IEA INTERNATIONAL ENERGY AGENCY

National Survey Report of PV Power Applications in JAPAN 2017

Revised in 11th September, 2018

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

PVPS

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TABLE OF CONTENTS

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 2017. 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 systems 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 2017 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2017, although commissioning may have taken place at a later date**.

1.1 Applications for Photovoltaics

Annual installed capacity in Japan in 2017 reached 7 459 MW (DC), an approximately 5,5 % decrease from the previous year (2016: 7 890 MW (DC)). Most of the PV systems were introduced under the Feed-in Tariff (FIT) program.

Table 1: PV power installed during calendar year 2017

			MW installed in 2017 - AC value	MW installed in 2017 - DC value
Grid-connected	BAPV	(1) Residential (< 10 kW)	636	636
		(2) Commercial (< 50 kW, including small-scale ground mounted)	1 620	2,090
		(3) Industrial (50 kW - 1 MW, including small-scale ground mounted)	965	1 201
		(4) Total of BAPV	3 221	3 927
	BIPV	(5) Residential (< 10 kW)	10	10
		(6) Commercial (10 - 250 kW)	25	25
		(7) Industrial (> 250 kW)		
		(8) Total of BIPV	35	35
	Ground-mounted	(9) c-Si and TF (1 MW ~)	2 704	3 488
		(10) CPV		
		(11) Total of ground-mounted	2 704	3 488
Off-grid		(12) Residential		
		(13) Other	9,4	9,4
		(14) Hybrid systems		
		(15) Total of off-grid	9,4	9,4
		(16) Total	5,969	7,459

(Revised in in 7th September 2018)

Table 2: Data collection process

Are the installation data reported in AC or DC?	AC: Estimated value based on the announcement by 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: Estimated value based on the announcement by 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
Other issues to be noted	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	2017 numbers	2016 numbers
Total power generation capacities (all technologies) *Including PV systems for self-consumption	321 GW_{AC} [2]	312 GW_{AC} [3]
Total power generation capacities (renewables including hydropower)	95 GW_{AC} [2]	88 GW_{AC} [3]
Total electricity demand (= consumption)	906 TWh	912 TWh
New power generation capacities installed during the year (all technologies)	8,9 GW_{AC} [2]	8,9 GW_{AC} [3]
New power generation capacities installed during the year (renewables including hydropower)	7,2 GW_{AC} [2]	6,9 GW_{AC} [3]
Total PV electricity production in GWh-TWh	45 840 GWh	40 950 GWh
Total PV electricity production as a % of total electricity consumption [1]	5,1 %	4,5 %

[1]: Total PV electricity production/ Total electric consumption x 100

[2]: The total value of the table of METI approval and the installed capacities under the FIT program were tallied. The PV installed capacity between October and December 2017 under the FIT program are estimated values based on the actual data as of the end of September 2017.

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

Table 4: Other information

	2017 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	**~41,554 MW**
Total capacity connected to the medium voltage distribution grid in MW	
Total capacity connected to the high voltage transmission grid in MW	**~7,575 MW**

(Revised in in 11th September 2018)

1.2 Total photovoltaic power installed

Cumulative PV installed capacity as of the end of 2017 reached 49 500 MW (DC). Cumulative PV installed capacity by application is; 171 MW for off-grid and 49 329 MW for grid-connected.

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
2017	8 822	162 072		49 328 733	49,499,627

(Revised in in 11th September 2018)

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 (End user prices)

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.
2017	131	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)		277
Grid-connected 10 kW- < 1 MW		244
Grid-connected Ground-mounted ≥ 1 MW	Power generation business	221
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
2017	277	244	221

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	131
Inverter	32
Mounting structure	26
Measurement/ monitoring instrument, etc.	10
Other (electric equipment/ materials of electric equipment, etc.)	8
Soft costs	
Installation	50
Other (promotion/ administration cost, etc.)	20
Total	277

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	76
Inverter	22
Mounting structure	20
Measurement/ monitoring instrument, etc.	3,4
Other (electric equipment/ transformer/ materials of electric equipment, etc.)	12
Soft costs	
Installation	45
Site development	23
Contribution for grid connection	6,8
Designing/ development	
Fund raising	
Other (promotion/ administration cost, etc.)	13
Total	221

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 financing through 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: Financing is available at very low cost in case own credit line or collateral such as real estate, etc. can be prepared. 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.
- 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.
- Infrastructure Fund Market: The Infrastructure Fund Market was established by the Tokyo Stock Exchange (TSE). This is the market where funds investing in infrastructure facilities are listed. Dividends are paid to investors, sourced from the usage fee of infrastructure facilities which are expected to gain stable income. For PV systems, the dividends are funded by the income from selling generated electricity. As of December 2017, four funds have been listed, all of which invest in PV power generation. Meanwhile, activities on private placement are also making progress, targeting only institutional investors.

There are other financing-related activities as well. Efforts on agri-solar loans utilizing farmland, which are designed to support PV systems on farmland while continuing farming activities, are promoted. Regional banks are increasingly working on co-financing MW-scale PV power plants. Establishment of funds to invest in renewable energy projects is on the rise. Major financial institutions are financing overseas PV projects developed by Japanese companies.

Table 11: PV financing scheme

Residential (solar loan/ sales on credit)	Long-term prime rate + approx. 1,5 % (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. 1,5 - 2,0 % 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. 1,0 - 1,5 % + up-front fee (approx. 1 % of the amount financed)
Asset-based lending (ABL)	ABL is a financing scheme in which loan is secured with collateral of assets of the power generation business such as power generation facilities, guarantee agreement, electric power selling agreement and insurance, etc.
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

Under the Feed-in Tariff (FIT) program, a wide variety of business models have been introduced by taking advantage of the long-term and stable revenues from selling electricity generated by PV systems fixed for the period of 20 years under the FIT program. Basically, 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. Under the current situation, the 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, such as the necessity to respond to the request for removal of facilities due to the change of the building owner, etc. There are some cases where a public tender is conducted for lease of the roofs of public facilities. Since the risks of collapse of business of the owner or removal of facilities are low compared with the lease of the roofs of private facilities, the tender is actively responded. Also, a service to directly supply electricity generated from rooftop PV systems without passing through power transmission grids, has started. i GRID Solutions started supplying off-grid electricity to supermarkets, etc.

As for crowd funding, etc. for the investment in PV power generation, there are some citizens' funds similar to crowd funding, as well as aggregation of small-amount of capital via the Internet to invest in the power generation business. Meanwhile, at present, PV projects can be surely financed with loan and lease programs by financial institutions at sufficiently low interest rates, so that advantages of crowd funding, which is not certain to secure funds, have not been recognized yet.

Since the FIT program started in Japan, installation of 10 to < 50 kW small-scale PV systems has advanced, and this capacity range now boasts the largest PV installed capacity on a cumulative basis. The current growth of this market segment can be attributed to the facts that stable profits from selling electricity can be secured, that it is easy to start the business with the low-voltage grid connection and that tax-saving schemes are available. Also, deferment of the tax payment through depreciation of profit and income was 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). From FY 2017, a preferential tax treatment under the Act for Facilitating New Business Activities of Small and Medium-sized Enterprises was started, which offers immediate depreciation and reduction of fixed property tax for PV systems for self-consumption (surplus electricity is sold).

