IEA INTERNATIONAL ENERGY AGENCY

National Survey Report of PV Power Applications in JAPAN 2016

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

PVPS

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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 2016. 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 2016 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2016, although commissioning may have taken place at a later date**.

1.1 Applications for Photovoltaics

Annual installed capacity in Japan in 2016 reached 7 890 MW (DC), an approximately 27 % decrease from the previous year (2015: 10 811 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 2016 reached 42 040 MW (DC). Cumulative PV installed capacity by application is; 153 MW for off-grid and 41 879 MW for grid-connected.

Table 1a: PV power installed during calendar year 2016

			MW installed in 2016 - AC value	MW installed in 2016 - DC value
Grid-connected	BAPV	Residential (< 10 kW)	766	766
		Commercial (< 50 kW, including small-scale ground mounted)	2 215	2 418
		Industrial (50 kW - 1 MW, including small-scale ground mounted)	1 246	1 396
		Total of BAPV	4 185	4 531
	BIPV	Residential (< 10 kW)	40	40
		Commercial (10 - 250 kW)		
		Industrial (> 250 kW)		
		Total of BIPV	40	40
	Ground-mounted	c-Si and TF (1 MW ~)	2 750	3 236
		CPV		
		Total of ground-mounted	2 750	3 236
Off-grid		Residential		
		Other	34,3	34,3
		Hybrid systems		
		Total of off-grid	34,3	34,3
		Total	7 051	7 890

Table 1b: Grid-connected PV power installed during calendar year 2016 (under FIT program) (Unit: MW)

	Capacity (AC-based)	Capacity (DC-based)
< 10kW	806	806
10 kW - < 50 kW	2 215	2 418
50 kW - < 500 kW	608	675
500 kW - < 1 MW	638	721
1 MW - < 2 MW	1 705	1 961
2 MW or more	1 045	1 275
Total	6 837	7 656

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 of PV modules

Table 3: PV power and the broader national energy market

MW-GW for capacities and GWh-TWh for energy	2016 numbers	2015 numbers
Total power generation capacities (all technologies) *Including PV systems for self-consumption	310 GW_{AC}	267 GW_{AC}[3]
Total power generation capacities (renewables including hydropower)	86 GW_{AC}	81 GW_{AC}[3]
Total electricity demand (= consumption)	912 TWh	953 TWh
New power generation capacities installed during the year (all technologies)	8,9 GW_{AC}	8,3 GW_{AC} [2,3]
New power generation capacities installed during the year (renewables including hydropower)	6,9 GW_{AC}	10,7 GW_{AC}[3]
Total PV electricity production in GWh-TWh	40 950 GWh	34 150 GWh
Total PV electricity production as a % of total electricity consumption [1]	4,5 %	3,5 %

[1]: Total PV electricity production/ Total power generation capacities x 100

[2]: Nuclear capacity decreased.

[3]: The total value of the table of METI approval and the installed capacities under the FIT program were tallied.

Table 4: Other information

	2016 Numbers
Number of PV systems in operation in Japan	**N.A.**
Capacity of decommissioned PV systems during the year in MW	**N.A.**
Total capacity connected to the low voltage distribution grid in MW	**~ 37 592 MW**
Total capacity connected to the medium voltage distribution grid in MW	
Total capacity connected to the high voltage transmission grid in MW	**~ 4 087 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
2016	8 822	152 672		41 878 684	42 040 178

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	190	N.A.
2016	189	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)		324
Grid-connected 10 kW- < 1 MW		245
Grid-connected Ground-mounted ≥ 1 MW	Power generation business	236
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
2016	324	245	236

2.3 Cost breakdown of PV installations

Cost breakdown of PV installations is the analysed results of hearing survey. 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	189
Inverter	40
Mounting structure	13
Measurement/ monitoring instrument, etc.	6
Other (electric equipment/ materials of electric equipment, etc.)	6
Soft costs	
Installation	50
Other (promotion/ administration cost, etc.)	11
Total	316

2.3.2 Utility-scale PV systems > 1 MW

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

Cost category	Average (JPY/W)
Hardware	
Module	98
Inverter	40
Mounting structure	10
Measurement/ monitoring instrument, etc.	4
Other (electric equipment/ transformer/ materials of electric equipment, etc.)	15
Soft costs	
Installation	69
Site development	
Contribution for grid connection	
Designing/ development	
Fund raising	
Other (promotion/ administration cost, etc.)	
Total	236

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. While Japanese financial institutions tend to focus on collateral, it is difficult for PV power plants to secure a collateral loan since the value of movable assets (power generation facilities, etc.) as collateral is low and the value of land as collateral falls below the value of the loan. Therefore, financial institutions and developers are now seeking financing utilizing a variety of measures. The Infrastructure Fund Market which was established by the Tokyo Stock Exchange (TSE) has been increasingly utilized. 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 the limit in many cases.
- 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 tends 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.
- Infrastructure Fund Market: Dividend to the investors is funded with the usage charge of the infrastructure facilities which are expected to earn stable income. In case of PV power plants, dividend is funded with the revenue from sales of electric power. In 2016, Takara Leben Infrastructure Fund and Ichigo Green Infrastructure Investment Corporation were listed on the Infrastructure Fund Market. In 2017, Renewable Japan Energy Infrastructure Fund was listed and other companies are preparing for the listing.

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 rate is high, loan without collateral is available in some cases using sales on credit. In case of the scheme of lease, the facilities are 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.
Infrastructure Fund Market	Raising capital from private investors who seek for long-term stable dividend through listing of stocks on the Infrastructure Fund Market which was established by the Tokyo Stock Exchange (TSE). Raised capital is used for development and operation of power plants and the revenue from sales of electric power is distributed to the investors as dividend.

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. In reality, however, right to lease 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 in 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 resigned every year. Power producers need to take a certain level of risk. Accordingly, the roof-lease model has not expanded very much. Ecosystem Japan started a service to lease roofs for individuals and corporations and promotes activities by combining it with electric power business while taking advantage of the support measures of Kanagawa Prefecture.

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.

10 to < 50 kW PV systems account for 30 % of annual PV installed capacity in 2016. 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, deferment of the tax payment through depreciation of profit and income is available by taking advantage of 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). A scheme of some 4 to 7 % tax break is available as well. The tax system to promote investment in plant and equipment to improve productivity was terminated in FY 2016.

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 19,52 JPY/kWh, 120 - 300 kWh/month 26,00 JPY/kWh, > 300 kWh/month 30,02 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 (2,25 JPY/kWh (April 2017), 2,64 JPY/kWh (May 2017 - April 2018))" 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 2017: -3,08 JPY/kWh). *3: There are various price plans depending on hours. *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 will be added in the same way as the one for households. Fuel regulatory costs will be added or reduced (fuel regulatory cost as of June 2017: -2,97 JPY/kWh). *3: There are various price plans depending on hours and seasons. (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 x (185 - power factor)/ 100 per 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 will be added in the same way as the one for households. Fuel regulatory costs will be added or reduced (fuel regulatory cost as of June 2017: -2,97 JPY/kWh). *3: There are various price plans depending on hours and seasons. (Source: TEPCO Energy Partner's website)
Population at the end of 2016	126,937 million (Statistics Bureau, Ministry of Internal Affairs and Communications (MIC), finalized in November 1, 2016)
Country size (km^2)	377 971 km^2 (Statistics Bureau, MIC) (as of October 1, 2015)
Average PV yield in kWh/kWp	1 000 - 1 100 kWh/kW/yr
Name and market share of major electric companies (based on electricity demand of December 2016)	1 TEPCO Energy Partner 31,1 % 2 Chubu Electric 15,3 % 3 Kansai Electric 15,0 % 4 Tohoku Electric 10,1 % 5 Kyushu Electric 9,6 % 6 Chugoku Electric 7,4 % 7 Hokuriku Electric 3,7 % 8 Hokkaido Electric 3,7 % 9 Shikoku Electric 3,2 % 10 Okinawa Electric 0,9 % (Source: Survey of Electric Power Statistics, METI)
Name and market share of electric utilities (based on electricity demand of December 2016)	1 Former General Electricity Utilities (10 electric companies from Hokkaido to Okinawa) 91,4 % 2 Power Producers and Suppliers (PPS) 8,6 % (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 2016

