as changes in the method to set the feed-in tariffs (FITs). The framework to promote installations of PV systems will be drastically reviewed. As a result, FITs will continue to be decreased, the financial burden on the nation will be eased and the environment for PV installations will change to realize a stable market. As for the PV market, it is expected that the market segment of large-scale (Megasolar) PV applications will be reduced, and introduction of PV systems for self-consumption led by municipalities for local production and consumption of energy and PV systems for self-consumption in various facilities which do not place burden on the electric grid will be increased.

METI is committed to consistently working on expanding PV installations with every possible political support to realize the best Energy Mix as of FY 2030, instead of just depending on the market. To this end, the national government started formulating the “Innovative Energy Strategy,” through which it aims to expand introduction of renewable energy to a maximum extent and curb the financial burden on the nation in parallel. The government is considering specific measures such as resolution of grid restrictions, regulatory reform and R&D. The government aims not only to increase installed capacity of renewable energy but also to create a low-carbon market, re-establish the renewable energy industry and develop overseas markets.

The PV industry is assumed to evolve its structure from the one focusing on manufacturing of PV cells and modules as well as inverters to the one which covers widely from the upstream sector to the downstream sector, thanks to the emergence of the PV-related service industry such as O&M and power generation businesses. Consequently, the PV industry is assumed to grow to one of the mainstream segments in the energy industry in Japan.