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 legal restrictions. A model to directly supply electricity without passing through transmission grids has started.
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 (2,64 JPY/kWh (April 2018), 2,90 JPY/kWh (May 2018 - April 2019))" 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 July 2018: -2,10 JPY/kWh). *3: There are various price plans depending on hours. *4: Electric companies announced various price plans of their own following the full liberalization of electric power including retail electricity prices for households 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 July 2018: -2,02 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 July 2018: -2,02 JPY/kWh). *3: There are various price plans depending on hours and seasons. (Source: TEPCO Energy Partner's website)
Population as of December 1, 2017	126,695 million (Statistics Bureau, Ministry of Internal Affairs and Communications (MIC), as of December 1, 2017)
Country size (km^2)	377 974 km^2 (Statistics Bureau, MIC) (as of October 1, 2017)
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 2017)	1 TEPCO Energy Partner 30,2 % 2 Chubu Electric 15,8 % 3 Kansai Electric 14,9 % 4 Tohoku Electric 10,0 % 5 Kyushu Electric 10,0 % 6 Chugoku Electric 7,4 % 7 Hokuriku Electric 4,0 % 8 Hokkaido Electric 3,5 % 9 Shikoku Electric 3,3 % 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 2017)	1 Former General Electricity Utilities (10 electric companies from Hokkaido to Okinawa) 87,4 % 2 Power Producers and Suppliers (PPS) 12,6 % (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 2017

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. Effective from April 2017, 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.

In August 2017, from the viewpoint of reducing the national burden, the Ministerial Ordinance which regulates overpanelling of PV modules after approval was revised. After the revision, in case total output capacity of PV modules is changed to the level above the stipulated standard value, the applicable feed-in tariff (FIT) will be changed to the latest one.

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 project, 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. While activities related to improvement of energy self-sufficiency ratio of buildings such as achievement of net zero energy building (ZEB) are promoted, NEDO implemented 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. were studied. In FY 2017, in the "Technological development for improvement of system performance and operation and maintenance (O&M)", efforts have been made to reduce the BOS cost (including construction cost) with new building material-integrated PV modules and improvement of durability.

Also, METI started a project on "International standardization of BIPV modules" in FY 2015, which is a three-year project until 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 support measures for 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 the changes in 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. Since the feed-in tariff (FIT) program was introduced, installation of PV systems 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. Accordingly, in remote islands of Tokyo Metropolitan Government (TMG), a demonstration test was started to realize both the introduction of renewable energy and stable management of electric grids.

3.1.1.4 Support for electricity storage and demand response measures

Installation of storage batteries was not subsidized within the budget for FY 2017. Storage batteries were included in the subsidies for installations of net zero energy house (ZEH) and demonstration projects of net zero energy building (ZEB). "Project to support net zero energy house (ZEH)" is implemented and a fixed amount of 750 000 JPY is subsidized for each eligible house. The Sustainable open Innovation Initiative (SII) is the liaison for this subsidy program. In case of introducing a storage system to the eligible ZEH, 40 000 JPY is granted for one kWh of storage capacity with the cap of either one-third of the eligible cost for the subsidy or 400 000 JPY, whichever is lower. For this subsidy program, ten rounds of public invitation were carried out, which received 7 747 applications in total. The number of

selected projects was 7 693. 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 500 MJPY/year. Two rounds of public invitation were carried out and the number of selected projects was 28 in total, 18 for the first round and ten for the second round. As for the “Subsidy for emergency responses to suspension of grid connection of renewable energy” under FY 2014 supplementary budget, reports on the program were released. Tokyo Metropolitan Government (TMG) has been conducting the “Project to expand introduction of renewable energy for local production and local consumption” for four years from FY 2016 to FY 2019 and supporting 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 project expenses to demonstrate establishment of virtual power plants (VPPs) utilizing energy resources on the consumer side”, was carried out jointly by the Institute of Applied Energy (IAE) and SII, and the following projects were conducted: 1) Demonstration projects to establish VPP; 2) Resource aggregator projects; 3) Projects to promote introduction of VPP resources and 4) VPP infrastructure projects. For the Projects to promote introduction of VPP resources, subsidy is granted to the equipment (storage batteries) and installation. For storage batteries for residential use, 40 000 JPY/kWh is subsidized, up to one third of the equipment cost. For installation cost, the lower amount of either 50 000 JPY or a half of the installation cost is subsidized. For industrial applications, 80 000 JPY per one kW of rated capacity is subsidized, up to one third of the equipment cost, and up to a half of installation cost is subsidized. It was decided to subsidize 1 752 projects, which amounted to approximately 1,1 BJPY.

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 was developed. Following the full liberalization of electricity retailing, 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. They evaluate demand response (DR) as a dispatching ability and implements pubic invitation.

Table 15: PV support measures (summary table)

	On-going measures residential	Measures that commenced during 2017 - residential	On-going measures - commercial + industrial	Measures that commenced during 2017 - commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2017 - ground mounted
Feed-in tariffs	Yes (purchase of surplus electricity)	- Cut in purchase price - Setting mid-term price target	Yes	- Cut in purchase price - Tender scheme (≥ 2 MW) introduced	Yes	- Cut in purchase price - Tender scheme (≥ 2 MW) introduced
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	Preferential tax treatment under the Act for Facilitating New Business Activities of Small and Medium-sized Enterprises - Intended for companies and individuals who file an income tax return on the blue form - Two options : immediate depreciation (100 %) or 10 % tax credit (until the end of March 2018) - Fixed Property Tax is reduced by 50 % for three years					
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 loans. The interest rate is approx. 1,5 - 2,6 %.		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 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 - In the areas such as remote islands and places where power distribution capacity is saturated, demonstration tests were started to realize both the introduction of renewable energy and stable management of electric grids			

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 support projects of 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	FIT for surplus electricity is set.
	5	Maximum timeframe for compensation of fluxes	Measured by installing two meters (sale/ 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	Surplus power purchase periods under FIT program: 10 years for < 10 kW and 20 years for ≥ 10 kW systems
	8	Third party ownership accepted	Roof-lease business model is available, mostly by using FIT. Third party ownership business models combined with electricity retailing started.
	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 that arise out of ancillary service, 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 systems. For ≥ 10 kW systems, there is no size limitation as far as power transmission and distribution operators permit.
	12	Additional features	Promotion and support measures for self-consumption have been strengthened, aiming for independence from FIT.

3.3 Collective self-consumption, community solar and similar measures

The Ministry of Economy, Trade and Industry (METI) prepared list of examples of smart communities which use energy within communities in a good manner and promoting smart communities across Japan through companies and organizations. “Kashiwa-no-ha Smart City”, which was jointly developed by Mitsui Fudosan and the smart city, both grid electricity supplied by an electric utility and distributed power sources such as PV systems and storage batteries are used in the buildings in districts within the smart city. Through the interchange of electricity generated by distributed power sources among the districts of the smart city, peak-cut of electricity has been realized for the smart city as a whole. This is also contributing to strengthening disaster-prevention capabilities in case of emergency.

3.4 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. Discussions on sharing of the maintenance and operation cost of power transmission and distribution grids are underway. Under the premises of charging a part of the wheeling charge to the power producer side, it has been proposed that the ceiling amount of the general burden should be revised.