3.1.1.1 Description of support measures excluding BIPV and rural electrification

The Ministry of Economy, Trade and Industry (METI) is taking initiative in supporting introduction of PV systems under the Feed-in Tariff (FIT) program. In order to achieve a well-balanced introduction of renewable energy while curbing of national burden, the "Act on Special Measures Concerning Procurement of Renewable Energy Sourced Electricity by Electric Utilities (Renewable Energy Act or FIT Act)" was amended and the "revised FIT Act" was enacted. As a result, the FIT program was fundamentally reviewed and revision of approval scheme, change of method to set FITs, change of entities obliged to purchase FIT electricity, improving transparency of issues related to electric grids and revision of the surcharge reduction system were implemented as shown in Table 14 below in preparation for the enforcement of the Act in April 2017.

Table 14 Key points of the review of the FIT program under the revised FIT Act

Item	Key points of the review
Revision of approval scheme	- Setting of new approval criteria to secure proper implementation of projects - Framework to comply with related laws and regulations - Securing safety of PV systems - Addressing delayed/ unrealistic projects
Change of method to set FITs	- Mid-term price target - FIT setting for multiple fiscal years - Introduction of Top-runner program and tender scheme
Change of entities obliged to purchase FIT electricity	- Retailers → Power transmission and distribution operators
Improving transparency of issues related to electric grids	- Disclosure of information on grid (open capacity and standard unit price) - Guideline for sharing cost - Establishment of rules for grid connection - Disclosure of information on supply and demand
Revision of the surcharge reduction system	- 80 % exemption → setting exemption rate based on energy-saving efforts

Support measures excluding BIPV and rural electrification are described in Table 15.

3.1.1.2 BIPV development measures

As for the building-integrated PV (BIPV), the New Energy and Industrial Technology Development Organization (NEDO) implemented "Demonstration project for diversifying PV applications" from FY 2013 to FY 2016. 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 at the moment. While activities related to improvement of energy self-sufficiency ratio of buildings such as achievement of net zero energy building (ZEB) are promoted, NEDO started a study project named “study on BIPV” from FY 2016 to collect information and identify issues for commercialization of BIPV.

Latest trends and global activities related to BIPV including power generation performance, effect on energy saving, market price, installation style, the most suitable types of PV module for each installation style and market potential, etc. are studied. Also, elements required for BIPV are studied to formulate a target which can serve as an indicator for dissemination of BIPV in the future by identifying challenges for dissemination, including future improvement of performance, outlook of cost reduction, as well as development of integrated systems with other energy technology, etc.

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 high-cost 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 in 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 high.

3.1.1.4 Support for electricity storage and demand response measures

Installation of storage batteries was not subsidized within the budget for FY 2016. Storage batteries were included in the subsidies for installations of net zero energy house (ZEH) and demonstration projects of ZEB. “Subsidy for project expenses to accelerate dissemination of net zero energy house (ZEH)” is granted with 1,25 million JPY per one eligible house as the fixed subsidy. Sustainable open Innovation Initiative (SII) is the liaison for this subsidy program. In case of introducing a storage system to the eligible ZEH, 50 000 JPY is granted for one kWh of storage capacity with the cap of either one-third of the eligible cost for the subsidy or 500 000 JPY, whichever is lower. For this subsidy program, five rounds of public invitation were carried out, which received 6 368 applications in total. Applications for the fifth round are under review and the number of selected projects of the first four rounds was 5 093. With “Demonstration project of net zero energy building (ZEB)”, part of the costs is subsidized to extension and renovation of existing buildings as well as new buildings which introduce high-performance building materials or equipment, etc. as component of ZEB. The subsidy rate is two-thirds or less of the eligible cost and the cap of the total subsidy is 1 BJPY/year. Three rounds of public invitation were carried out and the number of selected projects was 28 in total. Public invitation for “Subsidy for emergency responses to suspension of grid connection of renewable energy” under FY 2014 supplementary budget was continued and a part of the cost to introduce storage systems for adjustment of output

fluctuations of PV systems was subsidized. Systems with storage capacity of 10,0 kW or more were eligible for the subsidy. The subsidy rate was one-half or less of the eligible cost for small- and medium-sized entities (SMEs) and one-third or less for large companies. The cap of subsidy was 150 000 JPY per one kWh of storage capacity. Tokyo Metropolitan Government (TMG) started “Project to expand introduction of renewable energy for local production and local consumption” and supports private businesses which install renewable energy power generation facilities, etc. for self-consumption in Tokyo. Storage batteries which are introduced together with PV systems are also eligible for the subsidy. The subsidy rate is one-third or less of the eligible cost for SMEs with the cap of 50 MJPY and one-sixth or less of the eligible cost for other companies with the cap of 25 MJPY.

With regard to demand response, public invitation for “Subsidy for projects to establish virtual power plants (demonstrative projects to establish virtual power plants)”, the Institute of Applied Energy serving as a liaison, was carried out. Subsidy was granted for the eligible equipment cost (storage batteries) and installation cost, covering up to half of the cost. As for residential lithium ion batteries, storage batteries which cost 200 000 JPY/kWh or less are eligible for subsidy. A total of seven projects were selected. A total capacity of the storage batteries subject to output curtailment amounted to 19,1 MW.

Following the establishment of negawatt trading market in April 2017, a mechanism in which negawatt can be traded as a supply capacity as is the case with the generated electricity will be developed. Besides, general power transmission and distribution operators started public invitation for dispatching ability used for frequency control and adjustment of supply and demand balance within the service area. The government is investigating the possibility to evaluate the negawatt as a dispatching ability as well.

Table 15: PV support measures (summary table)

	On-going measures residential	Measures that commenced during 2016 - residential	On-going measures - commercial + industrial	Measures that commenced during 2016 - commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2016 - 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 to the end of March 2017)					
Self-consumption	No	No	There are subsidies intended for PV for self-consumption purpose (FIT is not provided)		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 systems 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 collateral nor consigner required, etc. 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 where electric companies or their subsidiaries carry out the PV power generation business - Multiple cases of storage batteries for adjustment are installed at substations or sites of thermal power plants in remote islands or the areas where capacity of electrical distribution is saturated, with the subsidy by the government			
Sustainable building requirements	Based on the "Act for the Improvement of the Energy Efficiency Performance of Buildings" promulgated in July 2015, a gradual change to conformity obligations to energy efficiency standards is promoted. Previous non-binding obligations were changed to conformity obligations for buildings with gross floor area of 2 000 m^2 or more from FY 2017 onwards and for buildings with gross floor area of < 300 m^2 from FY 2020 onwards 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 has advanced thanks to the subsidy program for demonstration projects of ZEB and ZEH. However, many of them are for emergency use at the time of electric outage, etc. or operated in the mode to store electricity in the middle of the night and discharge in the daytime and rarely used to mitigate the impacts of natural variable power sources on electric grids.

3.2 Self-consumption measures

Table 16: 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 for < 10 kW and 20 years for 10 kW or more 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	Purchase of surplus electricity for < 10 kW. For 10 kW or more, there is no size limitation as far as power transmission and distribution operators permit.
	12	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 grid connection capacity and tender for FIT capacity.

