International Energy Agency CO-OPERATIVE PROGRAM ON PHOTOVOLTAIC POWER SYSTEMS

Task 1 Exchange and dissemination of information on PV power systems

National survey report of PV Power Applications in Japan 2007

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i 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 23 member countries. The European Commission also participates in the work of the Agency.

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 nineteen participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), the United Kingdom (GBR) and the United States of America (USA). The European Commission and the European Photovoltaic Industry Association are also members.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, 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 <u>www.iea-pvps.org</u>.

ii Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. An important deliverable of Task 1 is the annual *Trends in photovoltaic applications* report. This report gives information on trends in PV power applications in the PVPS member and other countries and is largely based on the information provided in the National Survey Reports which are produced annually by each Task 1 participant. The public PVPS website also plays an important role in disseminating information arising from the programme, including national information. This template is intended to assist national experts and other participants of Task 1 in the preparation of their annual PVPS National Survey Reports.

As the *Trends in photovoltaic applications* report is based on the National Survey Reports it is important that experts follow this template when preparing their national reports. The *Trends* report is an external publication of the IEA-PVPS Implementing Agreement so it must not contain confidential information. Similarly, the National Survey Reports are now presented on the public PVPS website and Task 1 participants should make their own arrangements with their sources on how to treat confidential information (e.g. by ensuring anonymity of the data).

National Survey Reports should be produced before the end of May to enable the *Trends* report to be published by the end of August.

When preparing their national reports, experts must ensure that all the data are as accurate and correct as possible and follow the definitions given in this template. All sections must be completed as comprehensively as possible.

iii Definitions, Symbols and Abbreviations

For the purposes of the National Survey Reports, the following definitions apply:

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

<u>Installed PV power</u>: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m², cell junction temperature of 25°C, AM 1,5 solar spectrum – (also see 'Rated power').

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

<u>PV system</u>: 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.

<u>Module manufacturer</u>: An organization carrying out the encapsulation in the process of the production of PV modules.

<u>Off-grid domestic PV power system</u>: 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.

<u>Off-grid non-domestic PV power system</u>: 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'.

<u>Grid-connected distributed PV power system</u>: 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.

<u>Grid-connected centralized PV power system</u>: 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.

<u>Turnkey price</u>: 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 systems in a remote area are excluded).

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

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

<u>Market deployment initiative</u>: 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, utilities etc.

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

<u>Performance ratio:</u> 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.

Please specify the currency that is used throughout the NSR - countries of Euroland must use the euro (EUR). Please ensure that your NSR follows the recommendations of the internal PVPS report *Writing numerical values, quantities, units and symbols according to International Standards*. This will reduce confusion when preparing the *Trends* report, and will reduce the need for editing of material for consistency before loading on to the website.

National Survey Report of PV Power Applications in Japan

1 Executive summary

Significant ctivities regarding introduction and promotion of photovoltaic power (PV) systems in 2007 are as follows.

- 1) The Ministry of Economy, Trade and Industry (METI) revised the Law on Special Measures Concerning New Energy Use by Electric Utilities (Renewables Portfolio Standard Law, RPS Law) and set a target set the target usage amount of new and renewable energy in FY 2014 at 16 billion kWh. METI took measures to double count the electricity generated by the PV system under RPS law
- 2) The Ministry of Economy, Trade and Industry (METI) also formulated "Cool Earth 50", an energy technology innovation plan towards 2050 and set a long-term strategy for solar cells to achieve 40 % of conversation efficiency
- 3) New Energy and Industrial Technology Development Organization (NEDO) started projects for Verification of Grid Stabilization with Large-Scale PV Power Generation Systems with construction of 5-MW level PV plant in Wakkanai City, Hokkaido Prefecture and 2-MW level PV plant in Hokuto City, Yamanashi Prefecture.
- 4) Ministry of the Environment (MoE) continued "Solar Promotion Program" to promote introduction of PV systems and implemented "A Community Model Project of a Virtuous Circle for Environment and Economy"
- 5) 344 local governments continued to implement support programs for dissemination of residential PV system in 2007 (as of November 2007).
- 6) Various local governments expanded unique activities to promote dissemination of PV systems. Tokyo Metropolitan Government (TMG) started establishing measures to introduce 1 000 MW of solar energy.
- 7) Under the "Field Test Project on New Photovoltaic Power Generation Technology", 374 PV systems, totaling 21 MW, were installed at industrial and public facilities.
- 8) There were a slew of vigorous activities in Japan's PV industry to strengthen a group of PV related industries including the followings: 1) Enhancement of facilities and new entries by raw material and wafer manufacturers; 2) Large-scale expansion of production capacity and build-up of overseas foothold by leading PV solar cell manufacturers, in addition to improvement of solar cell performances; 3) Start of production and expansion of production capacity by newly-entering thin-film PV manufacturers; 4) Burgeoning of PV system integrators; 5) Expansion of production capacity and new entrants in the area of solar cell components; 6) Emergence of solar cell equipment manufacturers handling full turnkey solar cell production lines
- 9) Electric utilities achieved FY 2006 new energy quota under the RPS law and continued to introduce PV systems through "Green Power Fund". They started large-scale PV projects. Hokkaido Electric Power Co., Inc. started a demonstrative research of a 5-MW PV Plant and Electric Power Development Co., Ltd (J-POWER) started construction of a 1-MW PV plant in Kyushu region.