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 power transmission and distribution operators 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 2017, a total of 35 tender processes have been started throughout Japan, mainly in Tohoku region, Tokyo and Kyushu region, of which 12 processes have been completed.

- Tender for FIT capacity

Following the incorporation of the tender for FIT capacity in the revision of the Renewable Energy Act which was enacted on May 25, 2016, a tender scheme for 2 MW and larger PV projects was introduced from FY 2017. The first two years are positioned as trial period. The capacity for the first round of tender was 500 MW, and nine projects with a total capacity of

141,366 MW won the tender. The lowest bidding price was 17,20 JPY/kWh and the highest was 21,00 JPY/kWh, the same as the ceiling price. The winning projects are required to pay the second deposit (5 000 JPY/kW) and acquire approval. Among the nine winning projects, four projects with a total capacity of 40,86 MW paid the second deposit and the remaining five projects were withdrawn. There were no additional tender to fill the gap between the tender capacity and the winning capacity, nor carry-over of the remaining tender capacity to the next tender. After verifying the results of the first round of tender, discussions were made on the second and the third rounds of tender scheduled to be held in FY 2018. Based on the facts in the first round of tender that the bidding capacity was below the tender capacity and there was a bid at the ceiling price, it was proposed to disclose the ceiling prices of the second and the third rounds of tender only after the opening of the bids. It was also proposed that the tender capacity is 250 MW for the second round of tender. For the third round of tender, it was proposed that the tender capacity is 250 MW in principle, but in case the bidding capacity was below 250 MW in the second round, the tender capacity of the third round should be the same as the bidding capacity of the second round. According to the questionnaire survey to businesses asking why they did not participate in the first round of tender, some responded that it takes a long time for the study for grid connection so that they cannot forecast when they can sign connection contracts. It was found out that, due to the delay in signing connection contracts, there was a significant concern that the second deposit will be forfeited because they will not be able to acquire approval by the specified deadline. It was agreed that the risk of forfeiture of the second deposit should be reduced.

Table 17: Results of the first round of tender for FIT capacity in FY 2017

Item	Description
Subject of the tender scheme	≥ 2 MW PV systems
Tender capacity	500 MW (a uniform tender is conducted nationwide)
Winning bids	9 projects with a total capacity of 141,366 MW
Lowest bidding price	17,20 JPY/kWh
Highest bidding price	21,00 JPY/kWh (= ceiling price)
Withdrawal after winning the bid	5 projects with a total capacity of 100,506 MW
Paid the second deposit to acquire approval	4 projects with a total capacity of 40,86 MW

3.5 Direct Support measures

- Program to promote autonomous dissemination of renewable energy-based electricity and heat

  This program provides subsidy to PV systems, etc. for self-consumption. The FIT program is not applied under the subsidy.

- Subsidy for project expenses to implement a special scheme for surcharge under the FIT program

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

- Subsidy for project expenses to promote local production and local consumption of energy taking advantage of regional characteristics

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

- Program to promote low-carbon houses through introduction of net zero energy house (ZEH), etc.

  This program grants a fixed amount of subsidy for newly-built or existing detached houses which meet the requirements of the subsidy for net zero energy house (ZEH).

- Program to promote introduction of net zero energy building (ZEB) and saving of CO_2 emissions in commercial facilities, etc.

  This program grants a fixed amount of subsidy to pioneering demonstration projects, etc. which aim to realize ZEB in the facilities owned by local public organizations and small- and medium-scale private commercial buildings, etc.

- Subsidy for project expenses 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 for project expenses to support interest payment to establish the financing environment for renewable energy projects

  This subsidy program grants power producers a part of the interest of mezzanine loan for the amount equivalent to their own funds additionally required in order to execute project finance under the system of designated electric utilities.

- Subsidy for project expenses to support promotion of renewable energy introduction in Fukushima Prefecture

  This subsidy program supports demonstrative researches on introduction of renewable energy-based power generation facilities, establishment and improvement of storage batteries and power transmission lines, and toward commercialization of renewable-energy related technologies in Fukushima Prefecture.

3.6 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 (GIO)) 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, 29,2 BJPY in FY 2017 and 15,5 BJPY in FY 2018. Amount of purchased electricity generated by PV systems under the FIT program is around 133,1 TWh cumulatively as of the end of September 2017, exceeding 5,396 TJPY in total.

3.7 Indirect policy issues

3.7.1 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 a 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.

3.7.2 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 and the promotion of net zero energy house (ZEH)

Following the revision of the Act on the Improvement of Energy Consumption Performance of Buildings (Building Energy Efficiency Act) in FY 2015, from FY 2017, non-residential buildings that have a floor area of 2 000 m^2 or more are required to comply with energy conservation standards for new construction or for renovation/ expansion. As for the accomplishment of conventional energy conservation standards, the regulations for buildings that were duty of notification or obligation to make effort were strengthened and the construction cannot be started unless it is approved by a registered organization to judge energy conservation levels. By around 2020, medium-sized buildings that have a floor area of 300 m^2 or more, as well as all the buildings including houses, regardless of newly built or for renovation/ expansion, will be subject to the obligation to comply with energy conservation standards in a phased manner.

Concerning the energy conservation standards (standards of energy consumption performances), it requires that the design value of the “primary energy consumption”, which is the subtraction of the amount of energy generated by PV etc. from the accumulated amount of energy consumption such as air conditioning and ventilation, lighting, hot-water supply, etc., is below the standard value which is set for each region.

In addition, three ministries, namely METI, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the Ministry of the Environment (MOE), formulated a roadmap of the net zero energy house (ZEH). The roadmap aims to disseminate houses whose primary energy consumption is zero or below by improving energy saving performances such as heat insulation, and strengthening introduction of energy creation. By FY 2020, it aims to make more than half of the newly built detached houses built by advanced homebuilders ZEH. By FY 2030, it aims to make all the newly built houses ZEH on average in the country. In this occasion, realizing ZEH apartments is officially included. To realize the 2030 roadmap, subsidy programs and labelling system (BELS, a third-party certification which can be used to appeal ZEH) have been improved. From FY 2018, a subsidy program has started to support Life Cycle Carbon Minus (LCCM) houses (houses which realize negative net CO_2 emissions throughout the life cycle, something like installing a larger capacity PV system.).

Homebuilders, mainly the major ones, are installing PV systems as standard equipment for houses. Also, they are installing storage batteries and Home Energy Management System (HEMS) to cut lighting and heating expenses and launching products that meet the demand for self-consumption. With the progress in the liberalization of the electricity market, the activation of development and launch of the next-generation residential PV system is expected.

3.7.3 Policies relating to externalities of conventional energy

While the operation of nuclear power plants is 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 65 % in FY 2010, before the earthquake. In FY 2016, it rose to approximately 83 %, and the dependence on thermal power generation has stayed on a high level. By making an estimate based on the assumption that the suspended operation of nuclear power plants is replaced by the increase in thermal power generation, the fuel cost in FY 2016 increased by around 1,3 TJPY/year compared to the level before the earthquake, and the fuel cost by the increase in thermal power generation increased by about 15,5 TJPY in total after the earthquake. This is one of the causes of increase in electricity cost.

