Task 1 Strategic PV Analysis and Outreach

PVPS

National Survey Report of PV Power Applications in Japan 2018

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PHOTOVOLTAIC POWER SYSTEMS
TECHNOLOGY COLLABORATION PROGRAMME

Cover picture:

PV modules installed on the walls of the city hall of Saijo City, Ehime Prefecture

WHAT IS IEA PVPS TCP

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD). The IEA carries out a comprehensive programme of energy cooperation among its 30 member countries and with the participation of the European Commission. The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the collaborative research and development agreements (technology collaboration programmes) within the IEA and was established in 1993. The mission of the programme is to "*enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems*."

In order to achieve this, the Programme's participants have undertaken a variety of joint research projects in PV power systems applications. The overall programme is headed by an Executive Committee, comprised of one delegate from each country or organisation member, which designates distinct 'Tasks,' that may be research projects or activity areas. This report has been prepared under Task 1, which deals with market and industry analysis, strategic research and facilitates the exchange and dissemination of information arising from the overall IEA PVPS Programme.

The IEA PVPS participating countries are Australia, Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, and the United States of America. The European Commission, Solar Power Europe, the Smart Electric Power Alliance (SEPA), the Solar Energy Industries Association and the Copper Alliance are also members.

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WHAT IS IEA PVPS task 1

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 2018. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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DISCLAIMER:

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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 2018 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2018, although commissioning may have taken place at a later date.

1.1 Applications for Photovoltaics

Annual installed capacity in Japan in 2018 reached 6 662 MW (DC), an approximately 12 % decrease from 7 459 MW (DC) in 2017. Most of the PV systems were installed under the Feed-in Tariff (FIT) program.

1.2 Total photovoltaic power installed

Table 1: Annual PV power installed during calendar year 2018

		Installed PV capacity in 2018 (MW)	AC or DC
PV capacity	Off-grid	2	DC
	Decentralized (Residential + BIPV + non-FIT installed capacity)	808	DC
	Centralized	5 852	DC
	Total	6 662	DC

Table 2: PV power installed during calendar year 2018 (based on figures reported to METI, and the average panelling ratio according to the Purchase Price Calculation Committee) (MW)

			Installed PV capacity in 2018 [MW] AC value*	Installed PV capacity in 2018 [MW] DC value
Grid-connected	BAPV	(1) Residential (< 10 kW)	628	628
		(2) Commercial (< 50 kW, including ground-mounted)	1 409	1 804
		(3) Industrial (50 kW - 1 MW, including ground-mounted)	633	960
		(4) Total of BAPV	2 670	3 392
	BIPV	(5) Residential (< 10 kW)	10	10
		(6) Commercial (10 - 250 kW)	20	20
		(7) Industrial (> 250 kW)		
		(8) Total of BIPV	30	30
	Ground-mounted	(9) c-Si and TF (1 MW ~)	2 530	3 238
		(10) CPV		
		(11) Total of ground-mounted	2 530	3 238
Off-grid		(12) Residential		
		(13) Other	2	2
		(14) Hybrid systems		
		(15) Total of off-grid	2	2
Total		**(16) Total ((4) + (8) + (11) + 15))**	5 232	6 662

* The capacity of PV systems which started operation under the FIT program released by METI

Table 3: Data collection process

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	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	https://www.fit-portal.go.jp/PublicInfoSummary
Other issues to be noted	DC capacity was estimated in consideration of over-panelling of PV modules

Table 4 shows the cumulative PV installed capacify in Japan. The cumulative PV installed capacify in Japan as of the end of 2018 reached 56 162 MW (DC). The cumulative PV installed capacity by application is; 173 MW for off-grid and 55 989 MW for grid-connected applications.

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

Year	Off-grid (including large hybrids)	Grid-connected distributed (BAPV, BIPV)	Grid-connected centralized (Ground, floating, agricultural…)	TOTAL
1992	15 410	1 220	2 370	19 000
1993	19 370	2 300	2 600	24 270
1994	23 510	5 130	2 600	31 240
1995	29 660	10 820	2 900	43 380
1996	36 240	20 500	2 900	59 640
1997	45 300	43 100	2 900	91 300
1998	52 750	77 750	2 900	133 400
1999	56 700	149 000	2 900	208 600
2000	63 550	263 770	2 900	330 220
2001	66 827	383 086	2 900	452 813
2002	72 647	561 295	2 900	636 842
2003	78 893	777 830	2 900	859 623
2004	84 245	1 044 846	2 900	1 131 991
2005	87 057	1 331 951	2 900	1 421 908
2006	88 588	1 617 011	2 900	1 708 499
2007	90 150	1 823 244	5 500	1 918 894
2008	90 809	2 044 080	9 300	2 144 189
2009	94 633	2 521 792	10 740	2 627 165
2010	98 794	3 496 017	23 333	3 618 144
2011	103 274	4 741 464	69 210	4 913 948
2012	109 352		6 522 317	6 631 669
2013	123 440		13 475 729	13 599 169
2014	124 818		23 214 264	23 339 082
2015	127 194		34 023 264	34 150 458
2016	161 494		41 878 684	42 040 178
2017	170 894		49 328 733	49 499 627
2018	172 956		55 988 671	56 161 627

Table 5: Other PV market information

	2018 Numbers
Number of PV systems in operation in Japan	N.A.
Capacity of decommissioned PV systems during the year	N.A.
Total capacity connected to the low voltage distribution grid	~ 46 GW
Total capacity connected to the medium voltage distribution grid	
Total capacity connected to the high voltage transmission grid	~ 9,75 GW

Table 6: PV power and the broader national energy market

	2018 numbers	2017 numbers
Total power generation capacities (all technologies) *Including PV systems for self-consumption	270 GW_{AC} [1]	274 GW_{AC} [1]
Total renewable power generation capacities (including hydropower)	93 GW_{AC} [2]	87 GW_{AC} [2]
Total electricity demand (=consumption)	908 TWh [3]	906 TWh [3]
New power generation capacities installed during the year (all technologies)	7,5 GW_{AC}	8,9 GW_{AC}
New renewable power generation capacities installed during the year (including hydropower)	5 GW_{AC}	7,2 GW_{AC}
Total PV electricity production	56 161 GWh	45 840 GWh
Total PV electricity production as a % of total electricity consumption [1]	6,2 %	5,1 %

[1]: METI's Survey of Electric Power Statistics (Total power generation capacities of electricity retailers, general power transmission and distribution operators, power transmission operators, designated power transmission and distribution operators and power producers) (Distributed systems are NOT included.)

[2]: Total of hydro capacity + Cumulative installed capacity under FIT program + Total of renewable energy facilities by ten electric power companies (EPCOs)

[3]: Statistics on actual electricity demand by METI (Total of electricity demand from Jan. to Dec. each year)

1.3 Key enablers of PV development

Table 7 shows the information on key enablers contributing to PV development. The information available at the time of writing this report is listed in the table, since official statistics in Japan are released by fiscal year (April to March).

The shipment data of stationary lithium ion (li-ion) battery storage systems include not only distributed applications but also other applications such as grid-connected applications. However, applications for transportation (electric motorcycles, those related to vehicles, construction equipment and automated carrier machines, etc.) and industrial applications (robots, uninterruptible power system (UPS)) are not included. It is assumed that around 80 % of the reported figures are for residential applications.

A typical heat pump for residential application is "Eco Cute" highly efficient water heater which uses CO_2 as refrigerant. The subsidy program conducted between FY 2002 and FY 2010 encouraged the installation of this heat pump system, and total 6,02 million units of Eco Cute heat pump systems have been installed as of the end of June 2018. As for electric vehicles (EVs), the number of units sold in FY 2017 and the number of units owned as of the end of FY 2017 ended in March 2018 (equivalent to cumulative number of units sold) are listed in the table. Although the statistics for FY 2018 have not yet been released at the time of writing this report, it is reported that 50 000 to 60 000 units have been sold.

Table 7: Information on key enablers

	Description	Annual volume	Total volume	Source
Shipment data of lithium ion battery storage systems	Integrated lithium ion battery storage system consisting of li-ion battery, power conversion devices such as inverter and converter	FY 2017: 49 481 units (324 609 kWh)	As of end of FY 2017: 175 273 units (1 256 803 kWh)	The Japan Electrical Manufacturers' Association (JEMA)
Residential heat pumps	Residential heat pump water heater with natural refrigerant (Eco Cute)	FY 2016: 424 387 unites	As of end of June 2018: 6,02 mil. units	The Japan Refrigeration and Air Conditioning Industry Association, Heat Pump & Thermal Storage Technology Center of Japan (End of June 2018)
Electric vehicles (EV)	Passenger car (PC) Light car (LC)	FY 2017: PC: 23 634 units LC: 455 unites	As of end of FY 2017 PC: 91 357 units LC: 10 698 units	Next Generation Vehicle Promotion Center (Numbers of sales and ownership of EV, etc.)
Electric buses and trucks	EVs other than passenger car or light car, which are categorized as "Other" in the statistics	FY 2017: 68 units	As of end of FY 2017: 1 514 units	Same as above

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Table 8 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 utility-scale PV power plants.