Installed PV power

Total annual installed capacity of the PV system reached 210 395 kW, a drop of 26,6 % from 286 591 kW in 2006. Factors that largely contributed to the decline are the completion of budget for introduction of residential PV systems and a decrease in production volume of PV modules by Japanese PV manufacturers due to supply shortage of silicon feedstock for solar cells. The breakdown of installed PV systems in 2007 is 672 kW for off-grid domestic application, 890 kW for off-grid non-domestic application and 206 233 kW for grid-connected distributed application, mainly residential PV systems. 2 600 kW was newly installed for grid-connected centralized application, as demonstrative research projects of large-scale PV plants started. Primary factors of the flat growth were termination of the budget for "Residential PV System Dissemination Program" and shortage of silicon feedstock for solar cell. Accumulated installed capacity of the PV system in

Japan in 2007 was 1 918 894 kW, close to 2 GW level.

Costs & prices

The prices of PV modules and PV systems decreased owing to the Government's support measures on research and development (R&D) and dissemination measures for PV systems and enhancement of production capacity by PV manufacturers. Accordingly, the average price of PV modules for residential PV system in 2007 dropped by around 0,5% from 433 JPY/W in 2006 to 431 JPY/W. However, due to the increase of installation costs, typical price of 3- to 5-kW residential PV systems increased by 1,9%, from 683 JPY/W in FY 2006 to 696 JPY/W in FY 2007. Price of PV systems with more than 10 kW generation capacity for public and industrial facilities decreased to 640 JPY/W in FY 2007 from 802 JPY/W due to price decrease of PV module and components.

PV production

2007 production volume of solar cells and PV modules in Japan decreased to 845 MW, down from 927,5 MW in 2006, affected by supply shortage of silicon feedstock. While Japan has been the world's largest PV manufacturer since 1999, the share of Japan in the worldwide PV production has been decreasing in recent years.

The breakdown of production volume was as follows: 288 MW of single crystalline silicon (sc-Si) solar cells, 485 MW of multicrystalline (mc-Si) solar cells, 68 MW of amorphous silicon (a-Si) solar cells and 3 MW of CIS solar cells.

(Note: This figure is different from total reported figure by PV manufacturers in Table 5)

The market share of crystalline Si solar cells is approximately 93%. mc-Si solar cells have been overwhelmingly dominating the solar cell market in Japan for last 13 years and, as a major technology of solar cell, kept the status with the continuously growing solar cell market in Japan. Crystalline Si solar cells have been significantly growing in quantity along with the growth of the PV market for electric power use supported by the Government's "Field Test Project on New Photovoltaic Power Generation Technology" and "Project for Promoting the Local Introduction of New Energy", introduction of PV systems by electric utilities through "Green Power Fund", demand for general industrial applications such as traffic signs and telecommunications equipment, as well as expansion of export. As for a-Si solar cells, manufacturers are expanding production capacity to supply mainly to offshore utility markets. Commercial production of CIS solar cells started in 2007.

Budgets of PV

The FY 2007 national budgets for PV power generation for the Ministry of Economy, Trade and Industry (METI) and the Ministry of the Environment (MoE) totaled 23 986 MJPY, of which 4 580 MJPY (3 170 MJPY in 2006) was allocated for R&D including new and renewable energy other than PV, 14 600 MJPY (13 600 MJPY in 2006) for demonstration/ field test programs. The budget for market revitalization amounted to 4 800 MJPY (4 145 MJPY in 2006). Budget for supporting dissemination of PV and other types of new and renewable energy was allocated as well. The budgets for major national programs in FY 2007 are as follows;

