IEA INTERNATIONAL ENERGY AGENCY

NEDO

National Survey Report of PV Power Applications in JAPAN

2014

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

Prepared by
Hiroyuki YAMADA, New Energy and Industrial Technology Development Organization (NEDO)
Osamu IKKI, RTS Corporation

TABLE OF CONTENTS

Foreword

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

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

The participating countries and organisations can be found on the www.iea-pvps.org website.

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

Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. An important deliverable of Task 1 is the annual "*Trends in photovoltaic applications*" report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the country National Survey Report for the year 2014. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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

1 INSTALLATION DATA

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

For the purposes of this report, **PV installations are included in the 2014 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2014, although commissioning may have taken place at a later date**.

1.1 Applications for Photovoltaics

Annual installed capacity of 2014 reached 9 740 MW (DC-base), about 40 % increase from the previous year (2013: 6 968 MW). Almost all the PV systems were introduced under the Feed-in Tariff (FIT) program. Breakdown of the annual installed capacity of 2014 by application is; 0 MW for off-grid domestic, 1,4 MW for off-grid non-domestic, 9 739 MW for grid-connected (grid connected distributed plus grid connected decentralized).

1.2 Total photovoltaic power installed

Cumulative PV installed capacity as of the end of 2014 reached 23 339 MW. Cumulative PV installed capacity by application is; 8,8 MW for off-grid domestic, 116 MW for off-grid non-domestic and 23 214 MW for grid-connected.

Table 1: PV power installed during calendar year 2014

			MW installed in 2014 - AC value	MW installed in 2014 - DC value
Grid-connected	BAPV	Residential (<10 kW)	801	801
		Commercial (<50 kW, icluding small-scale ground mounted)	3 049	3 202
		Industrial (50 kW – 1 MW, cluding small-scale ground mounted)	2 238	2,526
		Total of BAPV	6 088	6 529
	BIPV	Residential (< 10 kW)	60	60
		Commercial (10 - 250 kW)		
		Industrial (> 250 kW)		
		Total of BIPV	60	60
	Ground-mounted	cSi and TF (1 MW ~)	2 597	3 150
		CPV		
		Total of ground-mounted	2 597	3 150
Off-grid		Residential		
		Other	1,4	1,4
		Hybrid systems		
		Total of off-grid	1,4	1,4
		Total	8 746	9 740

Table 1b: Grid-connected PV power installed during calendar year 2014 (under FIT program) (Unit: MW)

	Capacity (AC-based)	Capacity (DC-based)
< 10kW	860,58	861,00
10 kW - < 50 kW	3 049,435	3 201,91
50 kW - < 500 kW	980,0929	1 107,50
500 kW-< 1 MW	1 078,244	1 218,42
1 MW - < 2 MW	1 935,07	2 322,08
2 MW or more	662,099	827,62
Total	8 565,521	9 538,54

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

Table 2: Data collection process

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

Table 3: PV power and the broader national energy market

MW-GW for capacities and GWh-TWh for energy	2014 numbers	2013 numbers
Total power generation capacities (all technologies)	271 GW	260 GW
Total power generation capacities (renewables including hydropower)	83 GW	58,8 GW
Total electricity demand (= consumption)	965 TWh	979 TWh
New power generation capacities installed during the year (all technologies)	16,8 GW	7,4 GW
New power generation capacities installed during the year (renewables including hydropower)	10,4 GW	7 GW
Total PV electricity production in GWh-TWh	23 339 GWh	13 599 GWh
Total PV electricity production as a % of total electricity consumption	2,4 %	1,4 %

Table 4: Other information

	2014 Numbers
Number of PV systems in operation in Japan	**Residential PV system: ~ 1 710 000 systems**
Capacity of decommissioned PV systems during the year in MW	**N.A.**
Total capacity connected to the low voltage distribution grid in MW	**~ 19 630 MW**
Total capacity connected to the medium voltage distribution grid in MW	
Total capacity connected to the high voltage transmission grid in MW	**~ 1 187 MW**

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

Sub-market	Stand-alone domestic	Stand-alone non-domestic	Grid-connected distributed	Grid-connected centralized	TOTAL
1992	150	15 260	1 220	2 370	19 000
1993	200	19 170	2 300	2 600	24 270
1994	250	23 260	5 130	2 600	31 240
1995	300	29 360	10 820	2 900	43 380
1996	350	35 890	20 500	2 900	59 640
1997	400	44 900	43 100	2 900	91 300
1998	450	52 300	77 750	2 900	133 400
1999	500	56 200	149 000	2 900	208 600
2000	550	63 000	263 770	2 900	330 220
2001	600	66 227	383 086	2 900	452 813
2002	955	71 692	561 295	2 900	636 842
2003	1 101	77 792	777 830	2 900	859 623
2004	1 136	83 109	1 044 846	2 900	1 131 991
2005	1 148	85 909	1 331 951	2 900	1 421 908
2006	1 212	87 376	1 617 011	2 900	1 708 499
2007	1 884	88 266	1 823 244	5 500	1 918 894
2008	1 923	88 886	2 044 080	9 300	2 144 189
2009	2 635	91 998	2 521 792	10 740	2 627 165
2010	3 374	95 420	3 496 017	23 333	3 618 144
2011	5 546	97 728	4 741 464	69 210	4 913 948
2012	8 822	100 530	6 522 317		6 631 669
2013	8 822	114 618	13 475 729		13 599 169
2014	8 822	115 996	23 214 264		23 339 082

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

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

Table 6: Typical module prices of residential applications for a number of years

Year	Average price (JPY/W)	Best price (JPY/W)
1992	996	
1993	950	
1994	927	
1995	764	
1996	646	
1997	652	
1998	674	
1999	598	
2000	542	
2001	481	
2002	462	
2003	451	
2004	441	
2005	428	
2006	433	
2007	436	
2008	447	386
2009	393	347
2010	366	343
2011	327	306
2012	280	269
2013	252	242
2014	197	130

2.2 System prices

Table 7 shows typical applications and prices of PV systems by category. Table 8 shows the trends in system prices. The standardization of grid-connected PV systems has progressed with the growth of the PV market in Japan, and the prices have been decreasing. On the other hand, off-grid system prices are determined case by case because there are various types of applications and the size of each market is small.

Table 7: **Turnkey Prices of Typical Applications**

Category/Size	Typical applications and brief details	Current prices per W (JPY/W)
OFF-GRID < 1 kW	Telecommunications, lighting, traffic and road signs, ventilating fans, pumps, remote monitoring, navigation signs, clock towers, etc.	N.A.
OFF-GRID ≥ 1 kW	Agricultural facilities, communication facilities, disaster prevention facilities, mountain cottages, park facilities, housing in remote areas, lighthouses, etc.	N.A.
Grid-connected Rooftop < 10 kW (residential)		366
Grid-connected Rooftop 10 kW- < 1 MW		290
Grid-connected Ground-mounted ≥ 1 MW	Power generation business	241
Other category (hybrid diesel-PV, hybrid with battery…)		N.A.

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

	Residential PV systems (< 10 kW)	Commercial and industrial average (10 kW - 1 MW)	Ground-mounted average (≥ 1 MW)
1994	1 920		
1995	1 510		
1996	1 090		
1997	1 062		
1998	1 074		
1999	939		
2000	844		
2001	758		
2002	710		
2003	690		
2004	675		
2005	661		
2006	683		
2007	696		
2008	723		
2009	605		
2010	559		
2011	513		
2012	451	372	280
2013	413	342	275
2014	366*	290	241*

* System price for 2014: RTS Corporation (outcome from FY 2014 "Survey on Technology Development Trends on Cost Reduction of Photovoltaic Power Generation Systems")

2.3 Cost breakdown of PV installations

2.3.1 Residential PV System < 10 Kw

Table 9: Cost breakdown for a residential PV system

Cost category	Average (JPY/W)	Low (JPY/W)	High (JPY/W)
Hardware			
Module	197	130	266
Inverter	36	22	47
Mounting structure	28	11	60
Measurement/ monitoring instrument, etc.	13	7	22
Other (electric equipment/ materials of electric equipment, etc.)	7	4	11
Soft costs			
Installation	64	29	106
Other (promotion/ administration cost, etc.)	21	15	32
Total	366	218	544

2.3.2 Utility-scale PV systems > 1 MW

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

Cost category	Average (JPY/W)	Low (JPY/W)	High (JPY/W)
Hardware			
Module	84	70	100
Inverter	22	12	42
Mounting structure	29	16	44
Measurement/ monitoring instrument, etc.	3	1	8
Other (electric equipment/ transformer/ materials of electric equipment, etc.)	20	10	54
Soft costs			
Installation	68	21	104
Site development	15	3	34
Contribution for grid connection	3	1	5
Designing/ development	5	3	15
Fund raising	3	2	3
Other (promotion/ administration cost, etc.)	11	2	27
Total	241	133	386

2.4 Financial Parameters and programs (leasing…)

Since the FIT program started, a number of commercial PV power plants have been constructed one after another. With this trend, financing schemes have become more diversified. Since Japanese financial institutions tend to focus on collateral, it is difficult for PV projects to secure collateral finance since their value as collateral is low and the value of land as an asset cannot cover the loan. Therefore, developers are now seeking financing utilizing variety of measures. Below is the general financing measures in Japan.

- Corporate finance: Since financing is available at very low cost in case own credit line or collateral such as real estate, etc. can be prepared, many PV project owners use corporate finance. However, it requires to hold assets directly for a long term and the available assets for holding can reach a limit in many occasions.

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

- 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: Leasing companies own the facilities and operators pay the lease fee. Sometimes it is used by combining with other loans.