Table 8: 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.
2018	128	56

2.2 System prices

Table 9 shows typical applications and prices of PV systems by category. Table 10 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 9: **Turnkey PV system prices of different typical PV systems**

Category/Size	Typical applications and brief details	Current prices (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 roof-mounted, distributed PV systems < 10 kW	Residential	251
Grid-connected commercial and industrial 10 kW- < 1 MW	Commercial and industrial	222
Grid-connected ≥ 1 MW	Power generation business (mainly ground-mounted)	202
Other category (hybrid diesel-PV, hybrid with battery…)		N.A.

Table 10: National trends in system prices for different applications (JPY/W)

Year	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
2018	251	222	202

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 11: Cost breakdown for a residential PV system

Cost category	Average (JPY/W)
Hardware	
Module	128
Inverter	30
Mounting structure	18
Measurement/ monitoring instrument, etc.	10
Other (electric equipment/ materials of electric equipment, etc.)	8
Subtotal Hardware	**194**
Soft costs	
Installation	42
Other (promotion/ administration cost, etc.)	15
Subtotal Soft costs	**67**
Total (excluding consumption tax)	**251**
Average consumption tax (8 %)	20
Total (including consumption tax)	**271**

2.3.2 Utility-scale PV systems > 1 MW

Table 12: Cost breakdown for a utility-scale PV system

Cost category	Average (JPY/W)
Hardware	
Module	56,1
Inverter	18,5
Mounting structure	20,3
Measurement/ monitoring instrument, etc.	3,9
Other (electric equipment/ transformer/ materials of electric equipment, etc.)	16,6
Subtotal Hardware	**115,4**
Soft costs	
Installation	39,9
Site development	19,2
Contribution for grid connection	10,3
Designing/ development	
Fund raising	
Other (administration cost, etc.)	17,1
Subtotal Soft costs	**86,5**
Total (excluding consumption tax)	**201,9**
Average consumption tax (8 %)	16,1
Total (including consumption tax)	**217,9**

2.4 Financial Parameters and specific financing programs

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. Financing via the Infrastructure Fund Market which was established by the Tokyo Stock Exchange (TSE) as well as issuance of green bonds has been increasingly utilized. Below are 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 2018, five 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.
- Green bond: Bond which is issued for the purpose of raising funds to be allocated to the projects which are effective to improve the environment (green projects). The raised fund is used for development of PV power plants, etc.

There are other financing-related activities as well. Co-finance by regional banks and Japan Finance Corporation (JFC) and efforts by lease companies to support PV systems on farmland while continuing farming activities, are promoted. Regional banks are continuously working on co-financing MW-scale PV power plants. Establishment of funds to invest in renewable energy projects is also on the rise. Major financial institutions are financing overseas PV projects developed by Japanese companies and promoting issuance of green bonds.

Table 13: PV financing information in 2018

Residential (solar loan/ sales on credit)	Long-term prime rate + approx. 1,5 % (low-interest rate financing is available by combining with 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) which is paid to financial institutes at the time of financing
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.
Green bond	Bond which is issued for the purpose of raising funds to be allocated to the projects which are effective to improve the environment (green projects).

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. 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 necessary to respond to the request for removal of facilities due to the change of the building owner, etc., and there is a concern over a long-term management. Local governments are conducting public tenders for the 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 tenders are actively responded. Also, a service to directly supply electricity generated from rooftop PV systems without passing through power transmission grids, has started. As an example, Solar Frontier started a business to install PV systems for self-consumption for commercial or industrial customers with no initial investment. As for the lease of power generation facilities, some efforts have been made on supporting PV systems on farmland while continuing agricultural activities.

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. Energy & Environment Investment (EEI), in partnership with a Dutch company, plans to start the crowdfunding business for renewable energy in Japan.

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 growth of this market segment so far can be attributed to the facts that stable revenues 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. Until FY 2016, 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. From 2017, a preferential tax treatment under the Act for Facilitating New Business Activities of Small and Medium-sized Enterprises was started and continued in FY 2018, which offers immediate depreciation of corporate tax and reduction of fixed property tax for PV systems for self-consumption (selling surplus electricity).

Table 14: Summary of existing investment schemes

Investment Schemes	Introduced in Japan
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. Leasing is also utilized to support PV systems on farmland while continuing agricultural activities.
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	Financial products are handled as tax-saving products taking advantage of accelerated depreciation, etc. limited to small- and medium-sized enterprises (SMEs), mainly for 10 to < 50 kW small-scale PV projects

2.6 Additional Country information

Table 15: Country information

Retail Electricity Prices for a 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 as well as currency exchange (fuel regulatory cost of low-voltage supply in Kanto Area as of July 2019: -1,16 JPY/kWh). *3: There are various price plans depending on time zones. *4: Electric Power Companies (EPCO) 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 electricity volume 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 2019: -1,12 JPY/kWh). *3: There are various price plans depending on time zones 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 electricity volume 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 2019: -1,12 JPY/kWh). *3: There are various price plans depending on time zones and seasons. (Source: TEPCO Energy Partner's website)
Population as of December 1, 2018	126,435 million (Statistics Bureau, Ministry of Internal Affairs and Communications (MIC), as of December 1, 2018)
Country size (km^2)	377 974 km^2 (Statistics Bureau, MIC) (as of October 1, 2018)
Average PV yield in kWh/kW	1 000 - 1 100 kWh/kW/yr
Name and market share of major EPCOs (based on electricity demand of December 2018)	1 TEPCO Energy Partner 29,8 % 2 Kansai Electric 16,0 % 3 Chubu Electric 15,9 % 4 Tohoku Electric 10,0 % 5 Kyushu Electric 9,7 % 6 Chugoku Electric 7,4 % 7 Hokuriku Electric 3,7 % 8 Hokkaido Electric 3,3 % 9 Shikoku Electric 3,2 % 10 Okinawa Electric 0,9 % (Source: Survey of Electric Power Statistics, METI)
Name and market share of electric utilities (based on electricity demand of December 2018)	1 Former General Electricity Utilities (10 EPCOs from Hokkaido to Okinawa) 85,3 % 2 Power Producers and Suppliers (PPS) 14,7 % (Source: Survey of Electric Power Statistics, METI)

3 POLICY FRAMEWORK

Table 16: Summary of PV support measures

	On-going measures in 2018 — Residential	Measures introduced in 2018 — Residential	On-going measures in 2018 — Commercial + Industrial	Measures introduced in 2018 — Commercial + Industrial	On-going measures in 2018 — Centralized	Measures introduced in 2018 — Centralized
Feed-in tariffs	Yes (purchase of surplus electricity)	- Maintain mid-term price target until FY 2019	Yes	- Cut in purchase price - Tender scheme (≥ 2 MW)	Yes	- Cut in purchase price - Tender scheme (≥ 2 MW)
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. As for buildings with gross floor area of < 300 m^2, it was scheduled to be obliged from FY 2020, but it was postponed. 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						

3.1 National targets for PV

In the Fourth Strategic Energy Plan which was approved by the Cabinet in 2014, the significance of securing safety was added as the basics of energy policy, in addition to 3E (Energy Security, Economic Efficiency and Environment). In December 2014, the Long-term Energy Supply and Demand Outlook Subcommittee was established and started discussions on the future of the realistic and well-balanced structure of energy supply and demand. The subcommittee compiled a report on July 16, 2015 and the energy mix for FY 2030 was decided. The energy mix for FY 2030 is estimated to be as follows: 22 to 24 % by renewable energy, 20 to 22 % by nuclear power, 27 % by LNG thermal power, 26 % by coal-fired thermal power and 3 % by oil-fired thermal power. The breakdown of renewable energy sources is as follows: 8,8 to 9,2 % by hydro, 7,0 % by PV, 3,7 to 4,6 % by biomass, 1,7 % by wind and 1,0 to 1,1 % by geothermal power. As a national PV target, the cumulative installed capacity of 64 GW in FY 2030 was set. This target was set by capping the surcharge for the FIT program, which is a burden on the nation, at approximately 3 trillion JPY per annum.

3.2 Direct support policies for PV installations

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

  This program provides subsidy to PV systems, etc. for self-consumption and local production and local consumption of electricity. 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.

- Project to demonstrate establishment of virtual power plants (VPPs) utilizing energy resources on the consumer side

  This project aims to establish a technology to control VPPs, etc. and promote expansion of renewable energy introduction, enhancement of energy conservation and leveling of the load of electricity, etc.

- 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.

- Project to develop technology to reduce the amount of output curtailment of renewable energy

  This project aims to develop a system to instantly identify the status of output curtailment without manpower and establish a method to economically adjust output curtailment.

3.2.1 New, existing or phased out measures in 2018

3.2.1.1 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 17. 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. Since there emerged issues which prolonged the period of screening for project approval in 2018, efforts have been made to reduce the screening period. Effective from April 2018, reserving funds to cover the cost of disposal have become obligatory, and from the regular report in July 2018 onwards, reporting of the plan for reserving funds and its progress has become obligatory as well. In December 2018, retroactive measures have been decided to handle FIT-approved PV projects which have not started operation.