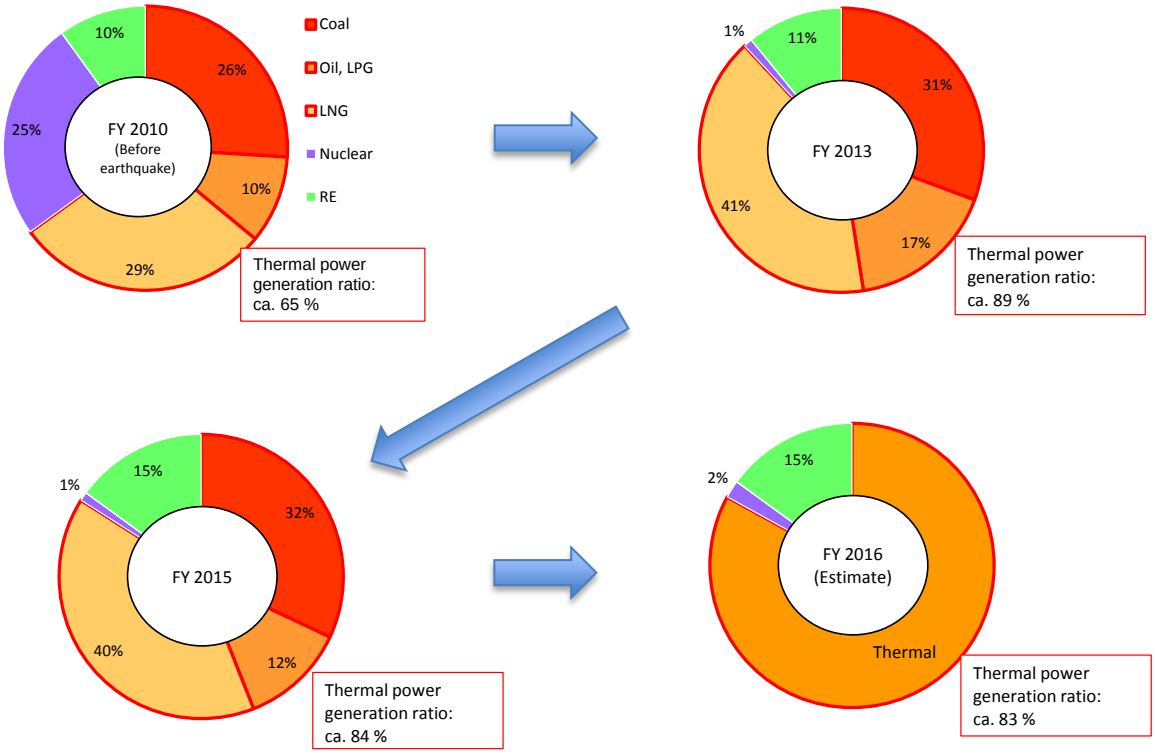

Figure 1 Generation mix of the electric companies

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

Following the increased operation of thermal power generation facilities, greenhouse gas emissions in the electricity sector has increased to approximately 548 million t-CO_2/year in FY 2013 from approximately 438 million t-CO_2/year in FY 2010, before the earthquake. In recent years, greenhouse gas emissions are turning to the declining trend, due to promotion of energy conservation, expansion of renewable energy introduction, restart of nuclear power plants, and so on. However, the estimated figure of FY 2016 is at a high level of 470 million t-CO_2/year. To achieve the mid-term target of the Paris Agreement, that is, by FY 2030, to reduce greenhouse gas emissions by 26 % from the FY 2013 level, further reduction of emissions is required. Under such circumstances, discussions on the Fifth Strategic Energy Plan were proceeded and the policy to realize the energy mix for 2030 has been considered. In the Strategic Energy Plan, it is stated that renewable energy, at present, is a promising and important domestic energy source that can contribute to energy security as well, although there are various issues in terms of cost and stable supply. Efforts to make renewable energy a “mainstream energy source” for the first time are being considered.

- 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 capability records of PV systems are also evaluated.

Table 18: Evaluation of power supply capabilities of PV systems in the summer by electric companies in Japan **(MW)**

Former General Electricity Utilities by area		Hokkaido	Tohoku	Tokyo	Chubu	Hokuriku	Kansai	Chugoku	Shikoku	Kyushu	Total
Summer of 2017 (Actual)	Assumption	80	730	1 940	1 910	170	1 190	960	640	1 370	8 980
	Actual supply capability records on a day and an hour of peak demand	**120**	**300**	**5 510**	**3 500**	**370**	**1 870**	**2 020**	**1 230**	**3 910**	**18 830**
	Actual output ratio	10,3 %	9,5 %	52,8 %	53,5 %	59,8 %	47,7 %	48,6 %	59,9 %	52,9 %	
	Installed capacity	1 170	3 160	10 440	6 540	620	3 920	4 160	2 050	7 390	39 440
	Peak demand date and hour in Japan	2 - 3 p.m., Thursday, Aug 24, 2017									-
	(Peak electricity demand)	3 910	11 510	51 710	24 730	4 780	26 090	10 770	5 140	15 480	154 100
	PV ratio to peak demand	3,1 %	2,6 %	10,7 %	14,2 %	7,7 %	7,2 %	18,8 %	23,9 %	25,3 %	12,2 %
Summer of 2018 (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.	2 - 3 p.m.	-
	Estimated supply capability	**100**	**790**	**2 290**	**2 230**	**190**	**1 300**	**1 160**	**680**	**3 320**	**12 130**
	Output ratio	**7,4 %**	**18,8 %**	**20,8 %**	**29,4 %**	**24,4 %**	**27,5 %**	**29,9 %**	**32,3 %**	**42,6 %**	**-**

Source: Report on electricity supply-demand verification by METI (October 2017 and May 2018)

*1: "Supply capability" of PV power generation is the installed capacity of PV systems which contributed in the peak demand 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: Output ratio is the ratio of actual output to the rated capacity of power generation facilities

As shown in Table 18, in the summer of 2017, electricity supply capability in the peak hours of the day with the peak demand was 18,83 GW in total against the PV installed capacity of 39,44 GW

(excluding Okinawa Prefecture), and PV contributed 12,2 % of the peak demand. It is estimated that the supply capability in the summer of 2018 will be 12,13 GW (excluding Okinawa Prefecture), which is below the previous year's result. This estimation is based on the assumption that, since the PV power generation cannot always expect sufficient irradiation in the peak hours of electricity demand, supply capability of PV is expected conservatively.

3.7.4 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. 289 JPY/t-CO_2 has been 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 greening and streamlining of fossil fuels. For instance, revenue from the Tax for Climate Change Mitigation 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. As for the effets of CO_2 emisison reduction via the Tax for Climate Change Mitigation, price effects (effects of curbing CO_2 emissions via taxation) and effects on financial resource (tax revenue for curbing energy-based CO_2 emissions) are expected.

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. The Fifth Basic Environment Plan, which was approved by the Cabinet on April 17, 2018, states that the ministry will promote making the whole taxation system greener.

3.7.5 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, etc.