- Loan for individual: Consumer credit companies or banks finance individuals without collateral. Consumer credit companies are relatively positive even though the availability of financing depends on the reliability, etc. of the individuals.

For small to medium-sized companies with excellent financial condition, there are many cases of investment with fully-owned resources in order to take advantage of the Green Investment Tax Break (terminated in FY 2014) in which one-time depreciation at the first fiscal year is available.

Table 11: PV financing scheme

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

2.5 Additional Country information

Table 12: Country information

Retail Electricity Prices for an household (Low voltage 100 V or 200 V)(TEPCO, Tokyo Electric Power Company)	Base rate: 280,80 JPY/10 A (1 kVA) Charge for the volume of usage: <120 kWh/month 19,43 JPY/kWh, 120 - 300 kWh/month 25,91 JPY/kWh, >300 kWh/month 29,93 JPY/kWh (TEPCO, 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 (0,75 JPY/kWh (April 2015), 1,58 JPY/kWh (May 2015 - April 2016))” will be added on top of the above-mentioned charge, depending on the electricity usage. *2: There are various price plans depending on hours and seasons. (Source: TEPCO’s website, May, 2015)
Retail Electricity Prices for a commercial company (High voltage: ≤ 6,6 V, extra high voltage: > 22 kV)(TEPCO)	Base rate: 1 684,80 JPY/kW Charge for the volume of usage: 17,13 JPY/kWh (summer), 15,99 JPY/kWh (other seasons)(TEPCO, high voltage electricity for commercial use) *1: same as above (Source: TEPCO’s website, May, 2015)
Retail Electricity Prices for an industrial company (High voltage: ≤ 6,6 V, extra high voltage: > 22 kV) (TEPCO)	Base rate: 1 782 JPY/kW Charge for the volume of usage: 15,78 JPY/kWh (summer), 14,78 JPY/kWh (other seasons)TEPCO, high voltage electricity (≥ 500 kW)) Base rate: 1 269 JPY/kW Charge for the volume of usage: 16,96 JPY/kWh (summer), 15,85 JPY/kWh (other seasons)(TEPCO, high voltage electricity A (< 500 kW)) *1: same as above (Source: TEPCO’s website, May, 2015)
Population at the end of 2014 (or latest known)	127,06 million (Statistics Bureau, Ministry of Internal Affairs and Communications (MIC), finalized in December 2014)
Country size (km^2)	377 962km^2 (Statistics Bureau, MIC)
Average PV yield in kWh/kWp	1 000 – 1 100 kWh/kW/yr
Name and market share of major electric companies (share by sales)	1 TEPCO 32,3 % 2 Kansai Electric 16,2 % 3 Chubu Electric 13,8 % 4 Tohoku Electric 9,9 % 5 Kyushu Electric 8,7 % 6 Chugoku Electric 6,1 % 7 Shikoku Electric 3,1 % 8 Hokkaido Electric 3,1 % 9 Hokuriku Electric 2,8 % 10 Okinawa Electric 0,9 % Source: Industry trends

3 POLICY FRAMEWORK

3.1 Direct support policies

Table 13: PV support measures (summary table) (1/3)

	On-going measures	Measures that commenced during 2014
Feed-in tariffs (gross / net?)	- The Feed-in Tariff (FIT) program for renewable energy power generation facilities took effect in July 2012 based on the "Renewable Energy Law". For newly-installed PV systems with the capacity below 10 kW, the surplus electricity generated aside from the self-consumption is covered. For newly-installed PV systems with the capacity of 10 kW or more, the gross electricity generated is covered by the program	-
Capital subsidies for equipment or total cost	- Subsidy for measures to support introduction of residential PV systems (METI, Ministry of Economy, Trade and Industry, issuing transaction only) - More than 1 000 local governments implement their own subsidy programs (budgets such as the Green New Deal Fund (MoE, Ministry of the Environment)) - Subsidy to support restoration through promoting introduction of renewable energy power generation facilities, etc. (METI) - Subsidy for measures for off-grid renewable energy power generation systems (Project to promote introduction of renewable energy power generation systems in communities) (METI) - Project to promote introduction of renewable energy through citizens' interaction in Fukushima Prefecture (METI) - Project to support introduction of technologies by small-sized local public organizations (MoE) - Subsidy for eco lease business promotion project for households and businesses (MoE) - Renewable energy integrated promotion project for revitalization of forestry and fishing villages (MAFF, Ministry of Agriculture, Forestry and Fisheries) - Eco-school pilot model project (MEXT, Ministry of Education, Culture, Sports, Science and Technology)	- Subsidy to support restoration through promoting introduction of renewable energy power generation facilities, etc. (single-year subsidy specifically for three quake-stricken prefectures) (METI) - Subsidy for projects to promote introduction of smart energy systems (specifically for three quake-stricken prefectures) (METI) - Green Plan Partnership project (METI) - Project to promote introduction of PV systems on waste disposal land (MoE) - Project to promote creation of low-carbon communities in remote islands (MoE) - Project to accelerate introduction of renewable energy and energy conservation in remote islands (MoE)
Green electricity schemes	- Electric companies terminated the green electricity fund program in connection with the start of the FIT program - Trading of green power certificates certified by the Green Energy Certification Center (operated by the Institute of Energy Economics, Japan)	-
PV-specific green electricity schemes	- Sales of "PV-Green", green power certificates for residential individual PV by a NPO PV-Net - Carbon offset business through green power certificates by Aomori Prefecture (cooperation with NPO)	-

Table 13: PV support measures (summary table) (2/3)

	On-going measures	Measures that commenced during 2014
Renewable portfolio standards (RPS)	- RPS was amended in connection with the start of the FIT program - Both newly-installed and existing PV systems are eligible for selling electricity, but newly-installed PV systems are shifting to take advantage of FIT	-
PV requirement in RPS	-	-
Investment funds for PV	- Investment funds for large-scale PV power plants by financial institutions - Investment funds for large-scale PV power plants by local governments and municipalities - "Green Fund" project to establish a fund to promote investment in low-carbon in local communities (MoE/ local financial institutions, etc.)	-
Income tax credits	Residential PV systems - Tax credit for the investment on renovation of energy conservation and barrier-free houses including PV systems: reduction of 10 % of cost from income tax is applicable for home renovation to improve energy conservation without loans, with the maximum reduced amount of 200 000 JPY (in case of introducing PV systems, the applicable maximum reduced amount is 300 000 JPY) (the maximum reduced amounts for both cases are increased by 50 000 JPY for those who start to reside from April 1, 2014) Non-residential PV systems - Tax reduction for green investment (for PV and wind power generation systems): special depreciation available for maximum of 30 % of acquisition cost, 7 % tax credit (only for small- and medium-sized enterprises (SMEs)) and immediate amortization (write off of 100 % of acquisition cost) (terminated in FY 2014) - Special measure of the tax basis related to renewable energy power generation facilities (fixed asset tax): reduction of the tax basis to two-thirds of the cost of the tax basis for renewable energy power generation facilities (including storage batteries, transformation units and power transmission facilities) acquired under the approval of the FIT program (limited to the fixed asset tax of three years from the fiscal year when the fixed asset tax is charged)	- "Green gift tax" system is approved in which installation of such as PV systems for newly-build houses and extension or reconstruction of houses is exempted from gift tax when donated to child or grandchild by Tax Reform Proposal of FY 2015
Prosumers' incentives (self-consumption, net-metering, net-billing…)	- Subsidy for measures for off-grid renewable energy power generation systems (METI) - Project to support introduction of lithium ion batteries for stationary installation (METI) - Project to promote zero-energy houses (MLIT, Ministry of Land, Infrastructure, Transport and Tourism) - Project to support net zero energy house (ZEH) (METI) - Project to promote enhancement of management by small- and medium-sized enterprises (SMEs), etc. through reduction of greenhouse gas emissions (MoE)	-

Table 13: PV support measures (summary table) (3/3)

	On-going measures	Measures that commenced during 2014
Commercial bank activities e.g. green mortgages promoting PV	- Low-interest loan programs - Introduction of PV systems to their own buildings - Syndicate loans for large-scale PV power plants - Asset Based Lending (ABL) by putting up facilities of MW-scale PV power plants as collateral	- Solar loan for financing < 2 MW PV systems which shortened fixed approval time (Sumitomo Mitsui Banking, SMBC) - PV mortgage in which loan is examined by combining income from electricity sales and annual income (Mizuho Bank)
Activities of electricity utility businesses	- Construction of large-scale PV power plants for in-house use - Introduction of large-capacity storage batteries and development of control technology	- Announced the suspension of accepting applications for grid connection contracts with an increase in PV installed capacity - Disclosed the maps of grid restriction and reported the possible hosting capacity. In some areas, tenders for grid connection were carried out - Each electric company started the periodical announcement of the situation of applications for grid connection contracts of renewable energy power generation facilities
Sustainable building requirements	- Energy conservation standards for houses and buildings were amended (self-consumption of PV systems is highly appreciated) - The national government aims to achieve net zero energy house (ZEH) in standard newly-built houses by 2020	- The government set a target of achieving net zero energy building (ZEB) of newly-build public building by 2020 and the average of newly-build architectural structure by 2030 under the Fourth Basic Energy Plan (approved in a Cabinet meeting in April 2014). As for residential houses, achievement of ZEH for newly-build standard houses by 2020 and the average of newly-build houses by 2030 is targeted - Compliance to energy-saving standards in stages for newly-build houses and buildings by 2020 was made compulsory

3.2 Direct Support measures

3.2.1 Support measures exiting in 2014

3.2.1.1 Description of support measures excluding prosumers, BIPV, and rural electrification

In 2014, the subsidy program for residential PV systems was terminated, while the feed-in tariff (FIT) program, which took effect in July 2012, was continued. In 2014, approximately 9.7 GW of PV systems were installed and started operation under the FIT program. For industrial applications, some ministries and agencies implemented support programs for specific applications and regions. Local governments using the Green New Deal Fund are implementing projects to promote introduction of renewable energy in communities. Also, support through tax treatment was also continued.