Table 17: Key points of the review of the FIT program under the revised FIT Act

Item	Key points of the revision
Revision of approval scheme	- Setting of new approval criteria to secure proper implementation of projects - Framework to comply with related laws and regulations - Review of the new scheme for securing safety, etc. of PV power generation - Consideration of additional measures to prevent occurrence of additional FIT-approved projects which have not started operation
Change of method to set FITs	- Setting of mid-term price target - Setting of FIT for multiple fiscal years - Introduction and expansion 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 16.

3.2.1.2 *BIPV development measures*

As for the building-integrated PV (BIPV), the New Energy and Industrial Technology Development Organization (NEDO) implemented "Demonstration Project for Versatile Photovoltaic Generation" from FY 2013 to FY 2016. As a result of the demonstration project, lightweight and low-cost PV module which decreases reflection of light 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 type of PV module for each installation style and market potential, etc. were studied. In FY 2017, in the "Project for Improvement of Efficiency and Development of Operation and Maintenance Technology of Photovoltaic Power Generation Systems", 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 worked on a project on "International standardization of BIPV modules" for three years from FY 2015 to FY 2017.

From April 2018, it started "International standardization of BIPV modules and systems" and has been promoting activities to revitalize international standardization and the BIPV market, covering not only BIPV modules but also BIPV systems.

3.3 Self-consumption measures

Table 18: Summary of self-consumption regulations for small private PV systems in 2018

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 (virtual self-consumption or metering)	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). For residential PV systems, responses to the mode to promote self-consumption (Green Mode) are being promoted, in preparation for the termination of the FIT purchase period
	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	Electricity system limitations	
	13	Additional features	Promotion and support measures for self-consumption have been strengthened, aiming for independence from FIT.

3.4 Collective self-consumption, community solar and similar measures

The Ministry of Economy, Trade and Industry (METI) prepared the list of examples of smart communities in June 2017, which use energy within communities in a good manner and is promoting smart communities across Japan through companies and organizations. In the areas stricken by the Great East Japan Earthquake, as part of the "Project to promote introduction of smart communities" which is designed to contribute to establishing smart energy systems and smart communities that are resistant to disasters, Katsurao Village of Fukushima Prefecture and Fukushima Electric Power will jointly construct their own power transmission lines in the central part of Katsurao Village. They plan to install a PV system with the maximum output capacity of 2 MW and a 3-MW storage battery in the village and transmit and distribute the generated electricity to general households, factories, public facilities, etc. The system is scheduled to start operation in July 2020.

3.5 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 was PV with 15 000 JPY/kW. Under the premises of charging a part of the wheeling charge to the power producer side, the ceiling amount of the general burden was revised in June 2018 to 41 000 JPY/kW for all the power sources.

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 2018, a total of 36 tender processes have been started throughout Japan, mainly in Tohoku region, Tokyo and Kyushu region, of which 25 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. Tender

capacity for Japan's second PV tender conducted in FY 2018 was 250 MW, in which nine projects with a total capacity of 196,96 MW participated. However, no project won the tender since there were no bids with the bidding price below the ceiling price of 15,50 JPY/kWh. While the ceiling price (21,00 JPY/kWh) was disclosed in the first tender, it was not disclosed in the second tender, as it was recognized that the disclosure of the ceiling price would have provided the bidders with predictability of the price. The lowest and the highest bidding prices were 16,47 JPY/kWh and 20,99 JPY/kWh, respectively. In the third tender, the tender capacity was set at 196,96 MW, the same as the total of bidding capacities in the second tender, and seven projects with a total capacity of 196,96 MW won the bidding. The ceiling price of the third tender was set at 15,50 JPY/kWh, the same as that of the second tender. The lowest and the highest bidding prices were 14,25 JPY/kWh and 15,45 JPY/kWh, respectively. The winning projects are required to firstly pay the second deposit (5 000 JPY/kW) and acquire approval. Six projects with a total capacity of 195,76 MW paid the deposit. One remaining project (1,2 MW), which ranked last among the winning bids, was withdrawn. For the winning project which ranked last among the winning bids, the portion of the bid capacity which exceeded the tender capacity was not awarded. The results of the second and the third tenders were verified, and discussions were made on the fourth and the fifth tenders scheduled to be conducted in FY 2019. In the upcoming tenders, the scope of PV projects subject to the tender scheme will be extended from ≥ 2 MW projects to ≥ 500 kW projects. The tender capacity will be 300 MW for the fourth tender and 450 MW in principle for the fifth tender. In case the bidding capacity of the fourth tender was below 300 MW, the remaining portion will be deducted from the scheduled tender capacity of the fifth tender. The ceiling price of the fourth tender will not be disclosed, and a discussion will be made to decide whether the ceiling price of the fifth tender will be disclosed or not. Also, regional and public projects will be added to the tender scheme. Based on the Act on Promoting Generation of Electricity from Renewable Energy Sources Harmonized with Sound Development of Agriculture, Forestry and Fisheries, projects certified by municipalities will be exempt from paying the first and the second deposits. Formerly, payment of deposit could be made only by cash, but it is now allowed to pay the deposit with the guarantee from financial institutions with a certain level of rating.

Table 19a: Results of the second tender for FIT capacity in FY 2018

Item	Description
Subject of the tender scheme	≥ 2 MW PV systems
Tender capacity	250 MW (a uniform tender is conducted nationwide)
Ceiling price	15,50 JPY/kWh (not disclosed at the time of bidding)
Winning bids	None (no bids were made below the ceiling price)
Lowest bidding price	16,47 JPY/kWh
Highest bidding price	20,99 JPY/kWh
Withdrawal after winning the bid	None
Paid the second deposit to acquire approval	None

Table 19b: Results of the third tender for FIT capacity in FY 2018

Item	Description
Subject of the tender scheme	≥ 2 MW PV systems
Tender capacity	196,96 MW (a uniform tender is conducted nationwide)*
Ceiling price	15,50 JPY/kWh (not disclosed at the time of bidding)
Winning bids	7 projects with a total capacity of 196,96 MW
Lowest bidding price	14,25 JPY/kWh
Highest bidding price	15,45 JPY/kWh
Withdrawal after winning the bid	1 (1,20 MW**)
Paid the second deposit to acquire approval	6 projects with a total capacity of 195,76 MW

* Since the bidding capacity of the second tender was below the tender capacity, the bidding capacity of the second tender was set as the tender capacity for the third tender.

** For the winning project which ranked last among the winning bids, the portion of the bid capacity which exceeded the tender capacity was not awarded. In case the last-winning project is withdrawn due to this reason, the deposit will be refunded.

3.6 Other utility-scale measures including floating and agricultural PV

Regarding floating PV (FPV) systems, although no specific measures have been taken to promote them, the installed capacity of FPV systems has been steadily growing in Japan.

As for PV systems for agricultural applications, solar sharing (PV system installation on farmland while continuing agricultural activities) has been growing in Japan. As shown in Table 20, the Ministry of Agriculture, Forestry and Fisheries (MAFF) issued a notification on solar sharing in 2013, which clarified the handling of solar sharing. This led to the expansion of installed capacity of PV systems for solar sharing. PV systems for agricultural applications were introduced in the Investments for the Future Strategy 2017 which was approved by the cabinet in June 2017. Furthermore, MAFF eased the regulations in May 2018 and extended the term of permission for conversion of farmland for PV installations from 3 years to 10 years, as part of encouraging installations of PV systems for agricultural applications.

Table 20: Policies related to solar sharing

Period	Responsible organization	Details
March 2013	MAFF[1]	Issuance of agricultural promotion notification No. 2657 (FY 2012) "Handling of PV power generation facilities, etc. under the permission system of farmland conversion, by installing PV systems above farmland with supporting poles and continuing agricultural activities".
April 2016	MAFF	Revision of the notification (final revision of the former notification)
March 2017	The Democratic Party[2]	Bill to promote solar sharing by the Democratic Party
June 2017	Cabinet of Prime Minister Shinzo Abe	PV systems for agricultural applications were introduced in the Investments for the Future Strategy 2017
November 2017	MAFF	Release of guidebook by MAFF
April 2018	MOE[3]	PV systems for agricultural applications were introduced in the Fifth Basic Environment Plan
May 2018	MAFF	Revision of the notification (Permission term for temporary farmland conversion was conditionally extended to within 10 years) "Changes in handling permission of farmland conversion for PV power generation facilities for agricultural applications"

1: Ministry of Agriculture, Forestry and Fisheries

2: Current Democratic Party For the People

3: Ministry of the Environment

3.7 Social policies

Although no specific programs are available for low-income families, regional public organizations are supporting the introduction of renewable energy and conducting advanced model projects to establish independent and distributed energy systems at public facilities, etc. Under the Program to promote autonomous dissemination of renewable energy-based electricity and heat, a part of costs for consideration of commercialization and facility installation will be subsidized for such cases as follows: 1) Projects which are conducted with active participation and involvement of regional public organizations; 2) Activities on installation of PV systems mainly on farmland on the premise of continuing agricultural activities; 3) Projects to install and utilize energy storage systems, etc. Under the Model project for advanced measures to reduce CO_2 emissions of public facilities, etc., it is planned to establish around ten advanced models of measures to reduce CO_2 emissions on a community level, which is more effective and efficient than measures to reduce CO_2 emissions at individual public facilities, by utilizing renewable energy facilities and own electric lines in the community district with multiple public facilities.