- Tender for grid connection capacity

The “tender process to secure the grid connection capacity” is conducted to bid for grid connection capacity in areas where projects of various power sources such as PV are concentrated into specific power transmission and distribution lines. Previously, construction

cost for the enhancement of grid was presented with the premise that grid connection is carried out individually by each business operator. However, under the tender process to secure the grid connection capacity, reduction of the burden of each business operator is aimed to be achieved through cost sharing with neighbouring projects. The cost for enhancement of bulk power system is the general burden which is widely covered by consumers based on the guideline released by METI in November 2015. As for the enhancement cost of power transmission and distribution facilities other than those for bulk power system, the ratios of general burden and burden for business operators (specific burden) are calculated for each tender process. A ceiling price was set for the general burden and the lowest among all power sources is PV with 15 000 JPY/kW.

The Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO) is the organizer of the tender process and the tender process can be started when the requirements are satisfied following the application for the start by the business operator. General electricity utilities are in charge of the procedures and they present tender capacity and minimum tender price (minimum unit price of tender burden) per kW for each area. Power producers bid for the planned system capacity and tender price (unit price of tender burden) per kW and the priority for grid connection is decided in descending order according to tender price. The tender process becomes effective when the product (result of multiplication) of unit price of tender burden and capacity exceeds the construction cost for that tender. As of December 2016, a total of 26 tender processes have been started throughout Japan, mainly in Tohoku region, Tokyo and Kyushu region.

- Tender for FIT capacity

From FY 2017, 2 MW and larger PV projects are subject to the tender scheme following the incorporation of the tender for FIT capacity in the revision of the Renewable Energy Act which was enacted in May 25, 2016, as shown in Table 17. Participants bid for purchase price and system capacity in order to acquire the right to apply for approval under the FIT program. During two years of trial period from FY 2017 to FY 2018, one round in FY 2017 and two rounds in FY 2018, a total of three tender rounds with a total capacity of 1 to 1,5 GW will be conducted. In addition to methodology to decide FITs, conditions for acquisition of approval and deposit, etc., the tender capacity for the first round and the ceiling price were revealed.

Table 17 Details of the first round of tender for FIT capacity scheduled in FY 2017

Item	Description
Subject of the tender scheme	≥ 2 MW PV systems
Tender capacity	500 MW (a uniform tender is conducted nationwide)
Timing of tender	Around October 2017
Items of tender	Purchase price (JPY/kWh, down to two decimal points) and system capacity shall be specified
Ceiling price	21 JPY/kWh (FIT for 10 kW - < 2 MW PV systems in FY 2017)
Methodology to decide FITs	Pay-as-Bid (bidding price of successful bidder will be set as FIT)
Conditions for acquisition of approval	After winning the bid, application for FIT approval must be submitted within 1 month and approval must be acquired within 3 months
Deposits	First deposit (500 JPY/kW), Second deposit (5 000 JPY/kW)

3.4 Direct Support measures

- Subsidy for projects to support renewable energy operators

  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 national budget.

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

  This subsidy program supports efforts to develop a pioneering energy system with local-production-and-local-consumption model.

- Projects to promote introduction of innovative energy conservation technologies in houses and buildings

  This program grants a certain amount of money for introductions of ZEH and demonstration projects of ZEB.

- Subsidy for projects to establish virtual power plants

  This subsidy program supports demonstration projects for establishment of business models in which energy facilities such as storage batteries are utilized and efforts towards demand response with high level of control. .

- Subsidy to supplement interest for measures to address grid restrictions

  This subsidy program grants a certain amount of money equivalent to the interest necessary for securing a loan from commercial banks, etc. which conduct financing business targeted at power producers who implement enhancement of local grid.

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 consumers 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 consumers such as manufacturers are entitled to reduction of surcharge under the FIT program. 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 the national budget. The budget amount is; 19,1 BJPY in FY 2013, 29,0 BJPY in FY 2014, 45,6 BJPY in FY 2015, 48,3 BJPY in FY 2016, and 29,2 BJPY in FY 2017. Amount of purchased electricity generated by PV systems under the FIT program is around 93,7 TWh as of the end of December 2016, exceeding 3,8 TJPY in total.

3.6 Indirect policy issues

3.6.1 International policies affecting the use of PV Power Systems

In order to achieve the reduction target of greenhouse gas emissions which was presented in the Intended Nationally Determined Contributions (INDC) of Japan, which was approved by the 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21), the national government formulated the "Plan for Global Warming Countermeasures" in May 2016, in which mid-term plan for Japan's global warming prevention is indicated. This plan specifies the actions to be addressed by the national government, local governments, business operators and general public and the national measures and draws a path 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". In November 2016, the Japanese government approved the accord on the Paris Agreement in the plenary session of the House of Representatives. Japan established a goal to reduce the CO_2 emissions by 26 % by FY 2030 compared to FY 2013 (25.4 % decrease from FY 2005) and by 80 % by 2050.

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. Besides, energy conservation standards for buildings are enhanced step by step.

- Promotion of levelling electricity demand

  In addition to conventional energy conservation, when electricity consumers 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 will contribute to addressing peak shifting.

- Enhancement of energy conservation standards in buildings

  Before 2016, accomplishment of energy conservation standards was either a reporting obligation or a non-binding obligation depending on the floor space of buildings. From 2016 onwards, they are changed to conformity obligations, step by step. From April 1, 2017 onward, the previous non-binding obligation was changed to a conformity obligation for new construction, extension and rebuilding of non-residential buildings with gross floor area of 2 000 m^2 or more. By around 2020, all buildings including houses covering the floor space of below 300 m^2 will also fall under the conformity obligation. 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. Subsidy is provided for promoting introduction of innovative energy-saving technology such as net zero energy buildings and houses (ZEB/ZEH).

3.6.3 Policies relating to externalities of conventional energy

While the operation of nuclear power plants are suspended after the Great East Japan Earthquake, electricity supply capacity has been secured by increasing the operation of thermal power generation facilities as shown in the following figure. The share of thermal power generation in the generation mix was approximately 62 % in FY 2010, before the earthquake. After the earthquake, it rose to approximately 85 % by FY 2015. Since Japan relies the majority of its fossil fuel demands on imports from overseas, there is always a risk of unstable supply due to the influence of changing situations in resource-producing countries. In FY 2016, the fuel cost is expected to increase by approximately 1,3 TJPY compared to the level before the earthquake (the average between FY 2008 and FY 2010). Compared to FY 2015, the increase of fuel consumption slowed due to the declining fuel prices, appreciation of the yen, energy conservation, etc., however, the cumulative increase of fuel cost is estimated to reach 15,5 TJPY.

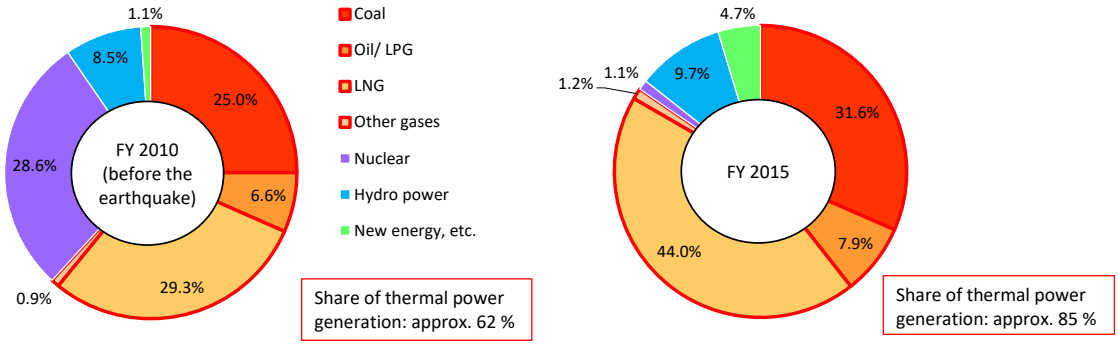

Figure 1 Generation mix of the electric companies

Source: Report on electricity supply-demand verification by METI (April 2017)

Following the increasing operation of thermal power generation facilities, greenhouse gas emissions from electricity generation has been significantly increasing. Greenhouse gas emissions in Japan increased to approximately 1,32 billion t-CO_2 in FY 2015 from approximately 1,30 billion t-CO_2 in FY 2010. Increase of emissions in the electricity generation sector is one of the major factors. Under such circumstances, securement of domestically-produced energy sources is recognized as one of the important issues in the "Long-term Energy Supply-demand Outlook" which was announced in 2015. In this outlook, 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 for peak demand hour

  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. Following full liberalization of electricity retailing from April 1, 2016, from the winter of 2016, supply and demand of all areas including Power Producers and Suppliers (PPS) were included in the scope of verification in addition to former General Electricity Utilities. Verification is conducted by OCCTO and the actual power supply records of PV systems are also evaluated.