3.2.1.2 Prosumers' development measures (self-consumption)

Under the FIT program, surplus electricity generated by PV systems with a capacity less than 10 kW is purchased at preferential rates. For these PV systems, if they are installed together with other power generators (gas cogeneration systems, etc.) or storage batteries, purchase prices are reduced. To promote self-consumption, METI implements "Subsidy for measures for off-grid renewable energy power generation systems" for the purpose of promoting introduction of renewable energy power generation systems, etc. for self-consumption. METI also implements a project to support introduction of storage batteries. As part of the "Demonstration projects of next-generation energy and social systems" designed to establish smart communities, demonstrative researches on self-consumption of the entire electricity generated by PV systems using home energy management systems (HEMS) have been implemented. MoE supports introduction of low-carbon equipment (PV systems for self-consumption, etc.) by small- and medium-sized enterprises (SMEs), aiming to reduce greenhouse gas emissions. Furthermore, the national government aims to achieve net zero energy (almost zero consumption of primary energy) in buildings and houses under the Strategic Energy Plan. Projects to support PV systems and other renewable energy power generation systems as well as demonstrative researches on storage batteries, etc. have been implemented via the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and METI. Along with such efforts by the national government, local governments are increasingly interested in achieving zero energy buildings and houses and promoting self-consumption of electricity, and some of them started support programs to address these issues. PV manufacturers and homebuilders are developing or demonstrating their products for self-consumption by combining PV systems with HEMS and/or storage batteries.

3.2.1.3 BIPV development measures

While there are no measures to vitalize the building-integrated PV (BIPV) market, NEDO implemented "Demonstration project for diversifying PV applications", which was initiated in FY 2013. For buildings under this project, development and demonstration of installation technology, design and materials have been underway, for walls, windows and balconies of buildings where it has been difficult to install PV systems for technical and cost reasons. NEDO also implemented development of exterior wall-integrated PV modules as part of R&D on commercialization of organic thin-film PV. These projects by NEDO were terminated in FY 2014 ending March 2015. Not limited to BIPV, but BIPV is planned to be utilized to achieve zero energy of buildings and houses as set in the Strategic Energy Plan by the national government. In response to this move, PV manufacturers are increasingly working on commercialization of BIPV modules and making proposals with them. METI plans to start a project on "International standardization of BIPV modules" in FY 2015, which will last for three years through to FY 2017.

3.2.1.4 Rural electrification measures

Since the entire nation is almost 100 % electrified in Japan, there are no rural electrification measures. However, there are measures to support introduction of renewable energy in islands in order to reduce carbon emissions in remote islands not having connection lines with electricity grids in mainland Japan. These islands depend on expensive fossil fuel-based energy such as diesel power generation. Thus, local economy is affected by increasing prices of fossil fuels. There is also an issue of large amount of CO_2 emissions. In 2014, MoE implemented "Project to accelerate renewable energy and energy saving in remote islands", to support formulating plans to set up a project to create low-carbon communities and to support introduction of renewable energy and energy saving facilities. Furthermore, budget has been allocated to projects for demonstration of storage batteries as part of supporting remote islands. Meanwhile, in 2014, remote islands faced issues related to introduction of renewable energy power generation facilities including electric companies' suspension of responses to applications for grid connection contracts and limitation of installed capacity such as output curtailment.

3.2.1.5 Other measures including decentralized storage and demand response measures

In 2014, ministries and agencies continued supporting technology development on establishing smart grid, storage battery systems, energy management systems, electricity demand response and so on, in order to stabilize electric grids at the time of large-scale introduction of renewable energy. Demonstration projects mainly on smart community were conducted both home and abroad. In FY 2014, METI continued and secured the budget of 6,0 BJPY for the "Demonstration projects of next-generation energy and social systems", a large-scale demonstrative research in four regions in Japan and 1,25 BJPY plus 3,0 billion of supplementary budget for the "Next-generation energy technology demonstration project" in four regions. Starting from FY 2014, budget has also been secured for other projects including the following: Improvement of technology to address surplus electricity generated by renewable energy sources; R&D on technology to address output fluctuations of electric grids; and Demonstration project to establish next-generation electric grids for distributed energy. METI took imitative of these projects. In 2014, MoE started a demonstrative research under the Model project to demonstrate control of storage batteries, etc. In order to increase grid connection capacity for PV and wind power generation systems, electric appliances manufacturers, led by electric companies, are participating in demonstrative researches at substations in remote islands to study the optimal method to control grid frequency variation by using storage batteries and other issues. Furthermore, NEDO conducts technology development on large-capacity storage systems and devices such as materials for storage batteries.

3.2.2 Support measures phased out in 2014

The subsidy program for residential PV systems was terminated in the end of FY 2013 ended March 31, 2014. Provision of the subsidy has been continued in April 2014 onward. Average installed capacity of approximately 130 000 PV systems for which subsidy provision was decided between April and December 2014 is 4,56 kW/system. From FY 2014 onwards, there are no subsidy programs to support dissemination of residential PV systems by the national government. Dissemination of residential PV systems is mainly supported by the Feed-in Tariff (FIT) program.

3.2.3 New support measures implemented in 2014

METI implemented "Subsidy to support restoration through promoting introduction of renewable energy power generation facilities, etc.", which is designed to support introduction of PV systems in nuclear disaster-stricken prefectures of Iwate, Miyagi and Fukushima, and provided subsidy to 70 projects with a total capacity of some 45 MW in FY 2014. Expecting a drastic increase in introduction of renewable energy in disaster-stricken areas under this program, METI aims to recover lost employment opportunities and to cultivate related industries. In 2014, MoE established various projects for the purpose of achieving low-carbon society. The “Green Plan Partnership Project” (5,3 BJPY) which supports formulating plans to introduce renewable energy and provides subsidy for introduction of renewable energy and energy-saving facilities with the leadership of communities, supported municipalities’ plans to establish smart communities and projects to establish model towns of low-carbon houses. For the “Project to promote introduction of PV systems in waste landfills, etc.” (0,25 BJPY), MoE selected three projects conducted by private companies. In addition, MoE newly started the “Project to promote creation of low-carbon communities in remote islands” (2,8 BJPY) and “Project to accelerate introduction of renewable energy and energy saving in remote islands” (0,4 BJPY).

3.2.4 Measures currently discussed but not implemented yet

As part of the FY 2015 budget, support measures related to introduction of renewable energy including PV are planned by ministries and agencies. From 2015, MoE implements projects to promote hydrogen-based society using renewable energy, partly in partnership with METI. In order to address pressing issues, some projects are expected to be started in 2015, funded by the FY 2014 supplementary budget. METI will implement Project to support introduction of storage battery systems for renewable energy power producers with a large budget of 74,4 BJPY, as urgent action to address electric companies’ suspension of responses to applications for grid connection of renewable energy and Project to support introduction of lithium ion storage batteries for stationary installation (13,0 BJPY). METI secured budget of 7,8 BJPY for “Subsidy for projects to promote wide use of renewable energy for local production and local consumption”, aiming to make maximum use of energy in local communities. With this subsidy, METI supports feasibility studies for introduction of renewable energy as well as project planning. While direct support for PV power generation alone has been reduced, activities to support introduction of energy management equipment such as HEMS as well as storage batteries in combination with PV systems are expanding, for the purpose of establishing smart communities and smart houses.

3.2.5 Financing and cost of support measures

Under the FIT program which took effect in July 2012, the largest incentive for PV dissemination, all the electricity users share the cost which electric companies paid for purchasing the electricity generated by renewable energy power generation systems, in the form of surcharge in proportion to the amount of electricity they consume. The surcharge is added to the electricity bill. In order to remove regional discrepancies in this surcharge collected by electric companies, “Organization to adjust cost burden” (consigned by the Green Investment Promotion Organization) collects the surcharge once and distribute the grant to electric companies in proportion to their records of purchasing renewable energy-based electricity. Under this scheme, however, high-volume electricity users such as manufacturers are entitled to reduction of the surcharge. In order to cover the expenses required to compensate the losses generated from the surcharge reduction and incurred by the Organization to adjust cost burden, METI established a subsidy program in FY 2013, by securing the budget of 19,1 BJPY in FY 2013 and 29,0 BJPY in FY 2014. In FY 2015, the budget was increased by almost 60 % year-on-year to 45,6 BJPY, reflecting the expansion of installed capacity of renewable energy power generation facilities under the FIT program. Amount of purchased electricity generated by PV systems under the FIT program is around 27,3 TWh as of the end of January 2015, exceeding 1,0 TJPY in total.

3.3 Indirect policy issues

3.3.1 International policies affecting the use of PV Power Systems

Regarding the target of reducing greenhouse gas emissions by 6 % from the 1990 levels in the first commitment period of the Kyoto Protocol, the Japanese government continued promoting efforts based on the Kyoto Protocol Target Achievement Plan (Cabinet approval in April 2005), and estimates that the reduction target can be achieved. The government decided not to participate in the second commitment period of the Kyoto Protocol. In FY 2013 onwards, however, based on the Cancun Agreements under the United Nations Framework Convention on Climate Change (UNFCCC), the government announced that it is determined to continue actively taking measures against global warming through setting a reduction target by 2020 and via global reporting and verification of progress to achieve the target. At the nineteenth session of the Conference of the Parties (COP 19) to the UNFCCC held in November 2013 in Warsaw, Poland, Minister of the Environment announced that, as a new target by 2020, Japan aims to reduce greenhouse gas emissions by 3.8 % from the 2005 levels.