3.8 Retrospective measures applied to PV

Since the start of the FIT program in July 2012, installation of ≥ 10 kW commercial PV systems rapidly increased, and the purchase price (FIT) more than halved from 40 JPY/kWh for FY 2012 to 18 JPY/kWh for FY 2018. Under the scheme where FIT is set at the time of approval, there are a large number of FIT-approved PV projects which have not started operation for a long time while keeping the high FIT, which brought up the following issues: 1) Concerns over the future increase in the financial burden of the nation; 2) Stagnation in new development and cost reduction and 3) Occupation of open grid capacity. In order to further increase the installed capacity of renewable energy while curbing the national burden, new measures were decided on December 5, 2018 to handle the FIT-approved PV projects which have not started operation, after the deliberations at the Subcommittee for Large-volume Introduction of Renewable Energy and Next Generation Electricity Network. Among the commercial PV projects which acquired FIT approval between FY 2012 and FY 2014 and have far exceeded three years, which is an indicative period of starting operation after acquisition of approval, the following measures have been taken for the projects for which the deadline for starting operation was not set: 1) FIT responding to the timing of starting operation is applied instead of the higher FIT based on the cost at the time of approval, if the preparations for starting operation have not started by the end of FY 2018 (March 31, 2019) in principle and 2) One-year deadline for starting operation is set in principle, in order to secure the start of operation as early as possible.

3.9 Indirect policy issues

3.9.1 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 remote 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, 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. In the Hahajima Island of the Ogasawara Islands, this demonstration test aims to cover half of the annual electric consumption of the island with PV power generation. TMG plans to disseminate the results of the demonstration test to other regions after establishing a model to utilize renewable energy in remote islands.

3.9.2 Support for electricity storage and demand response measures

Installation of storage batteries was not subsidized within the budget for FY 2018. 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 700 000 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, 30 000 JPY is granted for one kWh of storage capacity with the cap of either one-third of the eligible cost for the subsidy or 300 000 JPY, whichever is lower. For this subsidy program, 7 740 applications were made, of which 7 100 were selected. In FY 2018, "ZEH + Demonstration Project" was newly implemented, which has deeper consideration of energy conservation, targeting ZEH with expanded self-consumption. The fixed amount of 1,15 MJPY is subsidized to each eligible house, and in case of installing a storage system, 30 000 JPY/kWh of storage capacity is subsidized. The maximum amount of subsidy is either one-third of the eligible cost for the subsidy or 450 000 JPY, whichever is lower. For this subsidy program, 1 959 applications were made, of which 1 956 were selected. With "Demonstration project of net zero energy building (ZEB)", a part of the costs is subsidized to extension and renovation of existing buildings as well as new buildings which introduce high-performance building materials and equipment, etc. as components 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. 67 applications were made for the public invitation, of which 36 were selected. 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 two-thirds 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 by SII, and the following projects were conducted: 1) Projects to establish VPP infrastructure; 2) VPP aggregator projects; 3) V2G aggregator projects and 4) Projects to promote introduction of VPP resources. For the Projects to promote introduction of VPP resources, subsidy is granted to support the equipment cost including storage batteries and the installation cost. For storage batteries for residential use, 40 000 JPY/kWh was subsidized, up to one third of the equipment cost. For installation cost, the lower amount of either 100 000 JPY or a half of the installation cost was subsidized. For industrial applications, 80 000 JPY per one kW of rated capacity was subsidized, up to one third of the equipment cost, and up to a half of the installation cost was subsidized.

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 are conducting public invitation for dispatching ability used for frequency control and adjustment of supply and demand balance within the electricity supply service area. In order to utilize demand response (DR) as a dispatching ability, requirements for participation in public invitations have been improved to make it easier for DR operators to participate in the pubic invitation.

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 naturally variable power sources on electric grids.

3.9.3 Support for electric vehicles (and VIPV)

Since 2009, METI has been providing subsidy for the introduction of clean energy vehicles. This scheme has been reviewed following the change of policy, etc. The Subsidy for project expenses to introduce clean energy vehicles (CEV subsidy) for FY 2018 is applied to the following: 1) Electric vehicles (EV); 2) fuel cell vehicles (FCV) and 3) Plug-in hybrid vehicles (PHV) with the EV driving distance of 30 km or longer. The cap of the subsidy amount is also stipulated. As for EV, the subsidy amount is calculated as follows: Driving distance of one charging (JC08 mode value) x 1 000 JPY and 400 000 JPY or less. The amount ranges from 301 000 JPY/unit to 400 000 JPY/unit depending on the model. The subsidy amount for PHV was 200 000 JPY (capped at 200 000 JPY). The subsidy amount for FCV and clean diesel vehicles is based on the price difference with the gasoline vehicles of the same class. For FCV, however, the whole amount of price difference is the subsidy amount, and 2,02 to 2,08 MJPY is subsidized. The amount of subsidy for clean diesel vehicles varies from 15 000 JPY to 150 000 JPY since it is calculated with the subsidy rate of one-twelfth and 150 000 JPY or less. These subsidies are managed by the Next Generation Vehicle Promotion Center. There is another requirement that the beneficiaries of the subsidy are not allowed to change the vehicle for four years. The requirements of eligible models and grades are revised every fiscal year.

As for EV and PHV, they are 100 % exempt from the vehicle acquisition tax, as well as the vehicle weight tax. Also, 75 % tax reduction of the vehicle tax, which is set for payment in the next year of purchase according to the amount of displacement, is also applied. EV and PHV fall under the displacement category of 1 000 cc or less, and the annual vehicle tax is 29 500 JPY, which will be reduced to 7 500 JPY with the 75 % tax reduction applied.

In FY 2018, under the project to establish charging infrastructure, subsidies were provided to charging facilities installed at rest areas of express ways, roadside rest areas, commercial and accommodation facilities, condominiums, offices and factories.

3.9.4 Curtailment policies

Power generation amount of renewable energy sources such as PV varies depending on the natural environment. Accordingly, in case the power generation amount within a region exceeds the local electricity demand, output curtailment is conducted to maintain stable supply of electricity. Based on the priority dispatch rules which were stipulated by the Ordinance for Enforcement of the FIT Act and Operational guidelines for the power transmission and distribution business, etc. by the Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO), curtailment of thermal power generation, operation of pumped storage power generation and utilization of inter-regional interconnection lines will be conducted. In case where the power generation amount remains excessive even with these measures, output curtailment of renewable energy sources will be conducted. In October 2018, the first output curtailment on the mainland was conducted on the Kyushu mainland. Following this, the following efforts have been made to reduce the output curtailment: 1) Further utilization of inter-regional interconnection lines; 2) expansion of online control to enable flexible adjustment; 3) reduction of the minimum output capacity of thermal power generators and 4) economic adjustment of output curtailment to secure fairness among power producers and efficient output curtailment.

In FY 2018, “Project to develop technology to reduce output curtailment amount of renewable energy” was newly started, with the aim of developing a system to instantly identify the status of output curtailment and establishing a method to economically adjust output curtailment.

3.9.5 Other support measures

3.9.5.1 International policies affecting the use of PV Power Systems

In order to achieve the reduction target of greenhouse gas (GHG) 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 measures 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 GHG emissions by 80 % by 2050 as a long-term target. In this plan, it is stated 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 GHG emissions by 26 % by FY 2030 compared to FY 2013 (25,4 % decrease from FY 2005) and by 80 % by 2050.

The Ministry of the Environment (MOE) compiled the "Vision for international cooperation on measures to mitigate climate change" in March 2018. The vision states that, since it is essential to significantly reduce the GHG emissions not only within Japan but also across the world including developing countries whose emissions are on the increasing trend, to realize the Paris Agreement. It is also stated that innovation will be created along with significant reduction of emissions in Japan, and export of low-carbon infrastructure focusing on renewable energy is mentioned as part of the efforts by the energy sector, and that MOE is committed to contributing to the global community.

The Ministry of Foreign Affairs (MOFA) held a meeting of experts on climate change in February 2018 and compiled recommendations on Japan's energy policy, which state that the ministry would shift from diplomacy focusing on securing fossil fuels as it has conventionally focused, to diplomacy focusing on renewable energy, based on the Paris Agreement.

3.9.5.2 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 nation 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. 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 2018, non-residential buildings that have a floor area of 300 m^2 or more are required to comply with energy conservation standards. The

residential houses/ buildings whose floor area is below 300 m^2 are not subject to the obligation. 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 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. In FY 2018, the roadmap was reviewed, which set targets to make more than half of the newly built custom-built detached houses built by homebuilders ZEH by FY 2020, and to make all the newly built houses ZEH on average in the country by FY 2030. Discussion on realizing ZEH apartments has been officially added. 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.

Homebuilders, mainly the major ones, have been enhancing activities on ZEH, and proposing houses equipped with PV systems, storage batteries and HEMS. Also, major housing developers started offering ZEH condominiums.

3.9.5.3 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 Figure 1. The share of thermal power generation in the generation mix was approximately 65 % in FY 2010, before the earthquake. In FY 2017, it was approximately 81 % 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.