Table 18: Power supply capabilities of PV systems in the summer by electric company in Japan

(MW)

Former General Electricity Utilities by area		Hokkaido	Tohoku	Tokyo	Chubu	Kansai	Hokuriku	Chugoku	Shikoku	Kyushu	Total
Summer of 2016 (Actual)	**Actual PV installed capacity**	**1 037**	**2 672**	**8 575**	**5 548**	**3 908**	**594**	**2 860**	**1 742**	**6 287**	**33 223**
	Actual supply records on a day and an hour of peak demand	**152**	**1 327**	**4 176**	**3 101**	**1 077**	**281**	**1 470**	**1 006**	**2 834**	**15 424**
	Peak demand date and hour	Mon, Aug. 8 4–5 p.m.	Fri, Aug 5 2-3 p.m.	Tue, Aug 9 2-3 p.m.	Mon, Aug 8 2-3 p.m.	Mon, Aug 8 4-5 p.m.	Thu, Aug 25 2-3 p.m.	Thu, Aug 25 2-3 p.m.	Mon, Aug 22 3-4 p.m.	Mon, Aug 22 3-4 p.m.	-
	(Peak electricity demand)	4 050	12 280	46 600	24 250	23 750	5 160	10 420	5 350	14 550	146 410
	PV ratio to peak demand	3,8 %	10,8 %	9,0 %	12,8 %	4,5 %	5,4 %	14,1 %	18,8 %	19,5 %	10,5 %
Summer of 2017 (Forecast)	Estimated peak demand hour	2 - 3 p.m.	2 - 3 p.m.	2 - 3 p.m.	2 - 3 p.m.	2 - 3 p.m.	2 - 3 p.m.	2 - 3 p.m.	2 - 3 p.m.	4 - 5 p.m.	-
	Estimated supply capability	**80**	**730**	**1 940**	**1 910**	**1 190**	**170**	**1 190**	**640**	**1 370**	**8 980**
	Output ratio	**6.7**	**21.0**	**20.8**	**29.4**	**27.9**	**24.4**	**29.9**	**30.7**	**20.3**	**-**

Source: Report on electricity supply-demand verification by METI (October 2016 and April 2017)

*1: "Supply capability" of PV power generation is the installed capacity which PV systems supply power in the peak demand hours. 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: PV generated power used for self-consumption is evaluated as energy conservation and not included in supply capability. Only the surplus electricity connected to electric grids is evaluated here.

*3: As for the actual figures for the summer of 2016, supply capabilities of each former General Electricity Utility are accumulated. The forecast for the summer of 2017 is based on accumulation of all the areas.

As shown in Table 18, in the summer of 2016, electricity supply capability in the peak hours of each former General Electricity Utility was 15,424 GW in total against the PV installed capacity of 33,223 GW. It is estimated that the supply capability in the summer of 2017 (excluding Okinawa Prefecture) will be 8,98 GW, below the previous year's result. Due to increasing awareness of energy and electricity conservation, etc., in some areas, peak hours came in the late afternoon. Therefore, the supply capability of PV which is expected to respond to peak demand remained smaller against the installed capacity.

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

In Japan, "Tax for Climate Change Mitigation" has been imposed since October 2012, which requires the public to widely and fairly share the burden for the usage of all the fossil 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 added 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 920 JPY/t for coal. From April 2014 to March 2016, as part of the phased tax rate increase, the rates were increased to 2 540 JPY/kl, 1 600 JPY/t and 1 140 JPY/t, respectively. From April 2016 (start of FY 2016) onwards, when the phased tax rate increase was completed, the definitive tax rates have been applied and the rates are 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 Tax for Climate Change Mitigation 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 various 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 in consideration of geographical characteristics taking advantage of the Green New Deal Funds, etc.

The subjects of taxation under the Tax for Climate Change Mitigation are limited and the usage of tax revenue is limited to measures to address global warming. Accordingly, in order to archieve the commitment of the Paris Agreement, the Ministry of the Environment (MOE) started discussion on adopting the environment tax (carbon tax) which expands the subjects of taxation as well as the usage.

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.

In order to achieve the reduction target of greenhouse gas emissions, Japan has implemented the Joint Crediting Mechanism (JCM). The JCM is a mechanism in which credits issued depending on the reduced amount of greenhouse gas emissions are utilized to achieve target of Japan's greenhouse gas emissions reduction through support for dissemination of high-quality low carbon technologies, etc. to developing countries. As of February 2017, Japan has signed the bilateral documents with 17 countries namely Mongolia, Bangladesh, Ethiopia, Kenya, Maldives, Vietnam, Laos, Indonesia, Costa Rica, Palau, Cambodia, Mexico, Saudi Arabia, Chile, Myanmar, Thailand and the Philippines. From FY 2013 to FY 2016, a total of 105 funding projects and demonstration projects (MOE/ METI) were adopted in these countries and credits were issued in Mongolia, Indonesia and Palau. As of January 2017, 55 PV-related projects are promoted by Japanese companies. With these projects, introduction of high-efficient PV systems and appropriate O&M, application of PV system as a substitute for grid elecricity by diesel electric power generation or fossil fuel electric power generation, as well as for off-grid power system are carried out. Out of these projects, METI and NEDO are conducting 13 PV-related feasibility studies and 3 PV-related introduction demonstration projects.

MOE supports a total of 24 projects of subsidy for equipment including PV systems with a total capacity of approximately 118 MW (from FY 2013 to FY 2016). As for PV, a 50-MW PV power plant in Bangladesh is the largest project to date. In addittion, as for feasibility studies and JCM project planning studies (PS), MOE selected 15 PV-related projects.

NEDO is also conducting the Project to demonstrate technology and system for improving efficiency of international energy consumption. PV-related technology demonstration projects are underway in Indonesia and India.

Japan International Cooperation Agency (JICA) conducted 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 2016, a 20-MW scale PV power plant was planned under yen loan contract signed with the government of Egypt and a PV system was introduced to support improvement of an international airport under yen loan contract signed with the government of Sri Lanka. JICA also conducted a survey on preparation of PV system introduction plan in the Marshall Islands and selected business operators for project to support oversease business expansion of SMEs in which PV system is utilized. In addition, JICA financed the “Off-Grid Solar Power Project” in sub-Saharan Africa implemented by Japanese companies. The JICA Morocco office supported a project to promote introduction of a 30-kW concentrated PV (CPV) system.

Japan Bank for International Cooperation (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)” support program which was initiated from 2010. As of the end of March 2017 (end of FY 2016), JBIC approved 31 projects with a main focus on renewable energy projects planned in Mongolia, Philippines and Latin America.