At the COP 20 held in 2014, Japan was not able to submit the reduction target after 2020. However, the national government formulated a proposal of Long-term Energy Supply-demand Outlook in June 2015, and the Global Warming Prevention Headquarters under the Cabinet approved the FY 2030 target “to reduce greenhouse gas emission by 26 % from the FY 2013 levels” (draft commitment toward COP 21) on June 2, 2015. This target was announced by Prime Minister Shinzo Abe in June 2015 at the G7 Summit held in Germany. As for the measures addressing global warming, Japan set a plan to reduce greenhouse gas emissions and revised the Act on Promotion of Global Warming Countermeasures along with the plan. Large-scale factories remain obliged to report their greenhouse gas emissions.

3.3.2 The introduction of any favourable environmental regulations

Following the large-scale stoppage of nuclear power plants following the Great East Japan Earthquake, electricity supply and demand gap was created, which brought about the circumstances that may shake Japan’s energy security. Consequently, a law on energy conservation was amended in Japan, to make it possible for the national government to curb the energy usage on a long-term basis, including both supply side and demand side. In the newly-amended Act on the Rational Use of Energy (Energy Conservation Act), promotion of levelling electricity demand and expansion of the Top Runner program to cover building materials, etc. are specifically stated. Also, the government’s plan to enhance energy conservation standards for buildings step by step was also presented.

- Promotion of levelling electricity demand

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

- Enhancement of energy conservation standards in buildings

So far, energy conservation standards were either reporting obligations or non-binding obligations depending on the floor spaces of buildings. From 2016 onwards, they will be changed to conformity obligations, step by step. By around 2020, houses covering the floor space of below 300 m^2 will also fall under conformity obligations. Thus, housing and construction sector is forced to review their construction methods. In the standards to be reviewed, reduction of energy consumption by using

PV systems and HEMS will also be evaluated, which may offer a significant incentive for the installation of these systems. As of FY 2014, subsidy is provided for promoting introduction of innovative energy-saving technology such as net zero energy buildings and houses (ZEB/ZEH). This subsidy is continued in FY 2015.

3.3.3 Policies relating to externalities of conventional energy

Nuclear power plants which stopped operation after the Great East Japan Earthquake have not restarted operation since October 2013. Electricity shortage is covered mostly by thermal power generation. With the increase of power generation volume by fossil fuel-based power generation, dependence on fossil fuels as power source sharply increased from some 60 % before the earthquake to 90 %. Total greenhouse gas emissions in FY 2013 also increased by around 8 % from that of FY 2010. In particular, electricity-based CO_2 emissions increased significantly. Since imported fossil fuels are influenced by situations in politically-unstable countries or regions, there are rising concerns from the perspective of energy security. Under such circumstances, securing domestically-produced energy sources is recognized as one of the important issues in the "Proposed outline of Long-term Energy Supply-demand Outlook" which was announced in 2015. In this outline, renewable energy is positioned as one of the important low-carbon domestically-produced energy sources which is promising and versatile, and can contribute to energy security.

- PV's contribution

After the Great East Japan Earthquake, electricity supply and demand status has become tight in Japan. Accordingly, METI evaluates the actual performances and makes a forecast on electricity supply and demand from the viewpoint whether electricity can surely be supplied to cover the demand in peak hours in the summer and in the winter. METI' evaluation covers actual power supply records of PV systems.

Table 14: Power supply capabilities of PV systems in the summer by electric company in Japan

(MW)

Electric company		Hokkaido	Tohoku	Tokyo	Chubu	Kansai	Hokuriku	Chugoku	Shikoku	Kyushu	Total
Summer of 2014 (Actual)	**Actual PV installed capacity**	**400**	**1 060**	**4 350**	**2 750**	**2 040**	**270**	**1 420**	**830**	**3 390**	**16 310**
	Actual supply records on a day of peak demand	**160**	**310**	**1 920**	**1 150**	**890**	**130**	**440**	**390**	**940**	**6 330**
	Peak demand date	Aug. 4	Aug. 5	Aug. 5	Jul. 25	Jul. 25	Aug. 1	Jul. 25	Jul. 25	Jul. 25	-
	(Peak electricity demand)	4 590	13 600	49 800	24 520	26 670	5 180	10 610	5 260	15 220	155 450
	PV ratio to peak demand	3,5 %	2,3 %	3,9 %	4,7 %	3,3 %	2,5 %	4,1 %	7,4 %	6,2 %	4,1 %
Summer of 2015 (Forecast)	Purchase of surplus PV power	129	580	2 360	1 502	1 213	128	768	371	1 349	8 400
	Purchase of PV power (100 % from facility)	883	1 149	4 140	2 628	2 157	374	1 291	1 285	4 031	17 938
	Utility's own PV facilities	1	5	30	17	11	4	6	2	3	79
	Total estimated installed capacity	1 013	1 734	6 530	4 147	3 380	506	2 065	1 658	5 383	26 416
	Estimated supply capability	**0**	**259**	**1 227**	**1 051**	**821**	**108**	**502**	**471**	**659**	**5 098**

Source: Electricity Supply-Demand Verification Subcommittee under METI (October 2014 and April 2015)

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

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

As shown in Table 14, in the summer of 2014, electricity supply capability in the peak hours of electric companies was 6,33 GW in total against the installed capacity of 16,31 GW. It is estimated that the installed capacity in 2015 will be 26,416 GW, a large increase from 2014. In the service areas of some electric companies such as Kyushu Electric, peak hours come in the late afternoon (16:00 to 17:00) due to increasing awareness of energy and electricity conservation. In these areas, PV's supply capability or contribution is low.

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

In Japan, "Tax for Climate Change Mitigation (Carbon Tax)" has been imposed since October 2012, which requires the public to widely and fairly share the burden for the usage of all the folssil fuels including petrolium, natural gas and coal, in proportion to their enviromental load (CO_2 emissions).

This tax is imposed on top of the conventional Petroleum and Coal Tax, in proportion to the usage amount of fossil fuels. Tax rate has been increased step by step over three and half years. It has been decided that 289 JPY/t-CO_2 will be imposed from April 2016. For the period bewteen October 2012 and March 2014, in combination with the conventional Petroleum and Coal Tax, the tax rates were 2 290 JPY/kl for crude oil and oil products, 1 340 JPY/t for hydrocarbon gas and 1 340 JPY/t for coal. From April 2014, as part of the phased tax rate increase, the rates are 2 540 JPY/kl, 1 600 JPY/t and 1 140 JPY/t, respectively. Revenue from the Carbon Tax is approximately 262,3 BJPY, which is used for promoting introduction of renewable energy, drastic enhancement of energy-saving measures and so on. Measures to curb energy-based CO_2 emissions will be reinforced. In 2014, discussions were made on expanding the use of the Carbon Tax. Some ministries and agencies as well as local public organizations made a proposal to expand the use of the tax revenue for measures to address forest carbon sink, but the proposal was rejected due to the opposition from economic organizations. Since the tax rate increase in April 2016 onwards has been decided, economic organizations request drastic review of the Carbon Tax before the tax rate increase.

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

Japan has been promoting activities for international cooperation to disseminate PV power generation so that it can play an active role in disseminating PV power generation particularly in Asia, in order to address global warming issues, to improve living standards in developing countries, to reduce energy consumption in other countries, and to contribute to energy security. Although Japan is not paticipating in the second commitment period of the Kyoto Protocol, it has promoted projects overseas through clean development mechanism (CDM) and joint implementation (JI), based on the Kyoto Mechanism in the first commitment period of the Kyoto Protocol. As of May 2014, there are 777 CDM projects approved by the Japanese government, 556 projects registrered at the United Nations CDM Executive Boad and 55 JI projects approved by the Japanese government. Regarding PV power generation, there are 17 projects totalling over 100 MW are underway in the Philippines, Bangladesh, Vietnam and so on. As to Joint Crediting Mechanism (JCM), Japan signed bilateral documents with Mongolia, Bangladesh, Ethiopia, Kenya, Maldives, Vietnam, Laos, Indonesia, Costa Rica, Palau, Cambodia and Mexico.

The New Energy and Industrial Technology Development Organization (NEDO) conducts the Project to demonstrate technology and system for improving efficiency of international energy consumption. Among major PV-related projects in non-IEA PVPS countries, there are two projects as follows: Smart Community Demonstration Project in an Industrial Complex in Java Island, Indonesia (FY 2012 - 2015) and a technology demonstration project using large-scale PV systems in India (FY 2012 - 2015).

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

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

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

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

In Japan, the New Energy and Industrial Technology Development Organization (NEDO) has been leading to conduct research and development of PV power generation and the Japan Science and Technology Agency (JST) conducts some of the fundamental research projects. FY 2014 was the final year for the most of research projects conducted by NEDO and also a year to prepare technological research projects starting from FY 2015. In this regard, NEDO formulated a new guideline for technological development titled "NEDO PV Challenges, a strategy for developing PV power generation" and decided a new framework of technological research projects based on it. NEDO solicited and selected contractors for some of the new issues and started new research projects.

Newly developed "NEDO PV Challenges" significantly shifted its direction from "strategies to promote dissemination of PV power generation" to "strategies to support the society after penetration of PV power" on the background that full-fledged introduction and utilization of PV power as one of the core energy technologies has already started with significant growth of the PV market by the FIT program and other measures and significant price reduction of PV modules to the level of 0.7 USD/W.