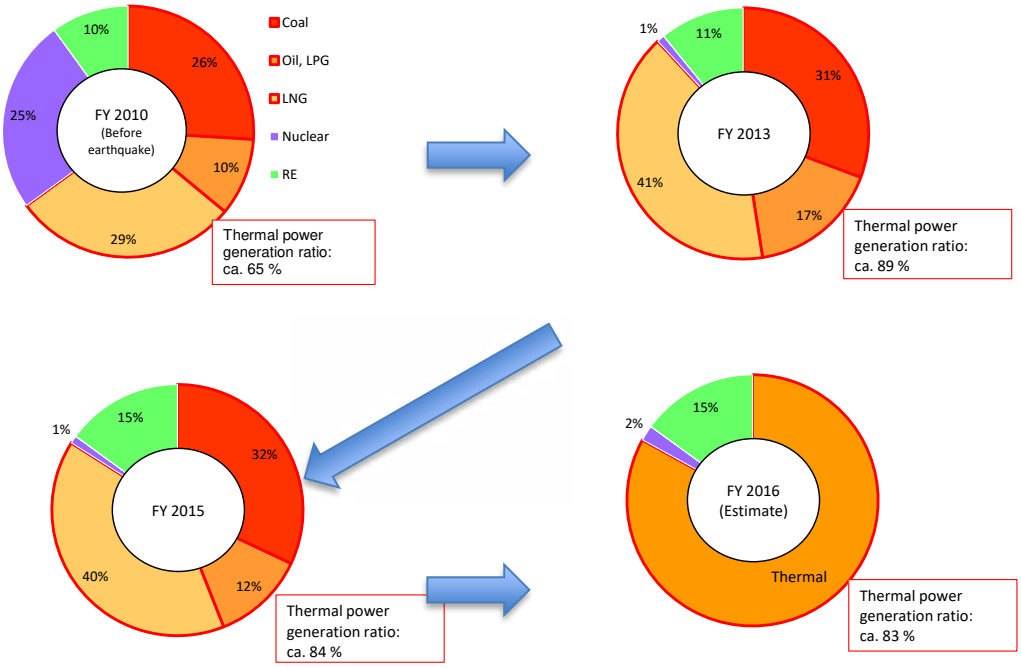

Figure 1 Generation mix of the electric companies

Source: Report on electricity supply-demand verification (October 2017) and White Paper on Energy 2019

Following the increased operation of thermal power generation facilities, greenhouse gas emissions in the electricity sector has increased to 573 million t-CO_2/year in FY 2013 from 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 figure of FY 2017 was at a high level of 492 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, the Fifth Strategic Energy Plan was approved by the Cabinet in July 2018, which shows the direction of Japan's new energy policy toward 2030 and further toward 2050. Japan will be committed to promoting efforts to realize the energy mix for 2030 and make renewable energy a mainstream power source. In the Strategic Energy Plan, it is stated that renewable energy does not emit greenhouse gases and is a promising and important domestic energy source that can contribute to energy security as well, although there are currently various issues in terms of cost and stable supply. Since a series of natural disasters such as typhoons and earthquakes occurred in 2018, efforts have been made to enhance resilience, including emergency inspection of important infrastructure.

- PV's contribution during peak demand hours

  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.

As shown in Table 21, in the summer of 2018, electricity supply capability in the peak hours of the day with the peak demand was 25,03 GW in total against the PV installed capacity of 45,22 GW (excluding Okinawa Prefecture). It is estimated that the supply capability in the summer of 2019 will be 12,92 GW (excluding Okinawa Prefecture), which is below the previous year's result. This estimation assumes 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.

Table 21: 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 2018 (Actual)	Assumption	100	790	2 290	2 230	190	1 300	1 160	680	3 320	12 050
	Actual supply capability records on a day and an hour of peak demand	**760**	**2 330**	**6 160**	**3 950**	**530**	**2 940**	**2 340**	**1 290**	**4 750**	**25 030**
	Actual output ratio	**55,2 %**	**54,6 %**	**52,3 %**	**59,4 %**	**72,6 %**	**47,7 %**	**60,1 %**	**53,3 %**	**58,5 %**	
	Installed capacity	1 380	4 080	11 780	6 650	730	6 160	3 890	2 420	8 120	45 220
	Peak demand date and hour in Japan	2 - 3 p.m., Friday, Aug 3, 2018									-
	Peak electricity demand	4 010	12 910	56 000	25 840	5 670	30 840	11 810	6 440	19 270	185 610
	PV ratio to peak demand	19,0 %	17,3 %	11,0 %	15,3 %	10,5 %	10,5 %	21,6 %	25,6 %	30,1 %	15,3 %
Summer of 2019 (Forecast)	Estimated peak demand hours	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**	**990**	**2 520**	**2 180**	**240**	**1 470**	**1 270**	**730**	**3 430**	**12 920**
	Output ratio	**6,5 %**	**19,3 %**	**21,4 %**	**28,1 %**	**24,8 %**	**28,9 %**	**30,2 %**	**32,3 %**	**42,6 %**	-

Source: Report on electricity supply-demand verification (November 2018 and April 2019)

*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

3.9.5.4 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. According to the estimate by a research institute on the price effects and the effects on financial resource by the Tax for Climate Change Mitigation, it is estimated to reduce CO_2 emissions by approximatly 0,5 % to 2,2 %, or reduce emission amount by around 6 million t to 24 million t by 2020 compared to the 1990 levels.

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.

3.9.5.5 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 2019, 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 2018, a total of 137 funding projects and demonstration projects (MOE/ METI) were adopted and credits were issued in six countries, namely Mongolia, Indonesia, Palau, Vietnam, Thailand and Laos. As of May 2019, 76 PV-related projects have been 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 40 projects of subsidy for equipment including PV systems with a total capacity of approximately 330 MW (from FY 2013 to FY 2018). 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 through the projects on autonomous and distributed renweable energy systems in communities 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 and one project in the Philipphines were selected in 2018.

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 2018, JICA signed a project finance loan agreement for the PV projects conducted by Baynouna Solar Energy Company of Finland, a special purpose company (SPC) jointly established by Masdar (Abu Dhabi) and Taaleri (Finland). Also, JICA concluded a grant contract on grant-in-aid with Guyana for the "Plan to introduce renewable energy and improve the electricity system," in order to improve efficiency of electricity supply and sustainability.

The Japan Bank for International Cooperation (JBIC) actively provides financing support to environmental preservation projects such as installation of PV systems and energy-efficient power plants 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 2019, 33 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.

3.10 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; 7 BJPY in FY 2012, 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, 15,5 BJPY in FY 2018 and 8,2 BJPY in FY 2019. Following the revision of the FIT Act in 2016 and the

enactment in April 2017, the surcharge reduction system was reviewed, and it was decided to set the reduction rate according to the type of business and the status of efforts to improve the electric consumption unit. Amount of purchased electricity generated by PV systems under the FIT program is around 199,4 TWh cumulatively as of the end of December 2018, exceeding 7,9463 TJPY in total.

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).

In FY 2018, NEDO conducted the following three technology development projects on PV power generation as follows: 1) "Development of Solar Power Recycling Technology (FY 2014 to FY 2018)"; 2) "Technological development for improvement of system performance and operation and maintenance (O&M) (FY 2014 to FY 2018)" and 3) Development of high performance and reliable PV modules to reduce levelized cost of energy (FY 2015 to FY 2019)".

Under the project of "Development of Solar Power Recycling Technology", which aims to ultimately achieve the disassembly treatment cost of 5 JPY/W or below (at the time of 200 MW/year treatment) in FY 2018, three demonstration researches on low-cost disassembly treatment technology and development of low-cost reuse technology were conducted. Also, emissions forecast was made in consideration of the distribution of PV installation in Japan.

Under the "Technological development for improvement of system performance and operation and maintenance (O&M)", the Japan Photovoltaic Energy Association (JPEA) and Okuji Kensan formulated PV system design guidelines and structural design examples in 2018 for ground-mounted PV systems which have high safety and economic efficiency against natural disasters and aging degradation. As a new research theme, a PV system technology development to realize ZEB by Kaneka was adopted and technology development on wall-mounted PV system was conducted jointly with a construction company, and a scenario for development of PV system toward realizing ZEB was prepared.

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. Regarding crystalline silicon (c-Si) and CIGS thin-film PV, in addition to development of low-cost and high efficiency solar cells, modularization technology, lower cost technology for mass production as well as technology to improve PV module reliability, aiming for commercialization of low-cost and high efficiency solar cells at an early date. Among the accomplishments of this project in 2018, Sharp achieved the then-world's highest conversion efficiency of 25,09 % on a hetero-junction back contact (HBC) single-crystalline silicon (sc-Si) solar cell with the size of 6 inch x 6 inch (240,6 cm^2). Solar Frontier achieved the then-world's highest 23,35 % conversion efficiency on an approximately 1 cm^2 CIS thin-film solar cell not including cadmium. Under the perovskite PV consortium led by The University of Tokyo on the development of commercialization technology of perovskite solar cell, Toshiba developed the world's largest ultra-light film type perovskite PV module. Toshiba achieved 11,7 % conversion efficiency on a 703-cm^2 PV module and 11,6 % on an 802-cm^2 PV module. Panasonic achieved 20,8 % conversion efficiency on an approximately 1-cm^2 perovskite solar cell, approaching the world record. Sekisui Chemical achieved 8,1 % on a 15 cm x 15 cm ultra-light submodule fabricated on a substrate material made of aluminium foil by adopting R2R process through all the processes. In 2018, this project newly selected four themes of technology development by Panasonic, Kaneka and others. These selected themes aim to establish an element technology to achieve the conventional cost targets by five years ahead of schedule, on a c-Si solar cell by combining cutting-edge technologies such as heterojunction technology and back contact technology. The new targets of power generation cost are 14 JPY/kWh by 2020 and 7 JPY/kWh by 2025. Kaneka is

working on a demonstration research on small-scale commercial production of low-cost HBC solar cell.