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 March 2018, 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 2017, a total of 122 funding projects and demonstration projects (MOE/ METI) were adopted and credits were issued in four countries, namely Mongolia, Indonesia, Palau and Vietnam. As of June 2018, 65 PV-related projects are promoted by Japanese companies. With these projects, support has been provided to projects to introduce PV systems and various feasibility studies have been conducted including the following: introduction of high-efficiency PV systems and appropriate O&M; application of PV systems as a substitute for grid elecricity by diesel power generation or fossil fuel power generation, as well as a substitute for self-consumption, and floating PV systems. Out of these projects, METI and NEDO are conducting 14 PV-related feasibility studies on JCM and 3 PV-related introduction demonstration projects.

MOE supports a total of 32 projects of subsidy for equipment including PV systems with a total capacity of approximately 190 MW (from FY 2013 to FY 2017). 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 17 PV-related projects. MOE is conducing “Project for collaboration among cities to realize a low-carbon society”, as part of the feasibility study. By taking advantage of experiences and know how of the cities in Japan regarding the establishment of a low-carbon society, the project promotes low carbonization in developing countries with the project for establishign an autonomous and distributed communities utilizing renweable energy as well as energy conservation technologies, etc. The project is conducted for the developing countries in Southeast Asia, South Asia, the Middle East, Latin America and Africa, with particular priority on 17 countries with which Japan has signed bilateral JCM partnership documents. In the area of PV power genration, one project in Indonesia, two projects in Myanmar and one project in the Philipphines were selected in 2017.

In addition to JCM, PV-related technology demonstration projects are conducted in Indonesia and India, under the Demonstration Project of Technology/System for International Energy Consumption Efficiency, etc. by NEDO.

The 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 2017, a survey was conducted on preparations and planning of renewable energy and energy-saving systems in Guyana, and a grant contract on grant-in-aid was signed with Republic of the Marshall Islands for the “Plan to install PV systems in Ebeye Island”. For the Pacific Ocean and surrounding areas with a base in Fiji, a technology cooperation project to install hybrid power genration systems including diesel and PV power generation was started.

The Japan Bank for International Cooperation (JBIC) actively provides financing support to environmental protection projects such as installation 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 2018, 31 projects were approved, mainly renewable energy projects planned in India, Turkey, Southeast Asia and Latin America. JBIC plays a central role in acquiring the emission right under the Kyoto Protocol.

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 promoted two demonstrative research projects and three technology development projects in FY 2017 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)" 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 treatment which was developed by 2016 and technology development on reuse of recovered PV modules which started in 2016 have been conducted. As the ultimate goal in FY 2018, disassembly and treatment cost of 5 JPY/W or below (at the time of 200 MW/year treatment) is targeted.

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, as well as O&M technology of PV systems including operation and diagnosis of the installed systems has been promoted. In 2017 onwards, four new themes were selected and low-cost and high-durability PV system technologies using BIPV modules and long-life modules are begin developed.

Meanwhile, under the project of "Development of high performance and reliable PV modules to reduce levelized cost of energy", PV device technologies and system reliability evaluation technologies have been mainly developed. In FY 2017, a total of 19 technology development themes and trend surveys were 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". As the accomplishments of this project, world's highest level conversion efficiencies were achieved on c-Si, CIGS thin-film, perovskite and III-V thin-film PV cells and modules. In 2017, Kaneka achieved 26,73 % cell efficiency and 24,5 % module efficiency with heterojunction back contact PV technology, whereas Solar Frontier achieved 22,9 % on CIS thin-film solar cell (ca. 1 cm^2) and 19,2 % on Cd-free submodule (30 cm x 30 cm). From a perovskite PV consortium led by The University of Tokyo, Toshiba achieved 10,5 % efficiency on a 10 cm x 10 cm film substrate and Panasonic achieved 12,6 % on a 20 cm x 20 cm (35 cells in series) glass-substrate module. Also, development of technology to measure reliability of PV cells/ modules as well as technology to evaluate power generation amount of PV systems with high accuracy has been promoted.

In addition, in FY 2017, NEDO started a new program covering PV technology, "Program to support technology innovation of new and renewable energy by venture businesses, etc.", aiming to commercialize developed technologies in four phases; feasibility study, fundamental research, R&D for commercialization and large-scale demonstration research. In FY 2017, a demonstration started on a system to collect energy from tracking type concentrating PV system,

which generates power and collect heat at the same time. Also, as new research themes, 10 projects related to PV power generation, mainly for R&D on commercialization, and a demonstration project on MW-scale large-capacity storage system were newly selected.

As for R&D activities administered by MEXT, in the “Strategic Creation Research Promotion Program” promoted by the Japan Science and Technology Agency (JST), research themes on fabrication of smart silicon ingot for solar cells using machine learning of data, as well as on exploration of innovative solar cell materials were selected as new research themes for FY 2017. In the “PV cell/ module and solar energy utilization system” as one of the technological fields of the “Advanced Low Carbon Technology Research and Development Program (ALCA)”, development of PV-related technologies has been continued, focusing on high quality silicon quantum dot PV, organic thin-film PV (OPV) and perovskite PV. In the ALCA project, R&D on the next-generation storage batteries is conducted as a technology area with special emphasis.

From FY 2017, the Japan Science and Technology Agency (JST) started “Future Society Creation Project” based on the Fifth Science and Technology Basic Plan (FY 2016 - FY 2020). In this project, “Realization of low-carbon society with ‘game-changing technology’” was set as one of the important themes for calls for proposals in FY 2017, and PV was set as an energy creation technology. Two R&D projects, one on Pb-free perovskite solar cell and the other on ultra-thin type c-Si triple-junction solar cell, were selected. For these two projects, the research facilities within FREA, Fukushima Renewable Energy Institute of AIST, National Institute of Advanced Industrial Science and Technology will be utilized. Under the “Future Society Creation Project”, collaboration is made with ALCA projects as well as “Unexplored challenge 2050” which started in FY 2017 as one of the leading programs on energy and environment by NEDO. This collaboration is expected to create synergies for facilitating the projects.

Demonstration research related to PV technology is mainly promoted by NEDO. 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 as well as technologies to reduce BOS cost including installation cost, snow load test, wind pressure experiment, sink test, etc., to ensure safety of PV system structure and electrical safety. In order to ensure safety against disaster risks, development of design method and technology, demonstration test and research of facilities are conducted. In December 2017, as part of “Demonstration to ensure safety”, sink test of a PV system was conducted in Hokuto City, Yamanashi Prefecture to understand the risk of electrical shock, etc. of PV systems in case of water disasters. 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.

In the demonstration research conducted under the “Program to support technology innovation of new and renewable energy by venture businesses, etc.”, ACTREE and Softbank jointly started a demonstration of a system to collect energy from tracking type concentrating PV system, which generates power and collect heat at the same time, in September 2017. Based on the results of the demonstration test, ACTREE aims to commercialize the technology in FY 2018. In the “Large-Scale Demonstration Study” (Phase D), “Large-scale demonstration development of gyro tracking type PV power generation system” of SolarFlame has been conducted since 2016. In 2017, a MW-scale large-capacity storage system by Excergy Power Systems, which realizes consumer applications and stabilizes grid at the same time, was newly selected.

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 2017 as cross-cutting projects. Demonstration projects were conducted to realize smart communities

and to improve technology to store electricity generated by PV systems, and technology to optimize electricity consumption (automated demand response (ADR), ICT technology). 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. Under the "Project to demonstrate technology and system to improve efficiency of global energy consumption", in FY 2017, NEDO conducted PV-related demonstration projects in Indonesia, Germany, India, Canada, USA, Portugal and so on.