Formerly, main focal point of the R&D was only "improvement of conversion efficiency and cost reduction". But under the framework of next phase technological development projects, new focal points, "Expansion of utilization of PV systems and enhancement of PV industry infrastructures in Japan" were added, in order to smoothly achieve the society with a large-scale dissemination of PV systems. As for the goal of development, PV power generation cost targets of system operation were set for 2020 (14 JPY/kWh) and 2030 (7 JPY/kWh).

NEDO formulated a five-year R&D project consisting three programs; "development for improving conversion efficiency and maintenance technology of PV systems", "development of recycling technology for PV power generation" and "technological development for lowering PV power generation cost for high performance and high reliability photovoltaic power generation". NEDO solicited proposals for the first two programs in FY 2014. Under the "development for improving conversion efficiency and maintenance technology of PV systems", the following three projects were started: improvement of PV system efficiency, development of maintenance technology of PV systems and trends survey of PV system technologies. Three projects also started under the "development of recycling technology for PV power generation"; technological survey on removal, recycling and separation of the end-of-life PV systems at lower cost, feasibility study (FS) (development) of low-cost decomposition technologies and recycling trends survey. 22 research projects starting from FY 2015 were selected for the "technological development for lowering PV power generation cost for high performance and high reliability photovoltaic power generation", targeting higher efficiency and cost reduction by succeeding the direction of the previous programs namely "R&D for High Performance PV Generation System for the Future" and "R&D on Innovative Solar Cells".

In FY 2014 NEDO conducted R&D projects titled "R&D for High Performance PV Generation System for the Future" started from FY 2010, "R&D on Innovative Solar Cells" started from FY 2008 and "Leading technological development for commercialization of organic PV" started in FY 2012. FY 2014 is the final year for these projects, and many achievements were reported in WCPEC-6, the 6th World Conference on Photovoltaic Energy Conversion held in November 2014 in Kyoto. Final evaluation of these projects is scheduled in FY 2016. It is expected that a number of research topics that have potential for further development will be included in the projects to be conducted under new programs on or after FY 2015. NEDO also has been conducting "Demonstration project for diversifying PV applications (FY 2013 to FY 2016)" since FY 2013, aiming at extension of PV utilization (installation) areas. In FY 2014, six subprojects for technology to add high values and one subproject for diversifying applications were additionally selected.

JST promotes two fundamental R&D programs, “Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells” and “Creative Research for Clean Energy Generation using Solar Energy”. 12 research projects are conducted mainly by universities, in order to achieve higher conversion efficiency and lower cost. JST already closed the application of new projects in 2012 and most of these projects are terminated by the end of FY 2014 (March 2015).

JST also conducts “FUTURE-PV Innovation Projects (FUTURE-PV Innovation) (FY 2012 to FY 2016)” aiming at highly efficient silicon nano-wire solar cells with 30 % or higher conversion efficiency under the Ministry of Education, Culture, Sports, Science and Technology (MEXT). Researchers moved its development site to newly-established Fukushima Renewable Energy Institute AIST (FREA) and started full-fledged research activities. The National Institute of Advanced Industrial Science and Technology (AIST) inaugurated FREA in April 2014 as a newly established research institute in Koriyama City, Fukushima Prefecture, aiming to contribute to reconstruction of regions damaged by the Great East Japan Earthquake. FREA promotes technological development, utilization technology development and demonstration of photovoltaic power generation, hydrogen energy and other renewable energies. The number of researchers in FREA reached about 300 as of the end of June 2015.

Regarding utilization technologies of PV systems, various technological development programs are conducted under demonstrative projects aiming at realizing smart communities.

A number of demonstrative projects on smart communities are conducted home and abroad and a large number of PV systems are introduced under such projects. These projects are aiming at global market development by localization of technologies to meet the needs of different countries and regions. The followings are major demonstrative projects conducted in FY 2014.

- Demonstration of Next-generation Energy and Social Systems (FY 2010 to FY 2014): Yokohama City of Kanagawa Prefecture, Toyota City of Aichi Prefecture, Keihannna Science City of Kyoto Prefecture and Kitakyushu City of Fukuoka Prefecture
- Demonstration Tests of Next-generation Energy Technologies (FY 2011 to FY 2014): Mie University Smart Campus in Mie Prefecture, Huistenbosch (amusement park), Sasebo City in Nagasaki Prefecture, Regional resources utilization project, Minamata City in Kumamoto Prefecture, Tottori Wakabadai Smart Grid Town, Tottori City, Tottori Prefecture, Seafront Smart Community, Fukuyama City in Hiroshima Prefecture, Kashiwanoha Campus, The University of Tokyo, Kashiwa City in Chiba Prefecture, Hitachi Smart City, Hitachi City in Ibaraki Prefecture
- Demonstration Project for World-leading Remote Island Smart Grid (FY 2011 to FY 2014): Maui Island, Hawaii, USA
- Smart Community Demonstration Project (FY 2011 to FY 2015): Lyon, France
- Model Project for a Microgrid System Using Large-scale PV Power Generation and Related Technologies (FY 2012 to FY 2014): Neemrana Industrial Park, Rajasthan, India
- Smart Community Demonstration Project (originally scheduled FY 2011 to FY 2013, which has been extended to FY 2015): Gongqing City, Jiangxi Province, China
- Smart Grid-related Technology Demonstration Project (FY 2011 to FY 2015): Malaga, Spain
- Smart Community Demonstration Project in an industrial park (FY 2012 to FY 2017): Java Island, Indonesia
- Smart Community Demonstration Project (FY 2014 to FY 2016): Manchester, UK

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

The FY 2014 budgets for PV system-related R&D, demonstration programs and market incentives are mainly based on national budgets as shown in Table 15.

The budget for R&D is the sum of “R&D on Innovative Solar Cells”, “R&D for High Performance PV Generation System for the Future”, “Leading technological development for commercialization of organic PV” financed by the Ministry of Economy, Trade and Industry (METI). The R&D budget for renewable energy and the budget from MEXT are not included.

The budget for the demonstration is FY 2014 spending for “Demonstration project for diversifying PV applications” started from FY 2013.

The budget for market incentives is based on “Subsidy for projects for establishing a fund for introducing residential PV systems as restoration measures” and “Subsidy for projects for establishing a fund for high penetration of residential PV systems as restoration measures”, formulated as multi-fiscal year funding within the FY 2011 3rd supplementary budget. These programs were finished in the end of FY 2013. While thenational government did not allocate incentives specific to PV power generation, other incentives for renewable energy dissemination such as “Subsidy for introducing renewable energy power generation systems as part of restoration measures” are used for introduction of PV systems (see Chapter 3 for details).

Table 15: Public budgets for R&D, demonstration/field test programmes and market incentives.

	FY 2012			FY 2013			FY 2014		
	R&D	Demo/ Field Test	Market Stimulat ion	R&D	Demo/ Field Test	Market Stimulat ion	R&D	Demo/ Field Test	Market Stimulat ion
National (BJPY)	10,4	0,04	119,38[1]	8,76	0,5	119,38[1]	10,3	0,8	
Regional (BJPY)	-	-	-	-	-	-	-	-	-

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

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

5 INDUSTRY

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

Table 16: Production information for the year for silicon feedstock, ingot and wafer producers in 2014

Manufacturers (or total national production)	Process & technology [1]	Total Production	Product destination	Price
Tokuyama	Polysilicon (Siemens process)	approx. 1 000 tonnes [2]		
M.SETEK	Polysilicon			
	sc-Si ingot			
Mitsubishi Materials	Polysilicon (for semiconductor, Siemens process)	Undisclosed		
Osaka Titanium technologies [3]	Polysilicon (for semiconductor, Siemens process)			
Ferrotec	Ingot			
	Si wafers			
Shin-Etsu Chemical	Si wafers			
Panasonic Corporation Eco Solutions Company	n-type sc-Si wafers for HIT (a-Si on c-Si) (125 mm x 125 mm)	Undisclosed		
Kyocera	mc-Si wafers (p-type, 156 mm x 156 mm)	Undisclosed		
Silicon Plus (Spower)	Ingot			
	Si wafers			
Clean Venture 21	Si wafers (spherical sc-Si)	0,2 MW		

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

[2]: Domestic production volume excluding the production for semiconductor. Domestic production capacity is 6 200t/year (incl. for semiconductor)

[3]: Polysilicon production is specialized for semiconductor. No production for PV

Source: answers from each company for the questionnaire by NEDO

Among activities in 2014 of Japanese manufacturers of silicon feedstock for solar cells, ingots and wafers, the characteristic one was the launch of a large-scale polysilicon production project in Malaysia by Tokuyama. The production facility started official operation in September 2014, however later, it became clear that the handling of semiconductor production was difficult and Tokuyama reported an extraordinary loss for it. As for solar-grade polysilicon (production capacity of

14 000 t/ year), the production activity and full-scale sales have been started and the operating rates of the production facility is in the process of upgrade aiming for full-scale production. Mitsubishi Materials, whose production is mainly supplied to semiconductor-grade, stopped production activities temporarily in consequence of the accident at its Yokkaichi plant which resumed operation later.

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

PV cell/ module manufacturers both home and abroad are gaining momentum thanks to the rapid expansion of the Japanese PV market supported by the FIT program. However, since the expansion of production capacity by the Japanese PV manufacturers is limited and OEM supply agreements are a common practice for them, Chinese and other overseas PV manufacturers are increasing their shipment to the Japanese market. Among new entries to the Japanese market, Vitec Global Solar, a joint venture company of ReneSola Japan and Vitec, as well as Denka Shinki constructed and started operation of a new factory. Regarding business expansion, Solar Frontier is constructing its Tohoku CIS thin-film PV module factory applying the most advanced technology. The Japanese base of First Solar of the USA started the operation of large-scale PV power plants using CdTe PV modules.