Furthermore, this project showed the possibility of supplying sufficient electricity for power, by installing a PV system on a vehicle with a limited installation area, through the development of PV module with the conversion efficiency of over 30 %. NEDO established the PV-Powered Vehicle Strategy Committee, which released an interim report in 2018 and announced the launch of an international research activity of IEA PVPS Task 17 “PV and Transport”, which is designed to contribute to dissemination of PV power generation in the transport sector.

NEDO also conducts technology development “RTD project toward cultivating seeds and commercialization of new and renewable energy, etc. (formerly “Program to support technology innovation of new and renewable energy by venture businesses, etc.”) based on potential technology seeds owned by small- and medium-sized enterprises (SMEs including venture businesses) covering PV technologies. This project aims to commercialize developed technologies in four phases, namely feasibility study, fundamental research, R&D for commercialization and large-scale demonstration research. In FY 2018, 13 new research themes including two PV-related themes were selected. In the PV sector, “Technology development of IoT system utilizing next-generation power line communication technology to realize sustainable PV power generation” by Girasol Energy and “Technology development of DC/AC hybrid power system for local production and local consumption of PV electricity” jointly by Techno-Lab and Tohoku University were selected for the phase of fundamental research.

As a major accomplishment in 2018 under the project to promote R&D by the Japan Science and Technology Agency (JST), TORAY Industries and RIKEN, Japan jointly developed ultra-thin type organic thin-film PV (OPV) cell which can serve as a wearable power source to be directly attached to clothes with a hot melt method. Furthermore, by applying this accomplishment, a joint research group of RIKEN, Japan and The University of Tokyo developed a heart monitor powered by flexible OPV cell, which can be taped to the skin.

At the Fukushima Renewable Energy Institute, AIST (FREA-AIST), the National Institute of Advanced Industrial Science and Technology (AIST) newly started “Project to support development and commercialization of renewable energy technology seeds by businesses, etc. operating disaster-stricken areas” in FY 2018. AIST will focus on supporting technology development toward commercialization of renewable energy-related products by consortiums led by businesses, etc. operating in disaster-stricken areas. In the area of PV power generation, “Development of Fukushima model PV module” led by a PV manufacture INFINI was selected.

Development of PV system utilization technologies has been conducted by METI and NEDO as part of demonstration projects aiming at realizing smart communities. NEDO’s cross-sectional international demonstration projects are designed to contribute to enhancing international competitiveness of Japanese companies and solving energy and environmental issues on a global scale through conducing demonstration projects on energy technology and systems which are strengths of Japan, in cooperation with the governments and public organizations of partner countries. Under the “Project to demonstrate technology and system to improve efficiency of global energy consumption, etc.”, in FY 2018, NEDO conducted PV-related demonstration projects in India, Germany, USA, China, Portugal, Slovenia, Poland and so on.

The followings are major demonstration projects conducted in FY 2018.

- Smart Community Demonstration Project: Slovenia (FY 2016 to FY 2020)
- Demonstration Project on Smart Grid Technology: Haryana, India (FY 2015 to FY 2018), Poland (FY 2016 to FY 2020)

- 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 Project for Validation of Redox Flow Battery Performance: California, USA (FY 2015 to FY 2020)
- Large-Scale Hybrid Power Storage System Demonstration Project: Niedersachsen, Germany (FY 2017 to FY 2019)
- Demonstration Project for ICT based green hospital: New Delhi, India (FY 2016 to FY 2019)
- Demonstration Project for Automated Demand Response (ADR) for air conditioning: Lisbon, Portugal (FY 2016 to FY 2019)
- Demonstration of Energy Management System for Aggregation of Power Demand and Supply Adjustment: Guangdong Province, China (FY 2017 to FY 2020)

In Japan, as part of support programs by METI and the Ministry of the Environment (MOE), demonstration projects on large-capacity storage battery systems are conducted by 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 2018, ten Japanese companies including Tokyo Electric Power (TEPCO), Kansai Electric Power (KEPCO) and ELIIY Power jointly started a demonstration test on the establishment of a large-scale virtual power plant (VPP). Tohoku Electric, in partnership with Sendai City of Miyagi Prefecture, will conduct a demonstration of a VPP using 25 facilities including PV systems and storage batteries installed at designated evacuation centers. SB Energy conducted demonstration of a service model to respond to output curtailment of PV power plants with multiple resource aggregators, and demonstration of VPP regarding offering of adjustment capability in preparation for the establishment of the supply and demand adjustment market. ENERES and KDDI, in partnership with Kyocera and Toda Corporation, conducted verification of technology to control storage batteries and a test on reverse power flow to the electric grid using storage batteries.

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. Study on the utilization of blockchain technology has started and MOE started a demonstration project on trading of the portion of CO_2 reduction of households by installing PV systems, etc. Electric companies and energy service providers such as ENERES, TRENDE (electricity retailing venture business under TEPCO) and KEPCO started discussions on the development of electricity trading service using blockchain technology and announced a plan of demonstration test. TEPCO Energy Partner conducted a demonstration experiment of the “Service to deposit surplus electricity from PV systems” at three districts of ready-built houses developed by TOYOTA WOODYOU HOME under the next-generation smart town project, in order to address the Year 2019 issue (many residential PV systems will face the termination of the FIT surplus power purchase period).

NEDO started construction of the world’s largest scale CO_2-free hydrogen-based energy system, using PV and other renewable energy sources in Namie Town, Fukushima Prefecture, in collaboration with Toshiba Energy Systems and Solutions, Tohoku Electric and Iwatani Corporation. After conducting the demonstration project, NEDO aims to start manufacturing and supplying hydrogen by 2020.

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

The FY 2018 PV system-related budgets are mainly based on national budgets as shown in Table 22. 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 22: Public budgets for R&D, demonstration/field test programmes and market incentives

	FY 2016			FY 2017			FY 2018		
	R&D	Demo/ Field Test	Market Stimulation	R&D	Demo/ Field Test	Market Stimulation	R&D	Demo/ Field Test	Market Stimulation
National government (BJPY)	5,65			5,4			5,4		
Local governments (BJPY)	-	-	-	-	-	-	-	-	-

5 INDUSTRY

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

Table 23: Silicon feedstock, ingot and wafer producer's production information for 2018

Manufacturers	Process & technology [1]	Total Production	Product destination	Price
Tokuyama	Polysilicon (for semiconductor, Siemens process)	Undisclosed		
Mitsubishi Materials	Polysilicon (for semiconductor, Siemens process)	N/A		
OSAKA Titanium technologies (OTC)	Polysilicon (for semiconductor, Siemens process)	Very small amount		
Ferrotec	Si ingot			
	Si wafer			
M.SETEK	sc-Si ingot			

[1]: Si: silicon, sc-Si: single crystalline silicon

Currently in Japan, the scale of production of polysilicon, silicon ingot and wafer for solar cells is not large. As for high purity polysilicon for semiconductor-grade silicon wafers, Tokuyama and Mitsubishi Materials manufacture it. Tokuyama manufactures polysilicon in full capacity at its factory in Shunan City, Yamaguchi Prefecture with the production capacity of 8 500 t/year. In 2018, in order to deal with the increasing demand for polysilicon for semiconductor, it improved yield of process capability by improving the manufacturing process with the existing facilities. Tokuyama has been differentiating itself from others by further increasing the purity of its product, in order to respond to finer semiconductors. Mitsubishi Materials is manufacturing polysilicon in Japan and the USA. OSAKA Titanium technologies (OTC) terminated the long-term polysilicon purchase agreement with SUMCO, a major semiconductor-grade silicon wafer manufacturer at the end of March 2019 which is earlier than the scheduled termination of the agreement and withdrew from the polysilicon manufacturing business.

M.SETEK, a subsidiary of a Taiwanese company AU Optronics (AUO), manufactures sc-Si ingots at its factory in Suzaki City, Kochi Prefecture and supplies to AUO, etc., whereas Ferrotec manufactures 150 mm (6 inch) and 200 mm (8 inch) semiconductor-grade silicon ingots and wafers in China. The company is also conducting test operation of facilities to manufacture 300 mm products. It will shift its silicon wafer business from the solar grade to the semiconductor grade product. As for the silicon wafer for solar cells, it will manufacture only for OEM and withdraw from selling on its own, because the prices have been significantly decreasing due to the price competition in China.