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

As for R&D activities of PV technology, the New Energy and Industrial Technology Development Organization (NEDO) is promoting technology development towards commercialization, which is administered by METI, and the Japan Science and Technology Agency (JST) is promoting fundamental R&D, which is administered by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). NEDO is advancing two demonstrative research projects and three technology development projects in FY 2016 based on the NEDO PV Challenges, a guidance for technology development in which a target to realize the power generation cost of 14 JPY/kWh by 2020 and 7 JPY/kWh by 2030 is set. As for technology development projects, three projects namely "Development of Solar Power Recycling Technology (FY 2014 to FY 2018)", "Technological development for improvement of system performance and operation and maintenance (O&M) (FY 2014 to FY 2018)" and "Development of high performance and reliable PV modules to reduce levelized cost of energy (FY 2015 to FY 2019)" are underway and mid-term evaluations on the former two projects were conducted. Under the project of "Development of Solar Power Recycling Technology", technology development on recovery and disassembly of used PV modules were completed by 2016. From 2017, demonstrative research using the technology of disassembly and treatment which was developed by 2016 started and technology development on reuse of recovered PV modules which started in 2016 is being continued. Under the project of "Technological development for improvement of system performance and operation and maintenance (O&M)", technology development on the issues such as technology to improve efficiency of PV systems including development of highly-efficient inverters, system technology corresponding to various installation environments, O&M technology of PV systems including operation and diagnosis of the installed systems was conducted. As for technology of system installation and O&M, although demonstrative researches on a part of the results of technology development remain to be accomplished, almost all of the technology development projects scheduled before 2016 were completed. From 2017 onwards, by adding new themes for public invitation, technology development aiming to achieve development goals and further reduce levelized cost of energy will be carried out focusing on the technology to improve efficiency of PV systems which is under development. Meanwhile, under the project of "Development of high performance and reliable PV modules to reduce levelized cost of energy", a total of 19 technology development themes and trend surveys are conducted regarding four technological development topics namely "Development of crystal silicon PV modules using advanced multiple technologies and high performance CIS modules", "Research and development of innovative new structure solar cells", "Development of common components for solar cells and modules" and "Development of Common Fundamental Technologies". Under the technology development, development of high efficiency solar cell technology and development of fundamental technologies for commercialization using pilot mass production line are carried out on various types of solar cells such as crystalline silicon solar cells, II-VI compound solar cells and organic solar cells. In the Results Report Workshop held in October 2016, achievement of the world' highest conversion efficiency of 26,33 % was reported on a practical size crystalline silicon solar cell. In addition, development of reliability measuring technology of solar cells and technology to evaluate power generation amount of PV systems are also continued. Mid-term evaluations on the project of "Development of high performance and reliable PV modules to reduce levelized cost of energy" is scheduled in 2017. Apart from the technology development by NEDO, "R&D project for international joint development of innovative technologies" are jointly conducted with G7 countries from 2015 and research themes on new structure solar cells were adopted in 2016.

As for R&D activities administered by MEXT, R&D activities on PV such as "Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells" and "Creative Research

for Clean Energy Generation using Solar Energy" which were basic R&D programs through the Japan Science and Technology Agency (JST) were concluded. In 2016, development on PV-related technology is continued under "PV cells /modules and solar energy utilization system", as one of the technological fields under the "Advanced Low Carbon Technology Research and Development Program (ALCA)". In 2016, one research topic was selected respectively for silicon tandem solar cells and perovskite solar cells as new research agendas and fundamental technology development is conducted. In 2017, call for proposals on new research themes under the "Mirai-Program (future society creation program)" is scheduled.

R&D activities conducted under the "FUTURE-PV Innovation Projects" at the Fukushima Renewable Energy Institute of the National Institute of Advanced Industrial Science and Technology (AIST-FREA) in association with reconstruction from the Great East Japan Earthquake were concluded in FY 2016 after five years of research period. In addition to conducting demonstration of wide gap silicon through quantum effect by nanowire or nanowall（new technologies such as PV system using spectral splitting and manufacturing technology of single crystalline silicon ingot by noncontact crucible (NOC) method were developed.

Demonstration research related to PV technology is mainly promoted by NEDO. Under the "Demonstration project for diversifying PV applications (FY 2013 to FY 2016)" aiming to extend PV utilization areas, validation of installation technologies for building walls, agricultural applications, slopes and water surfaces, etc. and power generation performance at these sites was conducted. Development and demonstration of solar thermal/ PV hybrid modules and systems as added value technologies including functions other than power generation or adding new applications were conducted. As a major achievement in FY 2016, Kaneka developed and started a demonstration test of an environmentally-friendly low-reflection wall-mounted PV system, aiming for realization of ZEB. This PV system has anti-glare function as a measure against light pollution. Flameless thin-film silicon PV modules in which high designability is achieved by using many different colors are adopted in this system. Nisshinbo Mechatronics developed and started a demonstration test of a high efficiency thermoelectric hybrid PV module whose total energy efficiency is 78,0 % (power generation efficiency: 15,5 %, heat collection efficiency: 62,5 %). Based on the results of demonstration, companies which join the collaborative research will aim for practical use and commercialization. Under the project of "Technological development for improvement of system performance and operation and maintenance (O&M) (FY 2014 to FY 2018)", development and demonstration are being conducted on technologies to increase power generation amount by improving functions of BOS, technologies to reduce BOS cost including installation cost. In 2016, under this project, NEDO started demonstrations on structure of PV systems and ensuring electrical safety. In order to ensure safety against disaster risks, development of design method and technology, demonstration test and research of facilities are conducted. Based on the knowledge acquired through demonstration test, NEDO aims to formulate a guideline for designing safer and more economical ground-mounted PV systems by the end of February 2019.

Under the "New Energy Venture Business Technology Innovation Program (from FY 2007)" in which PV technology is included as a subject, NEDO newly established a phase D for "Large-Scale Demonstration Study" in 2016. Fixed amount of subsidy ranging from 75 MJPY to 300 MJPY is granted to large-scale demonstration researches conducted by SMEs towards commercialization of extremely promising technology whose fundamental technology has already been established, though the commercialization risk is high. After public invitation in 2016, "Large-scale demonstration development of gyro tracking type PV power generation system" of SolarFlame was adopted.

Regarding utilization technologies of PV systems, METI and NEDO are conducting various technological development programs under demonstrative projects aiming at realization of smart communities. Although major domestic demonstration projects on smart community were

concluded in FY 2015, international demonstration projects continued in overseas in FY 2016 as cross-cutting projects. These projects are aiming at global market development through localization of Japan's excellent energy and system technologies to meet the needs of different countries and regions. The followings are major demonstrative projects conducted in FY 2016.

- Smart Community Demonstration Project: Lyon, France (FY 2011 to FY 2016), Java Industrial Park, Indonesia (FY 2012 to FY 2017), Manchester, UK (FY 2014 to FY 2016), Speyer, Germany (FY 2015 to FY 2017)
- Demonstration Project for World-leading Remote Island Smart Grid (FY 2011 to FY 2016): Maui Island, Hawaii, USA
- Smart Grid Demonstration Project (FY 2015 to FY 2018): Haryana, India
- Model Project for a Microgrid System Using Large-scale PV Power Generation and Related Technologies (FY 2012 to FY 2019): Neemrana Industrial Park, Rajasthan, India
- Demonstration for Hybrid Solar Inverter & Battery System with Monitoring and Control (FY 2015 to FY 2016): Oshawa, Ontario, Canada
- Demonstration Project for Validation of Redox Flow Battery Performance (FY 2015 to FY 2020): California, USA
- Demonstration project of High-Voltage Direct Current (HVDC) feeding system, etc. for data center (FY 2015 to FY 2016): Texas, USA
- Demonstration project of self-excited converter for High-Voltage Direct Current (HVDC) system (FY 2015 to FY 2017): Rome, Italy

Furthermore, various demonstration projects aiming to expand possible grid connection capacity of renewable energy and control the grid are conducted. Under the demonstration projects on large-capacity storage systems conducted as part of support programs by METI and MOE, by installing one of the world's largest storage systems in the premises of electric companies, demonstration on improvement of supply and demand balance utilizing electricity storage function and control of grid voltage and verification of the effect on expansion of introduction of renewable energy are carried out. Also, demonstration test on remote output curtailment of PV electricity, demonstration projects towards establishment of VPP as well as development and demonstration of hydrogen energy technology utilizing surplus PV electricity, etc. started in 2016 as part of support programs by METI. Demonstration test on remote output curtailment of PV electricity was implemented with large-scale PV power generation facilities mainly by electric companies. In addition, demonstration of power control technology using HEMS also started for remote output curtailment of residential PV electricity. In 2016, NEDO, jointly with electric companies and universities, started development and demonstration test of remote output curtailment system which enables output curtailment of small- to large-scale PV systems using communication lines under the "Mitigation Technologies on Output Fluctuations of Renewable Energy Generations in Power Grid (advancement of measures to expand grid connection of renewable energy)".