The followings are major demonstrative projects conducted in FY 2017.

- Smart Community Demonstration Project: Java Industrial Park, Indonesia (FY 2012 to FY 2017), Speyer, Germany (FY 2015 to FY 2017)
- 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 in areas with unstable power supply (FY 2015 to FY 2017): Oshawa, Ontario, Canada
- Demonstration Project for Validation of Redox Flow Battery Performance (FY 2015 to FY 2020): California, USA
- Demonstration Project for ICT based green hospital (FY 2016 to FY 2019): New Delhi, India
- Project for Automated Demand Response demonstration system for air conditioning in Portugal (FY 2016 to FY 2019): Lisbon, Portugal

In Japan, as part of support programs by METI and the Ministry of the Environment (MOE), demonstration projects on large-capacity storage systems are conducted in the premises of electric companies, aiming to increase possible hosting capacity of renewable energy and control grids. Technology demonstration of virtual power plant (VPP) is also conducted by a large-scale consortium with the support from METI. In 2017, in addition to VPP demonstration in combination with forecast of PV power generation amount conducted jointly by Kansai Electric Power and Mukogawa Women's University, VPP demonstration utilizing electric vehicle (EV) jointly by Tokyo Electric Power and car manufacturers such as Nissan Motor, demonstration on the use of frequency control system with residential storage batteries jointly by Kansai Electric and NEC, were started. Some electric companies and energy service companies started consideration for development or demonstration of electricity trading service utilizing block chain technology.

METI and MOE are also conducting a demonstration project on net zero energy building (ZEB), and PV technologies, as facilities to create energy, were adopted for a large number of projects.

NEDO also started a demonstration test of CO_2-free hydrogen, using PV and other renewable energy sources.

Furthermore, NEDO conducted a demonstration project for technologies to address global warming from FY 2011 to FY 2017, under the Joint Crediting Mechanism (JCM). Under the JCM, surveys on formulating demonstration projects are also conducted and in FY 2017, a floating PV project in Vietnam and a project to introduce PV module cleaning robots in Saudi Arabia were selected.

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

The FY 2017 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" and "Development of O&M and recycling technologies for 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.

While the PV dissemination programs by local governments have 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.

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

	FY 2015			FY 2016			FY 2017		
	R&D	Demo/ Field Test	Market Stimulation	R&D	Demo/ Field Test	Market Stimulation	R&D	Demo/ Field Test	Market Stimulation
National (BJPY)	4,894	0,608		5,65			5,4		
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 2017

Manufacturers	Process & technology [1]	Total Production	Product destination	Price
Tokuyama	Polysilicon (Siemens process)	Undisclosed		
Mitsubishi Materials	Polysilicon (for semiconductor, Siemens process)	N/A		
Osaka Titanium technologies	Polysilicon (for semiconductor, Siemens process)	Very small amount [2]		
Ferrotec	Ingot			
	Si wafers			
Panasonic	sc-Si ingot	Undisclosed		
	sc-Si wafer	Undisclosed		

[1]: sc-Si: single crystalline 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

Currently in Japan, the scale of production of polysilicon, silicon ingot and wafer for solar cells is not large. Tokuyama transferred its polysilicon manufacturing subsidiary in Malaysia to OCI of South Korea in the end of May 2017. As for high purity polysilicon for semiconductor-grade silicon wafers, Tokuyama continues to produce at Tokuyama Factory in Shunan City, Yamaguchi Prefecture, with the production capacity of 8 500 t/year. As measures to address increase in demand for semiconductors, Tokuyama plans to increase the production capacity to a little below 10 000 t/year at the maximum by FY 2020. In addition to Tokuyama, Mitsubishi Materials and Osaka Titanium technologies continue production of semiconductor-grade polysilicon.

Panasonic reorganized its production framework, with an aim of further increasing its competitiveness of its PV business. As part of it, in October 2017, Panasonic announced a plan to stop operation of its manufacturing factory (subsidiary) of solar-grade silicon ingot for internal use in Oregon, USA, and to liquidate the manufacturing subsidiary in March 2018. As for silicon wafer production at its factory in Malaysia, Panasonic decided to stop mass production and focus on production for research purpose. The company plans to procure silicon feedstock from third parties at a lower cost than that of its own product. M.Setek, a subsidiary of AU Optronics (AUO) of Taiwan, produces single-crystalline silicon (sc-Si) ingot at its factory in Susaki City, Kochi Prefecture to supply to AUO. M.Setek used to produce polysilicon at its Soma Factory in Fukushima Prefecture, but closed it in 2017. Ferrotec started construction of a new factory of 200 mm (8 inch) semiconductor-grade wafers in China in 2017. The company will shift its focus from the PV-related business which was formerly its main business to the growing semiconductor-related business.

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 which took effect in April 2017. Chinese manufacturers acted aggressively in the Japanese PV market, mainly for industrial applications by taking advantage of their price competitiveness. According to PV shipment statistics by the Japan Photovoltaic Energy Association (JPEA), total PV shipments by domestic production in Japan in 2017 (from January to December) were approximately 1,8 GW of solar cells (a 14 % decrease year on year) and approximately 2,1 GW of PV modules (a 25 % decrease year on year). The ratio of overseas production shipped in the domestic market grew to 67 %. 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, and they worked actively on offering PV systems for self-consumption as well as total solutions for ZEH. 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.

Major PV manufacturers experienced declines in their business performances of the PV business affected by the decrease of sales volume and the price reduction. In order to enhance competitiveness, they announced plans to reorganize their production frameworks, mainly at their factories in Japan. The PV module production in Japan in 2017 is estimated to be 2,8 GW, down by 20 % year on year.

In the area of technology development, several companies reported improvement of PV cell/ module conversion efficiency. Kaneka again renewed the world's record conversion efficiency of heterojunction back-contact crystalline silicon (c-Si) solar cell. In 2017, Kaneka achieved 26,63 % conversion efficiency on a practical size solar cell (180 cm^2) and 26,7 % on a 79,0 cm^2 solar cell. On a PV module using these solar cells, it achieved the world's highest 24,5 % conversion efficiency. Solar Frontier set a new world record of CIS thin-film solar cell (ca. 1 cm^2) efficiency of 22,9 % (23,3 % by its own measurement), which is the world's highest conversion efficiency of thin-film solar cells as a whole. Solar Frontier also achieved the world record conversion efficiency of 19,2 % on a 30 cm x 30 cm submodule, and 19,8 % on a 7 cm x 5 cm mini module. R&D on perovskite PV technology has also been promoted by universities, research institutes and private companies. Toshiba achieved the world's highest 10,5 % conversion efficiency on a 5 cm x 5 cm perovskite PV module fabricated on a film substrate by using its original coating technology.