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

Shipment volumes of Japanese PV cell/ module manufacturers stayed on the decreasing trend, influenced by such factors as the revision of the FIT program which took effect in April 2017. According to PV shipment statistics by the Japan Photovoltaic Energy Association (JPEA), total PV module shipments by domestic production in Japan in 2018 (from January to December) were approximately 1,5 GW (a 28,6 % decrease year on year). Chinese manufacturers were aggressively operating in Japan taking advantage of their price competitiveness, mainly for industrial applications. The ratio of overseas production shipped in the domestic market grew to 74,9 %, increased further from the previous year with 67,1 %. Major Japanese 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, Panasonic, Kyocera and Mitsubishi Electric reorganized their production frameworks, mainly at their factories in Japan.

Forecasting that the MW-scale PV market in Japan will shrink, the Japanese manufacturers are shifting their target PV markets by returning to the residential PV market and moving to the PV market for buildings and facilities. They are also enhancing proposals for post-FIT users (owners of PV systems whose FIT surplus power purchase period will be terminated from November 2019 onwards), actively working on offering PV systems for self-consumption and ZEH, as well as total solutions including HEMS, storage batteries, hybrid inverters and so on. Various companies started proposing services to install residential PV systems free of charge in combination with the electricity trading contract. Companies conventionally engaged in the PV module distribution business are shifting their business models to installation, O&M service, electricity trading and so on.

Table 24: PV cell and module production and production capacity information for 2018

Cell/Module manufacturer	Technology[1]	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	500			
3 Panasonic	c-Si (HIT)	Undisclosed	Undisclosed	Undisclosed	Undisclosed
4 Kaneka	sc-Si		22		
5 Mitsubishi Electric	sc-Si	Undisclosed	150	Undisclosed	530
6 Fujipream	sc-Si	0	3,9	0	6
7 Choshu Industry	sc-Si				
	mc-Si				
8 INFINI	sc-Si		10		85
	mc-Si		5		35
9 KIS	sc-Si		3,4		4,8
Thin film PV manufacturers					
1 Solar Frontier	CIS	530	530	1 050	1 050
2 Kaneka	a-Si		4		
3 FWAVE	a-Si	3		24	10
4 Mitsubishi Chemical	a-Si, OPV				
Cells for concentration					
1 Sumitomo Electric Industries	CPV		0		20
Totals [2]		**1 920 [2]**	**1 480 [2]**	**2 550 [2]**	**3 570 [2]**

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

[2]: Source: RTS Corporation

5.3 Manufacturers and suppliers of other components

- PV inverters

PV inverters for residential applications shifted towards certification of multiple-unit grid-connection type inverters. 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 shares.

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 (Germany), Huawei Technologies (China), Sungrow Power Supply (China), Delta Electronics (Taiwan) and ABB (Switzerland) have entered the distributed inverter market. Players in the central inverter market with the capacity range of 250 kW or more are heavy electric machinery manufacturers including Toshiba Mitsubishi-Electric Industrial Systems Corporation (TMEIC), Hitachi, Ltd., Fuji Electric, Daihen, Nissin Electric and Meidensha. Overseas manufacturers such as SMA Solar Technology, ABB, Schneider Electric (France), General Electric (GE) (USA) and Sungrow Power Supply also comprise this market. Installation of distributed inverters has advanced in MW-scale PV power plants as well as small- and medium-scale PV projects, 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.

For ≤ 20 kW inverters, a certification scheme by the Japan Electrical Safety & Environment Technology Laboratories (JET) has been introduced. JET certification is shifting to the certification of multiple-unit grid-connection type inverters. 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 companies are importing storage batteries from other countries such as South Korea and delivering to many storage system manufacturers.

Residential storage systems are sold as hybrid inverters, etc. by Sharp, Panasonic, Choshu Industry, ITOCHU, Nichicon, Kyocera and so on. The inverter capacity usually ranges from 4,5 kW to 5,9 kW and the capacity of storage batteries ranges from 2,7 kWh to 12 kWh.

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

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

In the service area of Hokkaido Electric Power, systems with MWh-level lithium ion batteries are operating 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 1 500 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, overseas manufacturers such as POWERWAY of China 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, automated installation systems as well as lightweight mounting structures for PV modules. 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 25: Estimated PV-related full-time labour places in 2018

Market category	Number of full-time labour places	
	2018	2017
Research and development (not including companies)	600	800
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	75 500	90 000
Distributors of PV products		
System and installation companies		
Electricity utility businesses and government		
Other		
Total	**76 100**	**90 800**

6.2 Business value

Table 26: Rough estimation of the value of the PV business in 2018 (Consumption tax is excluded)

Sub-market	Capacity installed in 2018 (MW)	Average price (JPY/W)	Value (MJPY)	Totals (MJPY)
Off-grid	2			
Grid-connected roof-top < 10 kW (for residential)	638	251	160 138	
Grid-connected for commercial	1 824	222	404 928	
Grid-connected for industrial	960	222	213 120	
Grid-connected ≥ 1 MW	3 238	201	650 838	
Total	6 662			1 429 024
Export of PV products				7 680
Change in stocks held				
Import of PV products				171 720
Value of PV business in 2018				**1 264 984**

Import value described in Table 26 is an estimated value of import of PV modules. Although some overseas manufacturers are exporting their inverters to Japan, the total amount of their shipment 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 538 (as of December 2018) 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 14,8 % (as of December 2018), 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 34,2 % (as of December 2018). The effects of gross bidding, etc. by former General Electricity Utilities to revitalize the trading have been observed. Under the liberalization, measures have been taken to address the issues of public interest, and it is aimed to establish the markets as shown in Figure 2, such as the capacity market, supply/ demand adjustment market and market for trading non-fossil value. Aiming to establish these new markets in the earliest possible timing around FY 2020, a detailed design of the scheme of each market has been prepared. 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. Accordingly, some electric utilities are preparing for the separation of power transmission and distribution business as separate companies.

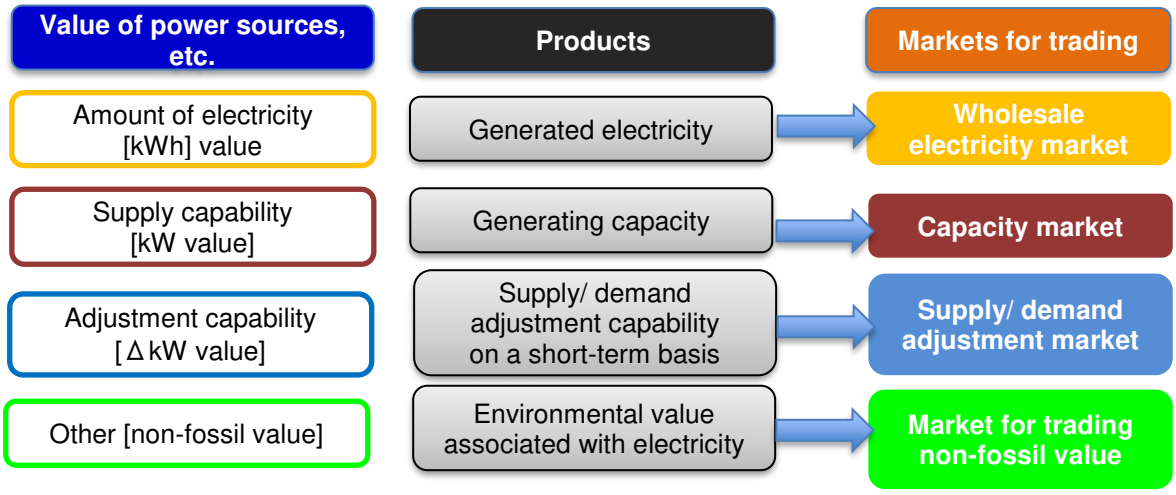

Figure 2: Direction in future development of markets

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 power purchase under the FIT program. Since it has been clearly stated in the Fifth Strategic Energy Plan that efforts will be made to make renewable energy a mainstream power source, electric utilities are advancing activities to promote renewable energy. TEPCO Holdings plans to promote the renewable energy business both home and abroad, to expand its business scale equivalent to that of its thermal power

generation business.

- Development of technology to forecast power generation amount

To assure stable operation of electric grids when PV systems are installed in large volume, 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 increased. To tackle this issue, efforts are being made to improve the accuracy of forecast. Hokkaido Electric and TEPCO Holdings jointly organized a contest of technology to forecast PV power generation amount. The contest was designed to seek for innovative forecasting methods and new approaches. The contestants competed with their proposals on the method to forecast PV power generation amount in Hokkaido Prefecture and the accuracy of the forecast technology. By achieving the higher accuracy power generation forecast, it is anticipated to expand PV dissemination and improve stability of electricity supply.

- 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-volume introduction of renewable energy, projects to introduce large-capacity storage batteries in substations, etc. were advanced as part of METI projects. The following demonstration projects are underway, and the accomplishments have been reported for each project. In addition, TEPCO Holdings and Nippon Telegraph and Telephone (NTT) launched a joint venture to establish new infrastructure services such as an energy business targeting decarbonization and business continuity plan (BCP).

- 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, in October 2018, the first output curtailment of renewable energy on the mainland was conducted on the Kyushu mainland. Total eight times of output curtailment (four times each in October and November 2018) were conducted on weekends when the electricity demand was relatively low. The appropriateness of output curtailment was verified, and the verification results were published by Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO).