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

The FY 2016 PV system-related budgets are mainly based on national budgets as shown in Table 19. 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 O&M and recycling technologies for PV systems" and "Development of technologies for improving conversion efficiency and

O&M 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. As for the budget for market incentives, while 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.

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.

Table 19: Public budgets for R&D, demonstration/field test programmes and market incentives

	FY 2014			FY 2015			FY 2016		
	R&D	Demo/ Field Test	Market Stimulation	R&D	Demo/ Field Test	Market Stimulation	R&D	Demo/ Field Test	Market Stimulation
National (BJPY)	10,3	0,8		4,894	0,608		5,65		
Regional (BJPY)	-	-	-	-	-	-	-	-	-

5 INDUSTRY

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

Table 20: Production information for the year for silicon feedstock, ingot and wafer producers in 2016

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	Polysilicon (for semiconductor, Siemens process)	Very small amount [2]		
Ferrotec	Ingot			
	Si wafers			
Panasonic	n-type sc-Si wafers for HIT (a-Si on c-Si) (125 mm x 125 mm)	Undisclosed		

[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 2016 of Japanese manufacturers of silicon feedstock for solar cells, ingots and wafers, one of the remarkable features was Tokuyama's withdrawal from manufacture of polysilicon (multicrystalline silicon) for solar cells. Tokuyama announced to sell its factory in Malaysia to OCI of South Korea for 98 MUSD and transferred the factories to OCI in May 2017, delayed from the original schedule of the end of March 2017. The Malaysian factory in which almost 200 BJPY was invested, reported large impairment losses twice because of technical troubles of manufacturing facilities and significant deterioration of the market condition of polysilicon for solar cells. Tokuyama will continue manufacture of polysilicon for wafers for semiconductor applications at its Tokuyama Factory located at its headquarters in Shunan City of Yamaguchi Prefecture.

Panasonic is conducting adjustment of production capacity following the slowdown in demand for solar cells. As part of it, Panasonic announced a plan to cut 40 % of its employees at its silicon ingot manufacturing factory for solar cells in Oregon, USA. Ferrotec announced to newly establish manufacturing lines of 200 mm (8 inch) semiconductor-grade wafers in Shanghai, China and establish a manufacturing company of semiconductor-grade silicon ingots in Yinchuan, China with the purpose of shifting its business focus to the growing semiconductor-related business from the PV-related business, which used to be the company's major line of business. 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 of Japanese PV cell/ module manufacturers continued to decrease year on year, influenced by such factors as the revision of the FIT program. Some Chinese manufacturers and start-up manufacturers began to increase their share in the Japanese industrial and residential PV market by taking advantage of price competitiveness. Forecasting that the MW-scale PV market in Japan will shrink, Japanese manufacturers are shifting their target PV markets by returning to the residential PV market and moving to the PV market for building applications. 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, Japanese companies actively promoted overseas expansion, preparing for the expected shrinkage of the domestic PV market. Amid the fierce global competitions, these companies are working on further reducing the cost and seeking business expansion by introducing new products for overseas markets. Japanese manufactures are considering the expansion of production capacity in parallel with development of overseas markets. Panasonic agreed to construct a factory of PV modules in the state of New York, USA as a joint venture with Tesla Motors (USA) (they are collaborating in production of storage batteries in the USA as well). In the domestic market, introduction of new products for residential applications and enhancement of sales strategy are promoted. Overseas manufacturers follow these trends, and the market share competition is getting intensified by means of responses to high-end products and various types of rooftop applications.

Thin-film PV module manufacturers are focusing on development of both domestic and overseas markets continuously. Solar Frontier and the government of Saudi Arabia agreed to conduct a joint feasibility study into the possibility of CIS PV module production in Saudi Arabia. The company also promotes the BOT (build - own - transfer) business. It announced the introduction of “SmaCIS”, a strategic product targeted at the domestic residential market.

In the area of technology development, several companies reported improvement of solar cell conversion efficiency. Kaneka achieved the world’s record solar cell conversion efficiency of 26,33 % on a practical-sized heterojunction back-contact crystalline silicon (c-Si) solar cell. Solar Frontier set a new world record of CIS thin-film PV module efficiency of 18,6 % with sub-module and 22,0 % with small-area cell (22,8 % according to in-house measurement).

According to PV shipment statistics by the Japan Photovoltaic Energy Association (JPEA), total PV shipments by domestic production in Japan in 2016 (from January to December) were approximately 1,6 GW of solar cells (a 17 % decrease year on year) and approximately 2,8 GW of PV modules (an 11 % decrease year on year).

Table 21: Production and production capacity information for 2016

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, mc-Si	1 100	-	-	-
3 Panasonic	HIT (a-Si on c-Si)	Undisclosed	Undisclosed	1 000	1 000
4 Mitsubishi Electric	sc-Si	Undisclosed	280	Undisclosed	530
5 Fujipream	sc-Si, mc-Si				
6 Choshu Industry	sc-Si				
	mc-Si				
7 Suntech Power Japan[2]	sc-Si, mc-Si				
8 Towada Solar	sc-Si	-	2,2	-	10
	mc-Si	-	3,8	-	50
9 Spower	c-Si				
10 PVG Solutions[3]	sc-Si (bifacial)	5	5	35	
11 KIS	sc-Si, mc-Si				
12 Denkasinki	Sc-Si				
Thin film manufacturers					
1 Solar Frontier	CIS	910	910	1 110	1 110
2 Kaneka	a-Si, a-Si/poly-Si hybrid	-	-	120	120
3 FWAVE	a-Si				
4 Mitsubishi Chemical	a-Si, OPV				
Cells for concentration					
1 Sumitomo Electric Industries	CPV		1		5
TOTALS		**2 116** [4]	**2 758** [4]	**3 790** [5]	**4 130** [5]

[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]: Suntech Power Japan does not manufacture cell/ module. As Shunfeng Group, the total production was 1 465,6 MW for solar cells and 1 433,2 MW for PV modules and the maximum production capacity was 1 300 MW/yr for solar cells and 2 400 MW/yr for PV modules.

[3]: Went bankrupt in 2016

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

[5]: Studied by RTS Corporation

Source: answers from each company for the questionnaire by NEDO

5.3 Manufacturers and suppliers of other components

- Inverters

Inverters for residential applications shifted towards certification of multiple-unit grid-connection type. In total, 21 manufacturers such as Omron, Tabuchi Electric, Panasonic, Kyocera, Sharp, Mitsubishi Electric, SMA Solar Technology of Germany and Delta Electronics of Taiwan have acquired certificates from the Japan Electrical Safety & Environment Technology Laboratories (JET) for their products.

For 10 kW to < 50 kW inverters for low-voltage grid connection, major inverters on the market used to include a 9,9-kW inverter, a 25-kW inverter and a 33-kW inverter by Tabuchi Electric; a 5,5-kW inverter, a 9,9-kW inverter, a 10-kW inverter and a 12,375-kW inverter by Omron; and 10-kW inverter by Yaskawa Electric, GS Yuasa, Sanyo Denki and Shindengen. Recently, overseas manufacturers such as SMA Solar Technology and Huawei Technologies of China are increasing their market share.