Some companies reestablished their business toward enhancing their competitiveness. Sharp decided to reconstruct manufacturing and sale of PV modules in the USA and Italy. Fuji Electric transferred the business of thin-film silicon PV modules to an overseas company while Noritz decided to withdraw from manufacturing and sales of residential PV systems at the end of 2015.

Japanese manufacturers have been making efforts to increase their production capacity and supply volume while improving performance of their products and additional value. Under such efforts, utilization of single-crystalline silicon solar cells was expanded and light-weight PV modules using thin glass were launched. In the R&D activities, Panasonic and Sharp achieved over 25 % conversion efficiency of solar cells with back contact and hetero-junction technology. Among other issues, Kyocera is in dispute with Hanwha Q-CELLS Japan over patents of four-busbar crystalline silicon PV cells. The dispute over intellectual property rights have been reported.

Some PV manufacturers home and abroad are enhancing the downstream PV business such as EPCs and power generation business with their comprehensive strength in the PV business. In the Japanese market, Sharp entered the business of construction and management of MW-scale PV power plants while Kyocera entered the business of operation and management (O&M) of PV power plants. Many other companies entered the power generation business, actively working to acquire knowhow in the new business in preparation for entering the O&M business and for the liberalization of electricity retailing.

Table 17: Production and production capacity information for 2014

Cell/Module manufacturer (or total national production)	Technology [1] (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
Wafer-based PV manufacturers					
1 Sharp	c-Si		(Shipment: 1 982 MW) [2]		200
2 Kyocera	sc-Si	Undisclosed	200	Undisclosed	200
	mc-Si	Undisclosed	1 100	Undisclosed	1 100
3 Panasonic Corporation Eco Solutions Company	HIT (a-Si on c-Si)	Undisclosed	Undisclosed	Undisclosed	Undisclosed
4 Mitsubishi Electric	sc-Si	Undisclosed	500	Undisclosed	530
5 Fujipream	sc-Si				
	mc-Si				
	sc-Si (BIPV)				
	mc-Si (BIPV)				
6 Choshu Industry	sc-Si				
	mc-Si				
7 Suntech Power Japan	sc-Si	-	0,24	-	99
	sc-Si (BIPV)	-	0,05	-	1
8 Itogumi Motech	mc-Si	-	0,5	-	20
	mc-Si (BIPV)	-	1,0	-	5
9 Towada Solar	sc-Si	-	1,5	-	3
	mc-Si	-	10,1	-	12
10 Noritz	mc-Si				
11 Japan Solar Factory	sc-Si				
	mc-Si				
12 Spower	c-Si				
13 PVG Solutions	sc-Si (bifacial)	16	5	45	10
14 Clean Venture 21	sc-Si	0,1	0,05	1	0,2
Thin film manufacturers					
1 Solar Frontier	CIS	952	952	980	980
2 Kaneka	a-Si, a-Si/poly-Si hybrid	26	26	120	120
3 Sharp	a-Si/μc-Si		(Shipment: 1 982 MW) [2]		200
4 FWAVE	a-Si	3		24	5
	a-Si (BIPV)		0		5 (commercial, 10 - 250kW)
5 Mitsubishi Chemical	a-Si, OPV				
Cells for concentration					
1 Daido Steel	CPV				
2 Sumitomo Electric Industries	CPV				
TOTALS		**2 781** [3]	**3 839** [3]	**3 705** [4]	**4 802** [4]

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

[2]: Shipment volume instead of production. The value represents sum of c-Si and a-Si/μc-Si

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

[4]: Studied by RTS Corporation

Source: answers from each company for the questionnaire by NEDO

5.3 Manufacturers and suppliers of other components

- Inverters

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

For 10 kW to < 50 kW inverters for low-voltage grid connection, major inverters on the market include a 9,9-kW inverter and a 25-kW inverter by Tabuchi Electric; a 5,5-kW inverter by Omron; and 10-kW inverters by Shindengen Electric Manufacturing, Yaskawa Electric, GS Yuasa and Sanyo Denki. Overseas manufactures such as SMA Solar Technology have also entered this area.

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

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

For ≤ 10 kW inverters, a certification scheme by the Japan Electrical Safety & Environment Technology Laboratories (JET) has been introduced.

JET certification is categorized into three types of inverters: 1) conventional type; 2) multiple-unit grid-connection type and 3) FRT-support type. Multiple-unit grid-connection type is designed for inverters that employ an islanding operation detection method by frequency feedback method with step reactive power injection (JEM-1498) and an FRT (Fault Ride Though) function. For > 10 kW inverters, approval is given by electric companies individually.

- Storage batteries

Storage batteries are used in zero energy house (ZEH) in combination with PV systems, as measures to address peak cut and peak shift as well as to stabilize electric grids. In particular, lithium ion storage batteries are used to achieve zero energy in houses. For the use of lithium ion storage batteries, the national support program called “Project to support introduction of lithium ion storage batteries for stationary applications” is available. Sustainable open Innovation Initiative (SII) is the contact window for this program. In 2014, approximately 20 000-level systems were installed, mainly in newly-built houses. A demonstrative research to ease fluctuations of power flow on a short- to mid-term basis was conducted by installing large-capacity power storage facilities in electric grids. As a result, sodium sulfur (NaS) batteries, redox flow storage batteries and lithium ion storage batteries were installed in electric grids of Hokkaido Electric, Tohoku Electric, Chugoku Electric and Kyushu Electric and so on and demonstrative researches were started.

- Battery charge controllers

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

- DC switch gears

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

- Supporting structures

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

6 PV IN THE ECONOMY

6.1 Labour places

Table 18: Estimated PV-related labour places in 2014

<table>
<tr><th></th><th>2013</th><th>2014</th></tr>
<tr><td>Research and development (not including companies)</td><td>1 000</td><td>1 000</td></tr>
<tr><td>Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D</td><td rowspan="5">100 300</td><td rowspan="5">125 000</td></tr>
<tr><td>Distributors of PV products</td></tr>
<tr><td>System and installation companies</td></tr>
<tr><td>Electricity utility businesses and government</td></tr>
<tr><td>Other</td></tr>
<tr><td>Total</td><td>101 300</td><td>126 000</td></tr>
</table>

6.2 Business value

Table 19: Value of PV business

Sub-market	Capacity installed in 2014 (MW)	Price (JPY/W)	Value (MJPY)	Totals (MJPY)
Off-grid < 1 kW				
Off-grid ≥ 1kW				
Grid-connected roof-top < 10 kW (for residential)	861	366	*315 126*	
Grid-connected for commercial	3 402	290	*986 580*	
Grid-connected for industrial	2 326	290	*674 517*	
Grid-connected ≥ 1 MW	3 150	241	759 080	
Total	9 739			*2 735 303*
Export of PV products				15 077
Change in stocks held				
Import of PV products				363 568
Value of PV business				2 386 812

Value of PV business has been significantly growing thank to a strong demand. Import value of PV products is on the increase. Although some overseas manufacturers started exporting their inverters to Japan, their export value is still small and is not included in this table. Import value described in Table 19 is an estimated value of import of PV modules.

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

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

Customers for 50 kW or over in extra-high voltage and high voltage electricity are institutionally deregulated, with approximately 62 % of electricity is in the scope of deregulation. However, the market structure of a virtual monopoly by the general electricity companies basically remains unchanged, and the present market is not competitive enough. Market share of new entrants in the retail market is only 3,6 % in FY 2011. On top of that, the Great East Japan Earthquake revealed structural problems of the current electricity system. Flexible and stable supply was difficult when nuclear power plants suspended operation due to the Earthquake and power supply and demand got stringent. They were not able to provide power through power interchange in wide areas or accommodate power from non-utility power generation. It became apparent that the current electricity system, established after World War II to support post-war high-growth period, is outdated in today's huge paradigm shift over power supply. Therefore, the government plans to promote deregulation of the electricity business in three phases as shown in Table 20 to establish revitalized market and a smarter and more robust electricity system.

Table 20: Schedule of Electricity System Reform

	Year	Summary	Content
First phase	2015	Establishment of wide-area coordinating body	- Development of nation-wide plan of demand/ supply and grid - Wide-area operation across the service areas of ordinary times - Instructions to supply electricity regardless of the demand control and service areas at the time of disaster - Acceptance of interconnection of new power sources and disclosure of grid information
Second phase	2016	Deregulation to enter into the retail market including residential sector	- Consumers have the freedom to choose electric companies and prices - Institutional revision of regional monopoly by major electric companies
Third phase	2018 - 2020	Separation of electrical power production from power distribution and transmission, removal of price regulation	- Separation of power distribution and transmission from electric companies - Remove retail price regulation in order to decrease the electricity price based on competition principle

7.2 Interest from electricity utility businesses

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

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

- Development of technology to forecast power generation volume

To operate power grids stably when PV systems are introduced in large scale, electric companies take initiative in technology development and demonstrative researches for forecasting PV power generation volume in short cycles as a subsidized project by METI. In addition to the 10 electric companies, the University of Tokyo, the Japan Weather Association and electrical manufacturers participate in the project. The 10 electric companies monitor pyranometers installed in 321 locations nationwide. The project focuses on two key objectives as follows:

1) Understanding of PV power generation output data

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

2) Development of PV output forecast technology in short cycles

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

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

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

- Enhancement of inter-area grid connection lines

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

- Response regarding the acceptance of grid connection

With an increase in PV installed capacity, some electric companies announced suspension to accept applications to new grid connection contracts in 2014. During period of suspension, they collect and analyse the output condition of grid-connected renewable energy power generation facilities and data related to electricity demand to examine the possibility of further interconnection. They also disclosed maps of grid restriction and reported the possible hosting capacity. In some areas, tenders for grid connection were carried out. Each electric company started the periodical announcement of the situation of applications for grid connection contracts of renewable energy power generation facilities.