- Enhancement of inter-regional grid connection 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 enhanced. In connection with the Electricity System Reform, discussions were made on the capacity of grid connection lines which need to be enhanced 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, which will make the total capacity of 3,0 GW. Construction to increase the grid connection lines between Hokkaido and Honshu (main island of Japan) from 600 MW to 900 MW is progressing, which started operation in 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. OCCTO has been considering the enhancement of interregional connection lines based on the evaluation of cost-benefit performance.

- 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/year or 360 hours/year. This is subject to revision as needed depending on the calculation results of each fiscal year. In case the "30-day, etc. output curtailment capacity" is exceeded, output curtailment will have "no limit without compensation". As of December 2018, six electric companies, namely Hokkaido Electric Power, Tohoku Electric Power, Hokuriku Electric Power, Chugoku 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 electric grids is released by electric companies. 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, rationalization of expected power flow has been started on the "Japanese version connect & manage" which thoroughly utilizes the existing grids, followed by advanced application of N-1 (N minus one) electric control. As such, efforts have been made to realize the "Japanese version connect & manage" at an early date.

7.3 Interest from municipalities and local governments

In addition to the national support programs, 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, Tokyo Metropolitan Government (TMG) subsidizes the cost to install PV modules at railway stations, covering the costs of PV modules, storage batteries and digital signage for transmitting information. TMG aims to promote PV power generation by installing PV modules at the stations where a lot of people gather and encourage them to install residential PV systems at home.

Following the expansion of PV introduction, many cases of troubles with local residents occurred one after another. Executive Committee for the Symposium on Nationwide Megasolar Issues, consisting of "Liaison Committee on PV Issues" based in Suwa City, Nagano Prefecture, held the

first meeting of the Symposium on National Megasolar Issues in Chino City, Nagano Prefecture. Kamogawa City of Chiba Prefecture conditionally permitted a forest land development plan to construct one of the largest PV power plants in Japan, in accordance with the Forest Act, on condition that the development permission may be cancelled in case of violating the Act. Ito City of Shizuoka Prefecture did not provide permission for occupancy of Yawatanogawa River which Izu Megasolar Park GK applied to the City regarding the plan to construct a large-scale PV power plant. Moreover, multiple municipalities are working on amending their guidelines on PV installations, expanding the scope of environmental impact assessment (EIA) and so on.

Efforts to realize local production and local consumption of energy are being made. In Kumejima Town, an island of Okinawa Prefecture, Kumejima STADTWERKE project is being conducted, which is designed to supply electricity to hotels and public facilities within the island from renewable energy-based power generation facilities such as PV and wind power generation systems. Furthermore, if a standalone energy system is successfully established in remote islands, it is expected to be utilized in island nations in Asia. Chichibu City of Saitama Prefecture, jointly with Miyama Power HD, established Chichibu PPS, aiming to supply electricity to public facilities in the City. Establishment of PPS is designed to revitalize the regional economy through establishing a framework to procure electricity locally and wholesale locally, enabling local production and local consumption of energy.

Following large-volume introduction of PV power generation, some municipalities are considering a recycle method with which 3R (reduce, reuse, recycle) and appropriate treatment of used PV power generation facilities, which are expected to be disposed in a large volume, will be promoted. Tokyo Metropolitan Government (TMG) established the “Study Panel on recycling of used PV facilities in Tokyo” and started discussion on an effective method to recycle useful metal and glass included in PV facilities toward promoting 3R and appropriate treatment of used facilities. It is estimated that, following the rapid growth of PV installations after the start of the FIT program, 500 000 t to 800 000 t of PV modules will be disposed annually as wastes from the late 2030s after the end of their life. As the challenges of recycle and appropriate treatment of PV facilities, the Panel listed the following three items: 1) Establishment of appropriate recycle and treatment route; 2) removal of inappropriate treatment and 3) scheme to avoid creation of wastes.

8 HIGHLIGHTS AND PROSPECTS

8.1 Highlights

The Japanese government made a cabinet decision on the Fifth Strategic Energy Plan administered by the Ministry of Economy, Trade and Industry (METI), which positions renewable energy as a mainstream power source of the future. As such, Year 2018 was a historical year for Japan's energy policy. Reflecting the global trend of renewable energy dissemination and price reduction with economic rationality, Japan has entered the new phase toward making renewable energy a mainstream power source.

Following the formulation of the Fifth Strategic Energy Plan, METI accelerated its efforts in solving the issues toward making renewable energy a mainstream power source, and promoted establishment of dissemination environment such as 1) measures for FIT-approved PV projects which have not started operation; 2) achieving price target ahead of schedule; 3) expansion of capacity range of PV projects subject to the tender scheme; 4) establishment of an liaison committee aiming for coexistence in harmony with the local community; 5) introduction of the Japanese version of connect & manage and 6) network cost reform in the era of large-volume introduction of renewable energy. Furthermore, following the cabinet approval of the Fifth Basic Environment Plan, the Ministry of the Environment (MOE) strengthened support to increase PV installations with the Program to promote acceleration and maximization of renewable energy introduction. The Ministry of Agriculture, Forestry and Fisheries (MAFF) also started supporting expansion of the PV installations in the agriculture sector with the measures to promote installation of PV systems on farmland while continuing agricultural activities.

Among activities by local governments, an increasing number of municipalities are regulating the construction of large-scale PV power plants under ordinances, for the purpose of ensuring PV installations in harmony with local communities. Meanwhile, an increasing number of PPS were established with the initiative of municipalities and introduction of renewable energy for local production and local consumption has advanced.

In the electricity industry, the first output curtailment of renewable energy on the mainland in Japan was conducted in the mainland Kyushu region, and activities on the Japanese version connect & manage started.

In the PV industry, since it was made clear to make renewable energy a mainstream power source, companies from conventional energy industries are entering the PV business one after another. Business deployment through new business models expecting the electricity system reform and the trends of expansion of energy from distributed power sources started. Major Japanese PV manufacturers reorganized their production frameworks for enhancing their competitiveness. They promoted re-establishment of the PV business through expansion of business areas, overseas business expansion and adoption of new business models, while promoting cost reduction through concentration of production bases, review of the cost of raw materials and so on.

Under such circumstances, cumulative FIT-approved capacity and cumulative installed capacity in Japan as of the end of December 2018 grew to 72,7 GW (AC) and 43,0 GW (AC), respectively. In 2018, annual installed capacity was 6,66 GW (DC), and the cumulative installed capacity reached 56,16 GW (DC), exceeding 50 GW.

8.2 Prospects

Entering the second year of the Fifth Strategic Energy Plan, policy measures are expected to be accelerated toward making renewable energy a mainstream power source. In preparation for the drastic revision of the current Renewable Energy Act scheduled to be completed by March 2021, the Japanese government will start working on re-establishing the policy measures for renewable energy toward making it a mainstream power source as well as the renewable energy policy with regard to the next-generation electricity network. Specifically, regarding the scheme according to the characteristics of power source, deliberations are underway on the following issues: 1) Effective policy measures according to the characteristics of each power source of renewable energy; 2) Cost reduction suitable for renewable energy as a mainstream power source and integration with the electricity market; 3) Appropriate installation of already-approved projects and promotion of new development and 4) Establishment of distributed energy supply structure in harmony with local communities. As appropriate business disciplines, the following are expected to be hammered out: 1) Securing long-term stable project management; 2) Responsible implementation of projects including appropriate disposal and 3) Securing continuation and expansion of renewable energy projects after the termination of the FIT power purchase period. As for the transition to the next-generation electricity network, the following are scheduled to be presented: 1) Responses to regionally-uneven distribution of sites suitable for renewable energy projects; 2) Appropriate sharing of costs related to the establishment of network and 3) the roles of renewable energy-based power producers in the network management.

Furthermore, it is expected that utilization and applications of renewable energy based on the policies, laws and regulations by ministries such as MOE, MAFF, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and Ministry of Internal Affairs and Communications (MIC) will be expanded. It is also expected that introduction of renewable energy aiming for local production and local consumption with the initiative of municipalities, as well as the transition of renewable energy utilization by the industry will be advanced.

The year 2019 is anticipated to be a turning point year where the business environment is supposed to change drastically towards the independence from the FIT program. As the new rules will be applied to the FIT-approved projects which have not started operation (purchase price ranges between 32 JPY/kWh and 40 JPY/kWh under the former FIT scheme), early installation or cancellation/ revocation of significant numbers of PV projects are expected. In addition, the purchase price for the 10 kW to < 500 kW projects will be reduced largely from 18 JPY/kWh to 14 JPY/kWh. In the tenders in FY 2019 (Apr. 2019 to Mar. 2020), the range of the projects subject to the tender scheme will be extended from ≥ 2 MW to ≥ 500 kW and the tender capacity will be limited to 750 MW/year. Furthermore, the purchase of surplus electricity at 48 JPY/kWh under the FIT program will be terminated for 530 000 residential PV systems with a capacity of 2 GW in total, and the integration to the electricity market will be strengthened.

The trends of the Japanese PV market are expected to shift from the ground-mounted MW-scale PV power plants for the power sales business which are accompanied by large-scale development, to a new era of rooftop systems for installations on buildings with electricity demand, the systems for supplying electricity in the neighbourhood (PV systems for integrated demand and supply), and the virtual MW-scale PV power plants which connect the above-mentioned systems with the communication function.