For the systems with a capacity of 50 kW or more, which are connected to high-voltage or extra-high voltage electric 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 25 - 50 kW, 100 kW, 250 kW, 500 kW, 600 kW and 1 000 kW. Tabuchi Electric, SMA Solar Technology, Huawei Technologies, Delta Electronics and ABB have entered this market sector. In regard to central inverters with a capacity of 100 kW or 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 Power Supply of China and other manufacturers newly entered this market. With an increase in the number of installation of distributed inverters in FY 2016, the competition between large-capacity central inverters and distributed inverters has intensified. In this sector of the market, DC voltage of systems has increased and more systems now correspond to DC 1 000 V, up from the conventional DC 600 V. As for extra-high voltage grids with the output capacity of 2 MW or more, the trend is shifting to higher-voltage products corresponding to DC 1 500 V systems. Reflecting an increasing demand in 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 ≤ 20 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 is requiring inverters to respond to remote-controlled output curtailment. Moreover, 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, inverters with storage function

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 for ZEH and major manufacturers launched new products one after another with long life time, large capacity and high reliability. Panasonic, GS Yuasa, Nichicon, NEC, Eliiy Power, etc., supply storage batteries in Japan.

Residential inverters with storage function are sold as hybrid inverters, etc. by Panasonic, Sharp, GS Yuasa, Eliiy Power, Omron, Tabuchi Electric, Kyocera, NEC and Nichicon. The inverter capacity usually ranges from 4,5 kW to 5,9 kW and the capacity of storage batteries ranges from 3,9 kWh to 12,65 kWh.

Some companies from abroad entered the Japanese market. PV manufacturers Hanwha Q CELLS Japan, Canadian Solar and others are selling residential PV systems equipped with storage batteries.

Large-scale lithium ion batteries with MWh level capacity, sodium-sulfur (NAS) batteries, etc., are installed for grid stabilization by electric companies and demonstration tests are conducted by Hokkaido Electric Power, Tohoku Electric Power, Chugoku Electric Power, Kyushu Electric Power, etc.

In the service area of Hokkaido Electric Power, systems with MWh-level lithium ion batteries started operation as a backup power supply for dispatching power source under the FIT program.

- 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 for MW-scale PV power plants have string monitors embedded which are used for operation and maintenance (O&M) of PV power plants. Overseas manufacturers in this area include Weidmueller of Germany and ABB.

Products applicable to DC 1 000 V are increasingly distributed in the market.

- 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 22: Estimated PV-related labour places in 2016

	2015	2016
Research and development (not including companies)	900	800
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	128 000	100 000
Distributors of PV products		
System and installation companies		
Electricity utility businesses and government		
Other		
Total	**128 900**	**100 800**

6.2 Business value

Table 23: Value of PV business

Sub-market	Capacity installed in 2016 (MW)	Price (JPY/W)	Value (MJPY)	Totals (MJPY)
Off-grid < 1 kW				
Off-grid ≥ 1kW				
Grid-connected roof-top < 10 kW (for residential)	806	324	*261 144*	
Grid-connected for commercial	2 418	245	*592 397,75*	
Grid-connected for industrial	1 396	245	*341 975,9*	
Grid-connected ≥ 1 MW	3 235,65	236	763 613,4	
Total	7 855			*1 959 131*
Export of PV products				24 893
Change in stocks held				
Import of PV products				160 301
Value of PV business				1 823 723

Import value described in Table 23 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

Following full liberalization of electricity retailing from April 2016, new players entered into electricity retailing business one after another. The number of registered electric retailers exceeded 350 (as of December 2016) and these Power Producers and Suppliers (PPS) and ten former general electricity utilities that used to conduct regional monopolistic business are competing in the electricity market. As shown in Figure 2, the situation of the electricity market in which former general electricity utilities are dominant remains unchanged and they maintain the share of over 90 % both in the generation sector and retailing sector. The share of trading quantity in the Japan Electric Power Exchange (JEPX) is as low as 3,4 % (as of December 2016). In order to revitalize the trading, introduction of gross bidding by former General Electricity Utilities is considered. As a final phase of the Electricity System Reform, legal separation of the power transmission sector and the power distribution sector of the former General Electricity Utilities is scheduled to be carried out by April 2020.

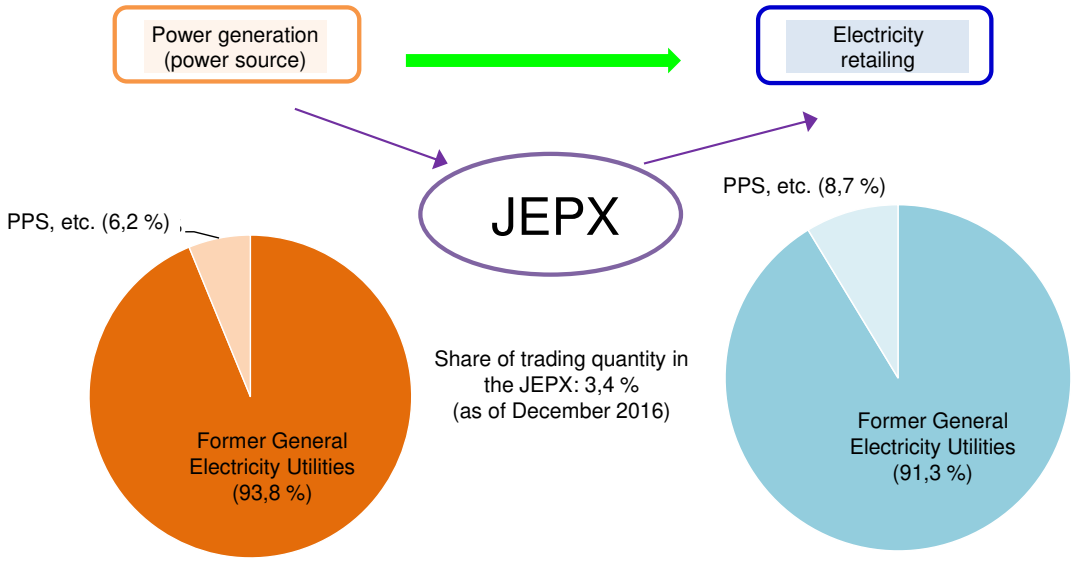

Figure 2 Power source and share of electricity retailing in Japan

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 ten general electric companies are members announced in October 2008 that the they would 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 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, technology development for forecasting PV power generation amount which contributes to controlling the balance between electricity supply and demand has been promoted. Kansai Electric Power developed a system to forecast PV power generation amount with satellite images of the Japan Meteorological Agency. By taking advantage of the forecasted amount of

insolation, the change of PV power generation amount can be forecasted by every three minutes over the next three and a half hours. This enables stable supply and demand control and effects to suppress the influence on the electric grid are anticipated. Tohoku Electric Power is developing a system to forecast PV power generation amount jointly with Mitsubishi Electric. They improved the accuracy of the forecast by analyzing the relationship between insolation and PV power generation amount using the actual performances of PV systems in the past and correcting the forecast value. Other electric companies are also conducting efforts on the forecast of PV power generation amount.

- 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. were conducted as part of METI projects. The following demonstrative researches are underway:

- 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)

- Output curtailment of PV electricity

Following the expansion of PV introduction, output curtailment of PV electricity was conducted in some islands in the service area of Kyushu Electric Power. Appropriateness of output curtailment was verified and the verification results were published by OCCTO.

- 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 Tokyo area and Chubu area 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, 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, construction to increase 900 MW is scheduled by FY 2020. The route for the increase of another 900 MW is also under discussion. Construction to increase the grid connection lines between Hokkaido and Tokyo from 600 MW to 900 MW is progressing to start operation by March 2019. Improvement plan of the grid connection lines between Tohoku and Tokyo was also announced. The construction will start from April 2017 to add 4.55 GW, which is scheduled to be completed in November 2027.