7.3 Interest from municipalities and local governments

In addition to the national support measures, PV support programs implemented by local governments and municipalities play an important role for the dissemination support of PV systems. Many local governments and municipalities nationwide have implemented subsidy programs to support installation of residential PV systems. Majority of them provide the residential subsidy ranging from 10 000 JPY/kW to 50 000 JPY/kW. To award subsidy or low-interest loans, some of them require that HEMS should be installed with residential PV systems at the same time. However, in FY 2014, many local governments and municipalities terminated subsidy programs following the termination of subsidy program provided by the national government in FY 2013. The reason for this is that most of these local governments and municipalities have been providing subsidies on top of the national subsidy, therefore, regarding the evaluation requirement for granting subsidy, they used to depend on the national subsidy program.

In addition to residential subsidy, there are subsidy for installation, loan facilitation and tax break for industrial PV systems. Some local governments and municipalities offer these support measures under the condition that the PV system is used as disaster prevention shelter base or for self-consumption purpose.

Moreover, there are many local governments and municipalities which implement support measures other than direct subsidy. The “roof-lease project” in which roofs of the public facilities including schools and apartments as well as public land are leased for the PV installation sites for profit or for free of cost and an effort of matching the unused roofs and sites by providing support map of renewable energy introduction taking advantage of the Internet are conducted. Also, in 2014, activities such as investment for the construction and operation of large-scale PV power plants by local governments and municipalities and promotion to install PV system after relaxation of regulations following amendment of ordinance have been proceeded.

In particular, Gunma Prefecture encourages the use of PV by relaxing the regulations related to the forest managed by the prefecture and Osaka Prefecture amended the ordinance in order to oblige the consideration to install renewable energy power generation facilities at the building of a certain size. Ota City of Gunma Prefecture established a power producer and supplier (PPS) company and Tokyo Metropolitan Government established a private-public fund to invest in power generation business using renewable energy. Calls for application of various business models were actively conducted, including call for “roof-lease” business models at a number of houses by Kanagawa Prefecture, call for proposal of PV project utilizing public property by Shiso City of Hyogo Prefecture. Utilization of agricultural zone and large-scale PV project with capacity of more than 100 MW have been developed. “Model business utilizing solar power generation to reinforce irrigation performance” by Tokushima Prefecture, 230-MW project by Setouchi City of Okayama Prefecture and the Tohoku region’s largest 125-MW large-scale PV project by Karumai Town, Iwate Prefecture are under development.

8 STANDARDS AND CODES

8.1 Standards

As for the standards regarding PV power generation, industrial associations for electric appliances, The Japan Electrical Manufacturers' Association (JEMA) and the Optoelectronics Industry and Technology Development Association (OITDA) are taking a major role in mapping out draft standards. The Japanese Standards Association (JSA) compiles the draft standards and proposes them to the Japanese Industrial Standards Committee (JISC) for deliberation based upon the Industrial Standardization Act. After these procedures, the Japanese Industrial Standards' (JIS) standards are formulated. Currently, a large number of standards are formulated according to the standardization framework listed in Table 21. Although the standards basically comply with the IEC standards by the International Electrotechnical Commission (IEC), some of them reflect unique circumstances of Japan. Recently, vigorous efforts have been made to establish standards for reliability of PV modules, balance of systems (BOS) and the entire PV system.

8.2 Certification

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

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

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

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

As the JETPVm certification system has been certified by the CB-FCS (Full Certification Scheme) of the IECEE (IEC System for Conformity Testing and Certification of Electrotechnical Equipment and Components), mutual certification procedures can be simplified with certificates of conformity and other documents. As of the end of May 2015, 15 107 models of PV modules from 113 manufacturers have been certified and registered. Certification system for PV module components is also operated by JET, and certification system for backsheets started in 2010. In 2012, certification systems for terminal boxes, connectors and cables also started. Certification system for direct current cables for PV systems started in June 2012 as well.

Reliability certification based on standard "JIS Q 8901" setting the requirements of PV modules for terrestrial installation - reliability assurance system (designing, manufacture and performance) was established with the start of the FIT program in July 2012. Four organizations, namely JET, TÜV Rheinland Japan, UL Japan and VDE offer the certification service. As of the end of May 2015, 1 123 models by six manufacturers are registered in the JET certification program.

JET conducts a certification program for "Grid-connected Protective Equipment etc. for Small Distributed Generation Systems" to certify inverters with a capacity of below 20 kW for small-sized distributed PV systems to connect to low-voltage power distribution lines. This certification program aims at smooth "preliminary technological discussions" at the time of connection to electricity grids of electric companies. Similar to certification of PV modules, product models are certified, factories are inspected and certification labels are issued for the products which satisfy the standards. Certification standards are based on the "Individual Test Method of Grid-connected Protective

Equipment etc. for Grid-connected PV Power Generating Systems (for PV Power Generating Systems) stipulated by JET. The standards are based on "Electricity Utilities Industry Law", as well as METI's "Ordinance to set technological standards on electrical facilities", "Official Interpretation of Technical Requirement of Electric Facilities under the Electricity Utilities Industry Law", "Grid-interconnection Technical Requirement Guidelines on Quality of Electricity" and so on.

JET started a new certification program for inverters for multiple grid-interconnection for PV systems in 2011. An inverter manufactured by Omron using "AICOT ®" technology was certified. "AICOT" is a technology to prevent islanding operation in case of installations of grid connection of multiple number of inverters for PV systems. So far, inverters from Tabuchi Electric, Kyocera, SANYO Electric, Sharp, YASKAWA Electric, Sanyo Denki, Delta Electronics, SMA Solar Technology, Diamond Electric Manufacturing, Hitachi Appliances, IDEC and Noritz were certified and registered. "JEM1498: frequency feedback system with step reactive power injection (system to detect standard active islanding operation of PV inverters)" was formulated in August 2012 as a related standard. In December 2013, test for instantaneous voltage drop and test for frequency fluctuations were added to the certification tests as tests for fault ride through (FRT) requirements. In July 2014, the general rule of test method and individual test method were revised. With the revision of the ministerial ordinance of the Ministry of Economy, Trade and Industry (METI) in January 2015, introduction of inverters equipped with function for output curtailment communication is newly required. As for JET certified products, in case of responding to output curtailment only with software change, it is treated as partial modification.

8.3 Standards and codes for PV systems

The 2013 addendum of "Technical Standards for Grid-interconnection JEAC-9701-2012 (Green Book)", concretely describing technical requirements for grid connection was published, clarifying FRT requirements in Japan. A new addendum was published in 2014 and some parts were amended.

In order to improve installation skills for residential PV system, "PV installer qualification test" has been regularly conducted since 2013 by the Japan Photovoltaic Energy Association (JPEA). A technical course related to designing, construction and maintenance of low voltage interconnected PV system with capacity of 10 kW - < 50 kW was started.

Table 21: Standardization Framework for PV Systems (1/2)

Category			JIS No.	Title	Remark
Terms and symbols			C 0617	Graphical symbols for diagrams	Revised in 2011
			C 8960; 2012	Glossary of terms for photovoltaic power generation (incl. solar cells)	Revised in 2012
System			C 8905; 1993	General rules for stand-alone photovoltaic power generating system	Formulated in 1993
			C 8906; 2000	Measuring procedure of photovoltaic system performance	Formulated in 2000
			C 8981; 2006	Standards for safety design of electrical circuit in photovoltaic power generating systems for residential use	Formulated in 2006
			C 8907; 2005	Estimation method of generating electric energy by PV power system	Formulated in 2005
			TS C 0055	Electromagnetic compatibility testing and measuring procedure of power conditioner for photovoltaic systems	Formulated in 2011
			JEM-TR 228	Guideline for maintenance and review of small output PV power systems	Revised in 2012
			-	Electromagnetic compatibility standard of PV power systems	Under discussion
			-	Guideline for field test of PV power systems	Under discussion
Solar Cell	Crystalline Solar Cell	Reference	C 8910; 2005	Primary reference solar cells	Formulated in 2005
			C 8904-2	Requirements for reference solar devices	Formulated in 2011
			C 8904-3	Measurement principles for photovoltaic (PV) solar devices with reference spectral irradiance data	Formulated in 2011
		Solar simulator	C 8912; 2011	Solar simulators for crystalline silicon solar cells and modules	Revised in 2011
		Crystalline silicon solar cells	C 8913; 2005	Measuring method of output power for crystalline silicon solar cells	Formulated in 2005
			C 8915; 2005	Measuring method of spectral response for crystalline silicon solar cells and modules	Formulated in 2005
			C 8920; 2005	Measuring method of equivalent cell temperature for crystalline silicon solar cells by the open-circuit voltage	Formulated in 2005
		Crystalline silicon PV modules	C 8918; 2013	Crystalline silicon solar PV modules	Revised in 2013
			C 8916; 2005	Temperature coefficient measuring methods of output voltage and output current for crystalline silicon solar cells and modules	Formulated in 2005
			C 8914; 2005	Measuring method of output power for crystalline silicon PV modules	Formulated in 2005
			C 8917; 2005	Environmental and endurance test methods for crystalline silicon PV modules	Formulated in 2005
			C 8919; 2005	Outdoor measuring method of output power for crystalline silicon solar cells and modules	Formulated in 2005
			C8990; 2009	Crystalline silicon terrestrial photovoltaic (PV) modules -- Design qualification and type approval	Formulated in 2009
	Amorphous Solar Cell	Reference cell/ module	C 8904-2	Requirements for reference solar devices	Formulated in 2011
			C 8904-3	Measurement principles for photovoltaic (PV) solar devices with reference spectral irradiance data	Formulated in 2011
		Solar simulator	C 8933; 2011	Solar simulators for amorphous silicon solar cells and modules	Revised in 2011
		Amorphous silicon solar cell	C 8934; 2005	Measuring method of output power for amorphous silicon solar cells	Formulated in 2005
			C 8936; 2005	Measuring methods of spectral response for amorphous silicon solar cells and modules	Formulated in 2005
		Amorphous silicon PV modules (thin-film PV modules)	C 8939; 2013	Amorphous silicon PV modules	Revised in 2013
			C 8937; 2005	Temperature coefficient measuring methods of output voltage and output current for amorphous silicon solar cells and modules	Formulated in 2005
			C 8935; 2005	Measuring method of output power for amorphous silicon PV modules	Formulated in 2005
			C 8938; 2005	Environmental and endurance test methods for amorphous silicon PV modules	Formulated in 2005
			C 8940; 2005	Outdoor measuring method of output power for amorphous silicon solar cells and modules	Formulated in 2005
			C8991; 2011	Thin-film terrestrial photovoltaic (PV) modules -- Design qualification and type approval	Revised in 2011