Table 21: Production and production capacity information for 2017

Cell/Module manufacturer	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 Energy Solutions	c-Si	Undisclosed	Undisclosed	Undisclosed	Undisclosed
2 Kyocera	c-Si	850			
3 Panasonic	sc-Si (HIT)	Undisclosed	Undisclosed	> 1 000 (not including Buffalo Factory)	Undisclosed
4 Kaneka	sc-Si		16		
	mc-Si		3		
5 Mitsubishi Electric	sc-Si	Undisclosed	200	Undisclosed	530
6 Fujipream	sc-Si	0	3,7	0	6
7 Choshu Industry	sc-Si				
	mc-Si				
8 Towada Solar	sc-Si	-	-	-	10
	mc-Si	-	-	-	50
9 Spower	c-Si				
10 INFINI	sc-Si		22		85
	mc-Si		10		35
11 KIS	sc-Si		3.3		4.8
12 Denkasinki	sc-Si				
Thin film manufacturers					
1 Solar Frontier	CIS	690	690	1 050	1 050
2 Kaneka	a-Si, a-Si/poly-Si hybrid		15		
3 FWAVE	a-Si	3		24	10
4 Mitsubishi Chemical	a-Si, OPV				
Cells for concentration					
1 Sumitomo Electric Industries	CPV		0		5
TOTALS		**2 550** [3]	**2 490** [3]	**3 790** [3]	**4 010** [3]

[1]: c-Si:crystalline silicon ,sc-Si: single crystalline silicon, mc-Si: multicrystalline silicon, a-Si: amorphous silicon, OPV: organic thin-film PV
[2]: Shipment statistics by the Japan Photovoltaic Energy Association (JPEA)
[3]: Studied by RTS Corporation

Source: Answers from each company for the questionnaire by NEDO

5.3 Manufacturers and suppliers of other components

- Inverters

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, Huawei Technologies of China and Delta Electronics 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, 660 kW, 750 kW, 1 000 kW and 2 000 kW. Tabuchi Electric, SMA Solar Technology, Huawei Technologies, Delta Electronics and ABB of Switzerland 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 and Schneider Electric of France, General Electric (GE) of the USA, Sungrow Power Supply of China also comprise this market. Installation of distributed inverters has advanced in small- and medium-scale PV projects as well as large-scale PV power plants, and 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. TMEIC established a factory in India and started full operation in 2017 for shipment to Southeast Asia, Europe and so on. Tabuchi Electric is enhancing overseas business development, 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 net 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, Eliiy Power, etc., supply storage batteries in Japan. In 2017, Murata Manufacturing acquired battery business from Sony, whereas Looop launched its original brand storage batteries for residential use. As such, new entries have advanced. Some major trading companies are importing and selling storage batteries from other countries such as South Korea. Meanwhile, NEC withdrew from the lithium-ion battery business.

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 3,2 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. Schneider Electric started the sale of hybrid inverters in 2017.

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 supply 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, Kawamura Electric and Wave Energy, 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. In addition to the products applicable to DC 1 000 V, adoption of products applicable to DC 1500 V is increasing.

- Supporting structures

For supporting structures, hot-dip steel plate with high corrosion resistance, molten hot-dip galvanizing steel plate and single-tube pipes, aluminium 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, products exclusive for rooftop installation, 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 2017

	2016	2017
Research and development (not including companies)	800	800
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	100 000	90 000
Distributors of PV products		
System and installation companies		
Electricity utility businesses and government		
Other		
Total	**100 800**	**90 800**

6.2 Business value

Table 23: Value of PV business

Sub-market	Capacity installed in 2017 (MW)	Price (JPY/W)	Value (MJPY)	Totals (MJPY)
Off-grid < 1 kW				
Off-grid ≥ 1kW				
Grid-connected roof-top < 10 kW (for residential)	646	277	178 900	
Grid-connected for commercial	2 125	244	518 451	
Grid-connected for industrial	1 201	244	293 101	
Grid-connected ≥ 1 MW	3 488	221	770 884	
Total	7 460			1 761 337
Export of PV products				12 591
Change in stocks held				
Import of PV products				205 632
Value of PV business				1 568 296

(Revised in in 11th September 2018)

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 was 449 (as of December 2017) 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. Although the share of PPS increased to 12,7 % (as of December 2017), the situation of the electricity market in which former General Electricity Utilities are dominant remains unchanged and the same situation is observed in the power generation sector. The share of trading quantity on the Japan Electric Power Exchange (JEPX) rose to 7,8 % (as of December 2017). The effects of gross bidding by former General Electricity Utilities to revitalize the trading are starting to be observed. Under the liberalization, measures have been taken to address the issues of public interest, and it is aimed to establish the markets in the earliest possible timing around FY 2020, as shown in the figure below, such as the capacity market, supply/ demand adjustment market and market for trading non-fossil value. 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.

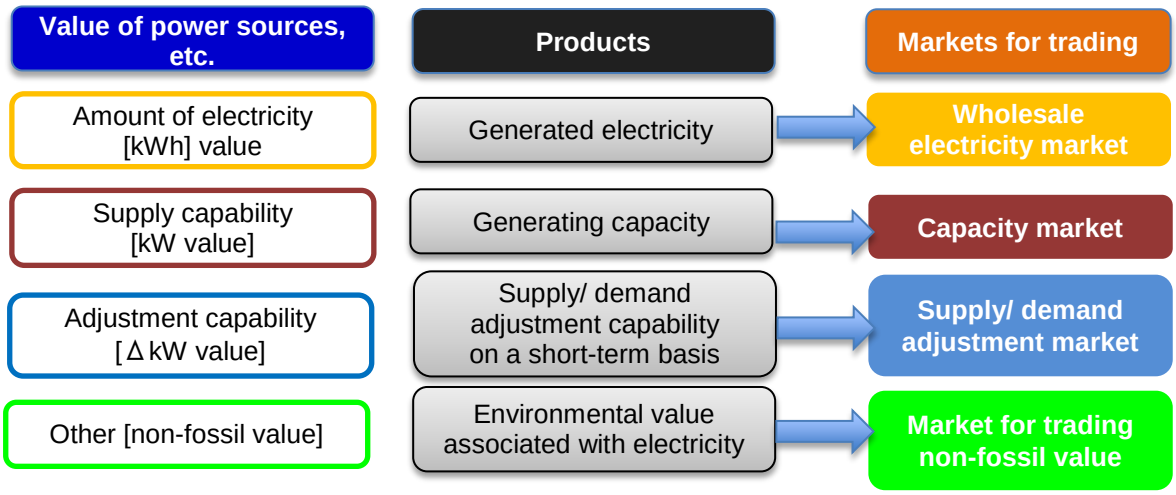

Figure 2 Direction in future development of markets

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 Electricity Utilities are members announced in October 2008 that 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. Some electric companies are engaged in PV projects in emerging countries such as South America.

- Development of technology to forecast power generation amount

To assure stable operation of electric grids when PV systems are installed in large scale, technology for forecasting PV power generation amount which contributes to controlling the balance between electricity supply and demand has been developed. There is an issue of imbalance occurrence due to inaccurate forecast of generation amount of PV systems, whose

installations have been increasing. To tackle this issue, efforts are being made to improve the accuracy of forecast. The Central Research Institute of Electric Power Industry (CRIEPI) developed a system to estimate and forecast irradiation using the images of Himawari 8 weather satellite. This system can make an accurate forecast of irradiation for the next two to three hours. Based on this forecast, it is possible to calculate generation amount of PV systems. Kyushu Electric Power newly introduced a system to forecast power generation amount of PV systems and started a full-scale operation. 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 advanced as part of METI projects. The following demonstrative researches are underway. In addition, Tokyo Electric Power Company Holdings is working on a new project toward stable supply of electricity by utilizing storage batteries at telecommunication facilities of Nippon Telegraph and Telephone (NTT).