- Responses to accept grid connection

Along with the growth of PV installed capacity, some electric companies announced that they would suspend responses 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. They report calculation results of each fiscal year. In case the capacity for grid connection exceeds the “30-day, etc. output curtailment capacity”, output curtailment will have “no limit without compensation”. As of March 2017, five electric

companies, namely Hokkaido Electric Power, Tohoku Electric Power, Hokuriku Electric Power, Shikoku Electric Power and Kyushu Electric Power has taken this measure. In parallel with these restrictions, a variety of 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 and residential PV systems at the same time. Moreover, some local governments and municipalities started to provide service of low-interest loan of credit type in cooperation with financial institutions and subsidy program for conventional homes which introduce a set of PV system and storage batteries. As for support programs for industrial PV systems, subsidy for installation, loan support and preferential tax treatment are granted. 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, Tokyo Metropolitan Government (TMG) started supporting municipalities (wards, cities, towns or villages) by providing the entire cost of installing free-of-charge charging stands of smartphones, etc. powered by PV modules in Tokyo.

Following the expansion of PV introduction, many cases of damaged PV systems due to local heavy rainfalls and gust of wind were announced one after another. Some prefectures set up regulations on the installation of PV systems in order to prevent such situations. Tsukuba City of Ibaraki Prefecture, to prevent deforestation and sediment disaster and conserve natural environment, enforced an ordinance which regulates installation of renewable energy power generation facilities in the areas of Mount Tsukuba and Mount Houkyou. Kochi Prefecture is formulating draft guidelines to require power producers to gain consensus from the local community, based on the lessons learned from past troubles with local residents over construction of PV power plants. Some other local governments and municipalities are also formulating ordinances and guidelines on the installation of PV systems.

In preparation for the 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. Kobe City of Hyogo Prefecture started to create a mechanism of local production and local consumption in which renewable energy is effectively used by establishing a goal to reduce greenhouse gas emissions. More than ten companies and organizations including Kawasaki Heavy Industries and Obayashi are expected to participate in the consultation.

Some municipalities proactively supporting introduction of PV and other renewable energy sources are setting installation targets and formulating action plans to achieve the targets. Gifu Prefecture announced a proposal for the Next Generation Energy Vision in which creation of renewable energy, promotion of local production and local consumption of energy and important policies to determine the direction towards establishment of applications are included. Fukushima Prefecture released a draft revision of the Action Plan for the renewable energy pioneer prefecture, in which approximately 30 % of energy demand within the prefecture is expected to be supplied by renewable energy in FY 2018.

8 HIGHLIGHTS AND PROSPECTS

8.1 Highlights

In Japan, the Feed-in Tariff (FIT) program for renewable energy power generation facilities started under the Act on Special Measures Concerning Procurement of Renewable Energy Sourced Electricity by Electric Utilities (Renewable Energy Act or FIT Act) in July 2012. Under the FIT program, which is a driver to skyrocket the installation of PV systems in Japan as well, the approved capacity of PV systems reached 80,8 GW (AC-based) and the commissioned capacity reached 32,0 GW (AC-based) as of the end of 2016. However, various types of social issues such as increase of national burden, grid restrictions, etc. became obvious following the rapid growth of PV introduction. Therefore, the Japanese government fundamentally reviewed the FIT Act and newly enacted the revised FIT Act on April 1, 2017. The FIT program under the revised FIT Act is significantly different from the previous program regarding the following fundamentals: 1) creation of a new approval scheme; 2) cost-efficient introduction; 3) introduction of power sources with a long lead time; 4) review of surcharge exemption system; and 5) transition to power purchase by transmission and distribution operators. As a result, prevention of un-commissioned PV projects, implementation of appropriate power generation projects for a long time, realization of mid- to long-term cost reduction, support for expansion of introduction of power sources such as geothermal, wind and hydro power and expansion of introduction of renewable energy through wider-area power interchange, etc., will be encouraged by means of these fundamentals. Following the enactment of the revised FIT Act, the Ministry of Economy, Trade and Industry (METI) established and held a meeting of the Study group for enhancement of PV competitiveness, looking ahead the post-FIT era and the future of PV power generation, and compiled the “Report by the Study group for enhancement of PV competitiveness (October 2016)” which shows the future direction of PV introduction. In this report, the “current status and issues of PV power generation” are analyzed to indicate measures for the “realization of competitive PV power generation”. The measures for the future are presented by appealing the importance of the enhancement of PV competitiveness from the viewpoints of both “enhancement of competitiveness as an energy source” in comparison with conventional energy sources and “enhancement of international competitiveness as an industry” to survive the global market. Besides, the direction of PV which should be taken for the future development is set as a new direction for “realization of stable and reliable PV” and the “era of autonomous and accelerated introduction of PV”. In addition to showing the direction for realization of long-term stable power generation and the measures against grid constraints towards elimination of the barriers for PV dissemination, the image of the “new way of living and society” so-called a future-oriented solar life, which will be realized based on PV as a mainstream energy source, and the corresponding directions are indicated.

METI formulated the “Innovative Energy Strategy” towards realization of energy mix by FY 2030 (ratio of renewable energy: 22 - 24 %), which was formulated in July 2016. Through this strategy, energy investment and technology development will be facilitated. In addition to promoting three following pillars: 1) thorough energy conservation; 2) expansion of renewable energy and 3) establishment of a new energy system, paradigm shift of energy conservation policies, creation of the low-carbon power supply market, reestablishment of the renewable energy industry, innovation of energy industry by means of Internet of Things (IoT), strategy development of hydrogen-based society for the post-2030 era, realization of Fukushima new and renewable energy society initiative will be deployed.

Local governments embarked on enhancement of regulations in order to prevent disorganized introduction of renewable energy while promoting local production and consumption of renewable energy.

Following the enactment of the revised FIT Act, the Japanese PV industry started business expansion, product development and expansion to overseas markets in preparation for the post-FIT era.

In the electric utility industry, Kyushu Electric Power conducted output curtailment in an island in its service area.

As for technology development, the world's highest conversion efficiency was achieved by Japanese manufacturers both on solar cell and PV module (Kaneka, Sharp) and demonstration of virtual power plant (VPP), which views multiple distributed power plants in different locations including PV power plants as a single power plant, started.

8.2 Prospects

With the enactment of the "revised FIT Act" in which the former FIT Act was fundamentally reviewed, in April 2017, progress of PV introduction in Japan entered a new phase. Japan will start moving towards realization of renewable energy introduction target (22 - 24 % of the energy mix) by FY 2030, while achieving the maximum introduction of renewable energy and curbing the nation's financial burden at the same time.

METI will establish a new energy supply system by coordinating conventional centralized power generation and distributed power generation with renewable energy such as PV through shifting from previous policies focusing on the expansion of PV installation to new policies which aim for the era of accelerated installations of autonomous PV systems by means of reform of cost structure, formation of internationally competitive industry including manufacture, power generation business and O&M, realization of long-term stable power generation, solutions to grid restrictions, additional measures for expansion of introduction such as regulations, constraints to site locations, etc. Through the Ministerial Council on Renewable Energy, Hydrogen and Related Issues, the Japanese government formulated the Action Plan for collaboration of the Cabinet Office, related ministries and agencies toward expanding introduction of renewable energy to work for dissemination of renewable energy.

Since installation of PV projects which were approved under the former FIT program and installation of new projects which will newly acquire business approval under the new FIT program are carried out in parallel, annual PV installed capacity in Japan is not expected to drop significantly over the coming years. Although negative growth is anticipated, 5 to 6 GW of PV systems are expected to be installed.

Meanwhile, in addition to the manufacturing business which follows the conventional business flow, power generation business and O&M business which depend on stocks joined the Japanese PV industry. These businesses are expected to develop as new key players of the energy industry to encourage the independence of the PV industry as a sustainable industry which do not rely on the FIT program.