Table 21: Standardization Framework for PV Systems (2/2)

Category		JIS No.	Title	Remark
Solar Cell	Other types of solar cells	C 8904-7	Computation of the spectral mismatch correction for measurements of photovoltaic devices	Formulated in 2011
		C 8944; 2009	Measuring methods of spectral response for multi-junction solar cells	Formulated in 2009
		C 8942; 2009	Solar simulator for multi-junction solar cells and modules	Formulated in 2009
		C 8943; 2009	Indoor measuring method of output power for multi-junction solar cells and modules (Component reference cell method)	Formulated in 2009
		C 8945; 2009	Temperature coefficient measuring methods of output voltage and output current for multi-junction solar cells and modules	Formulated in 2009
		C 8946; 2009	Outdoor measuring method of output power for multi-junction solar cells and modules	Formulated in 2009
		TS C 0052	Measuring methods of spectral response for CIS solar cells	Published in 2010
		TS C 0049	Secondary reference CIS solar cells	Published in 2010
		TS C 0051	Measuring method of output power for CIS solar cells and modules	Published in 2010
		TS C 0053	Temperature coefficient measuring methods of output voltage and output current for CIS solar cells	Published in 2010
		TS C 0050	Solar simulator for CIS solar cells	Published in 2010
		OITDA PV01	Evaluation method of performance for dye-sensitized solar devices	Formulated in 2009
	Modules	JIS C 8992-1; 2010	Confirmation of safety eligibility of PV modules - No. 1: Requirements for structure	Formulated in 2010
		JIS C 8992-2; 2010	Confirmation of safety eligibility of PV modules - No. 2: Requirements for testing	Formulated in 2010
		-	Standards for compatibility of PV modules and arrays	Under discussion
		JIS Q 8901	Requirements of PV modules for terrestrial installation - reliability assurance system (designing, manufacture and performance)	Formulated in 2012
	Other	-	Method to establish traceability of reference cells	Under discussion
Components	Array	C 8951; 2011	General rules for photovoltaic array	Revised in 2011
		C 8952; 2011	Indication of photovoltaic array performance	Revised in 2011
		C 8953; 2006	On-site measurements of crystalline photovoltaic array I-V characteristics	Formulated in 2006
		C 8954; 2006	Design guide on electrical circuits for photovoltaic arrays	
		C 8955; 2011	Design guide on structures for photovoltaic array	Revised in 2011
		C 8956; 2011	Structural design and installation for residential photovoltaic array (roof mount type)	Revised in 2011
	Inverter	C 8980; 2009	Power conditioner for small photovoltaic power generating system	Revision under discussion
		C 8961; 2008	Measuring procedure of power conditioner efficiency for photovoltaic systems	Revised in 2008
		C 8962; 2008	Testing procedure of power conditioner for small photovoltaic generating systems	To be integrated with C 8980
		JEM 1498	JEM1498: frequency feedback system with step reactive power injection (system to detect standard active islanding operation of PV inverters)	Formulated in 2014
		C 8963; 2011	Test procedure of islanding detection measures for utility-interconnected photovoltaic inverters	Formulated in 2011
		-	Safety standards of inverters	Under discussion
		-	Test method for preventing islanding operation of inverter	Under discussion
	Terminal box	JEM 1493	Terminal box and junction box for PV systems	Revised in 2013
		JEM	Relay terminal box for PV systems	Under discussion
Lead acid battery for PV		C 8971; 1993	Measuring procedure of residual capacity for lead acid battery in photovoltaic system	Formulated in 1993
		C 8972; 1997	Testing procedure of long discharge rate lead-acid batteries for photovoltaic systems	Formulated in 1997

* TS: Technical Specifications (standard specification sheet), TR: Technical Report (standard information)

Source: The Japan Electrical Manufacturers' Association (JEMA)

9 HIGHLIGHTS AND PROSPECTS

9.1 Highlights

The Japanese government reviewed its "Strategic Energy Plan," a guideline for the national energy policy, and formulated the "Fourth Strategic Energy Plan." Renewable energy, which had not been positioned as a mainstream energy in the past strategic energy plans, has been newly positioned as "one of the important low-carbon domestically-produced energy sources which is promising and versatile, and can contribute to energy security. It is clearly specified that the government will accelerate the maximum introduction of renewable energy so that it can become an independent energy source on a mid- to long-term basis.

In 2014, the third year of the FIT program for renewable energy which took effect in July 2012, PV system installations have rapidly increased. Total capacity of approved PV systems under the FIT program was 70,9 GW (AC-based) as of December 31, 2014, exceeding 70 GW. Annual PV installed capacity in 2014 was 8,6 GW on an AC basis, or 9,7GW on a DC basis. Japan's cumulative PV installed capacity reached 23,3 GW (DC-based). Earlier, the Japanese PV market had been dominated by the residential PV applications with a capacity of 10 kW or below. In 2014, over 10-MW PV power plants were increasingly installed across the nation, broadening the landscape of the PV market in Japan.

20 years have passed since the Japanese government formulated the "Basic Guidelines for New Energy Introduction" in 1994 and started efforts to expand dissemination of renewable energy as a nation. Over the 20 years, Japan's cumulative PV installed capacity exceeded 20 GW. Under the FIT program, the capacity of approved PV systems recently mushroomed to exceed the possible grid connection capacity of some electric companies. These electric companies suspended responses to applications for grid connection contracts. Under such circumstances, the national government announced possible grid connection capacity of electric companies who do not have much capacity left for grid connection, and decided to drastically review the FIT program in FY 2015 onwards. Under the review, significant changes were made including the timing when purchase prices (FITs) are settled, rules for the change of facility and output curtailment, and so on.

In the PV market in Japan, in addition to manufacturing of PV cells and modules as well as inverters, a new market segment of service businesses such as O&M and power generation business. The size of the PV industry sharply increased to 2,5 TJPY annually. In the PV cell/ module manufacturing technology, Panasonic achieved the world's record conversion efficiency of 25,6 % on a practical size crystalline silicon solar cell (143.7 cm^2).

9.2 Prospects

After the termination of the initial three-year preferential period of the FIT program to accelerate the introduction of renewable energy power generation systems, it is expected that PV installation will continue under the new tariffs and revised rules in April 2015 onwards. Furthermore, among the PV systems approved during the preferential period, an increasing number of 1-MW or larger ground-mounted PV systems will be constructed and start operation. Accordingly, it is expected that annual PV installed capacity in 2015 is expected to remain at the level of 6 to 7 GW (AC-based). The feed-in tariff for < 10-kW PV systems in FY 2015, between April 1, 2015 to March 31, 2016, is set at 33 JPY/kWh in the service areas of Tokyo Electric Power (TEPCO), Chubu Electric Power and Kansai Electric Power (KEPCO), where there is no obligation to install devices to address output curtailment. In the service areas of the electric companies where it is required to install devices to address output curtailment, namely Hokkaido Electric Power, Tohoku Electric Power, Hokuriku Electric Power, Chugoku Electric Power, Shikoku Electric Power, Kyushu Electric Power and Okinawa Electric Power, the FIT is set at 35 JPY/kWh. For 10-kW or larger PV systems, the FIT is set at 29 JPY/kWh for the period between April 1 and June 30, 2015, and 27 JPY/kWh for the period between July 1, 2015 and March 31, 2016.

In 2015, "Long-term Energy Supply-demand Outlook towards 2030" is scheduled to be formulated based on the "Fourth Strategic Energy Plan." In this outlook, Japan's energy mix will also be decided. On the assumption that electricity cost will be reduced, it is stipulated that dependence on nuclear power generation will be reduced to a maximum extent and greenhouse gas emissions will be reduced to the world's lowest level. It is expected that the ratio of renewable energy in the energy mix will be set at an aggressive figure of over 20 %. As for PV power generation, it is expected that over 53 GW of PV systems will be installed by 2030. Introduction of PV power generation will be expanded on a long-term basis.

Definitions, Symbols and Abbreviations

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

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

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

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

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

CPV: Concentrating PV

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

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

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

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

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

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

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

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

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

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

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

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

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

PV support measures:

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

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