- 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 systems

Following the expansion of PV introduction, output curtailment of PV systems was conducted in some remote 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 were made on the capacity of grid connection lines which need to be reinforced and a guideline for cost sharing was established. As for the frequency conversion station, construction to increase 900 MW is scheduled by FY 2020, and another 900 MW enhancement is scheduled by FY 2027. Construction to increase the grid connection lines between Hokkaido and Honshu (main island of Japan) 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 started 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. This is subject to revision as needed depending on the

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 December 2017, five electric companies, namely Hokkaido Electric Power, Tohoku Electric Power, Hokuriku Electric Power, Shikoku Electric Power and Kyushu Electric Power have taken this measure. In parallel with these restrictions, a variety of information including open capacity of distribution lines is released by electric companies. The Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO) announced its long-term policy on the cross-regional coordination of electric grids and set out an initiative of utilizing the existing grids to the maximum. In order to overcome grid restrictions, discussions have been promoted to realize the "Japanese version Connect & Manage", which fully utilizes the existing grids, at an early date.

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 credit type loan 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 self-consumption, 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. Furthermore, Toyama City of Toyama Prefecture completed a renewable energy-related model facility at a farming support center. The city plans to establish and utilize the facilities for solar sharing (PV system installation on farmland while continuing agricultural activities) to promote dissemination of the environment-friendly agriculture.

Following the expansion of PV introduction, many cases of troubles with local residents occurred one after another. Some municipalities set up regulations on the installation of PV systems in order to prevent such situations. Co-existence in harmony with local communities is put high importance from the perspective of long-term stable power source. Kyotamba Town of Kyoto Prefecture requires project developers to hold a briefing seminar to explain about the projects to neighbouring residents before the start of construction of PV power plants. Numata City of Gunma Prefecture enforced an instruction guideline on installation of renewable energy-based power generation facilities, in order to protect landscape, maintain harmony with the living environment of citizens, and to prevent unregulated development. Ito City of Shizuoka Prefecture announced a draft of ordinance to oblige project developers to explain to local residents and submit a notification to the mayor on the installation of PV systems. Furthermore, several municipalities are working on formulation of 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 local consumption of energy. Partnerships between municipalities and private companies advanced as well. Matsusaka City of Mie Prefecture, in partnership with Toho Gas, The Daisan Bank and The Mie Shinkin Bank, established a new electricity retailing company. In order to revitalize the regional

economy, the new company will contribute the profit from electricity sales by selling the electricity to public facilities in the city, after deducting the working capital.

Some municipalities proactively supporting introduction of PV and other renewable energy sources are setting installation targets and formulating action plans to achieve the targets. Okayama Prefecture compiled the revision of the Okayama New and Renewable Energy Vision. The revised vision covers ten types of energy sources and technologies for high level utilization of energy set under the Act on Promoting Use of New Energy (New Energy Act) and sets the new and renewable energy introduction target ratio at 21,1 % by FY 2020.

8 HIGHLIGHTS AND PROSPECTS

8.1 Highlights

With the start of the Feed-in Tariff (FIT) program in 2012 under the FIT Act (the Renewable Energy Act), Japan has succeeded in drastically increasing its PV installed capacity. As of the end of September 2017, the facility-approved capacity of PV systems reached 71,7 GW (AC-based) and the commissioned capacity reached 36,8 GW (AC-based). 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 based on 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. The new FIT program is designed to accomplish the purposes of preventing projects which were approved but have not started operation for a long time, implementing the appropriate power generation projects on a long-term basis, realizing cost reduction on a mid- to long-term basis, supporting expansion of introduction of power sources such as geothermal, wind and hydro power, as well as expanding introduction of renewable energy through wide-area power interchange, etc. Changes from the former FIT Act to the new FIT Act were severe and significant, including the transition in the approval scheme from facility approval to approval of PV project business plan, and the introduction of tender scheme for PV projects with a capacity of 2 MW or more.

The Ministry of Economy, Trade and Industry (METI) started a review on the Fourth Strategic Energy Plan (2014 - 2018), which is the basic of Japan's energy policy. Focusing on realizing the energy mix toward 2030 which was formulated in 2015, the challenges and policy direction for each energy source will be reflected and the Fifth Strategic Energy Plan is planned to be formulated in 2018. In the discussion on the new Strategic Energy Plan, renewable energy is positioned as a mainstream power source, for the first time in the history of Japan's energy policy. It was also decided to include a long-term perspective toward 2050 in the Fifth Strategic Energy Plan. In parallel, in preparation for the large-volume introduction of renewable energy in the future, the Subcommittee for Large-volume Introduction of Renewable Energy and Next Generation Electricity Network was established under the of the Advisory Committee for Natural Resources and Energy (ACNRE). This Subcommittee picked up important political issues to promote introduction of renewable energy toward the future, such as enhancement of cost competitiveness, smooth grid integration, and establishment of the business environment. From this perspective, discussions are underway on establishing new rules and direction toward compiling an interim report in 2018.

Among activities by local governments, power producers and suppliers (PPS) have been established one after another based on active utilization of renewable energy for local production and local consumption, while an increasing number of municipalities formulated ordinances or guidelines for regulating the construction of MW-scale PV power plants, for the purpose of ensuring PV installations in harmony with local communities.

From the Japanese PV industry, the Japan Photovoltaic Energy Association (JPEA) released its outlook titled "JPEA OUTLOOK 2050," which aims to achieve PV installed capacity of 100 GW by 2030 and 200 GW by 2050, and presented the image of the growth of PV power generation. The Japanese PV industry has been promoting re-establishment of the PV business, technology development and overseas business expansion.

8.2 Prospects

Once the Fifth Strategic Energy Plan by METI, which positions renewable energy as a mainstream power source, and the Fifth Basic Environment Plan by the Ministry of the Environment (MOE), which reflects the concept of SDGs, are approved by the Cabinet, it is expected that efforts on the utilization of renewable energy will expand to all the ministries and agencies as well as the Cabinet Office, all the 47 prefectures in Japan, all the industries and the entire nation.

Toward achieving the 2030 energy mix, METI will work on addressing the issues that disturb dissemination of PV power generation, such as power generation cost, establishment of the business environment, grid restrictions, and securement of dispatching capabilities, through employing all policy measures. Specifically, METI will aim to achieve PV dissemination independent of the FIT program by promoting maximum introduction of renewable energy through technology development, establishment of new rules, dissemination measures, enhancement and easing of regulations, as well as preferential taxation system. Meanwhile, other ministries and agencies as well as the Cabinet Office will work together for promoting utilization of renewable energy through policy measures and laws, as well as the Ministerial Council on Renewable Energy, Hydrogen and Related Issues.

Local governments will revitalize regional economies by using renewable energy while keeping PV power generation in harmony with local residents and ensuring safety and reassurance.

With the cumulative PV installed capacity approaching the 50 GW level in Japan, the PV industry will enhance development of an independent industry of PV taking the role as a mainstream power source, not only through business expansion based on the new PV installations, but also through the creation of an industry structure based on the cumulative installed capacity, including long-term stable power generation business as well as O&M business.