- 1) Technological research and development on new and renewable energy: 4 580 MJPY (mainly PV systems)
- 2) Field test project on new energy technology: 10 800 MJPY (mainly PV systems, including solar thermal)
- Verification of Grid Stabilization with Large-scale PV Power Generation System: 3 500 MJPY
- 4) Project for Supporting New Energy Operators: 31 600 MJPY (overall new and renewable energy including PV systems)
- 5) Project for Promoting the Local Introduction of New Energy: 4 500 MJPY (new and

renewable energy including PV systems)

- 6) Project for Establishing New Energy Vision at Local Level: 1 300 MJPY (overall new and renewable energy including PV systems)
- Project for Promotion of Non-profit Activities on New Energy and Energy Conservation: 70 MJPY (overall new and renewable energy including PV systems)
- 8) Demonstrative Project of Regional Power Grids with Various New Energies: 500 MJPY (overall new and renewable energy including PV systems)
- Model Project of Promotion of PV Power Generation for Global Warming Countermeasures (Solar Promotion Program): 4 850 MJPY (overall new and renewable energy including PV systems)
- 10) Project for Developing Technology to Prevent Global Warming: 3 300 MJPY
- 11) International Cooperative Demonstration Projects for Stabilized and Advanced Grid-connection PV Systems: 300 MJPY

Besides METI and MoE, the Ministry of Land, Infrastructure and Transport (MLIT), the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and other ministries and agencies are promoting introduction of PV systems, but amounts of their budgets were not published.

Local governments and municipalities have implemented their own subsidy programs for residential PV system, but their budgets are unknown.

2 The Implementation of PV systems

2.1 Applications for photovoltaics

PV system market in Japan is dominated by grid-connected distributed PV systems, mainly for private housing, shared housing, public facilities, industrial and commercial facilities as well as buildings. Research and Development (R&D) in the PV market is focused on residential PV systems with the capacity of 3 - 5 kW, as well as PV systems with the capacity of 10 - 1 000kW for public facilities, industrial and commercial facilities and buildings. Residential PV systems account for 85,8% of the overall demand for PV systems in Japan, leading the grid-connected distributed PV system market. Installation of medium- and large-scale PV systems for public and industrial facilities as well as commercial buildings has been increasing, mainly with the support of the Ministry of Economy, Trade and Industry (METI). PV systems for public facilities accounts for 3,6% of the entire PV market while demand for PV systems had been installed for demonstrative researches and no new systems had been since FY 1995. In FY 2007, however, under the national demonstrative research projects of large-scale PV systems in FY 2007, construction of two large-scale PV plants, each with the capacity of 2 MW and 5 MW started, part of which started operation.

The size of off-grid residential PV system market, which covers PV systems for mountain huts, remote areas, isolated islands and some public and industrial facilities, is relatively small. Off-grid non-residential PV system market consists mainly of street lights, power source for telecommunications, power source for observation, pumps, disaster prevention, agriculture, road and traffic signs and ventilating fans. Off-grid non-residential market has already established an independent market requiring no subsidies.

2.2 Total photovoltaic power installed

Table 1 shows annual installed capacity of PV systems in 2007 by application. Total installed capacity in 2007 reached 210 395 kW. The annual installed capacity for each application is as follows: 672 kW for off-grid domestic, 890 kW for off-grid non-domestic, 206 233 kW for grid-connected distributed, mainly for housing. 2 600 kW was newly installed for grid-connected centralized application as demonstration researches of large-scale PV plants started.

| Sub-market/ application | Off-grid domestic | Off-grid non-domestic | Grid-connected distributed | Grid-connected centralized | Total |
|----------------------------|-------------------|--------------------------|-------------------------------|----------------------------|---------|
| Installed PV power [kW] | 672 | 890 | 206 233 | 2 600 | 210 395 |

| Table 1 | The installed PV power in 4 sub-markets in 2007 |
|---------|---|
| | |

Table 2 shows cumulative installed capacity of the PV system by application. In 2007, total cumulative installed capacity almost reached 2 GW at 1 918 894 kW. Cumulative installed capacity for each application is as follows: 1 884 kW for off-grid domestic, 88 266 kW for off-grid non-domestic, 1 823 244 kW for grid-connected distributed, 5 500 kW for grid-connected centralized.

| Sub-market/ application | 31 Dec. 1992 kW | 31 Dec. 1993 kW | 31 Dec. 1994 kW | 31 Dec. 1995 kW | 31 Dec. 1996 kW | 31 Dec. 1997 kW | 31 Dec. 1998 kW | 31 Dec. 1999 kW | 31 Dec. 2000 kW | 31 Dec. 2001 kW | 31 Dec. 2002 kW | 31 Dec. 2003 kW | 31 Dec. 2004 kW | 31 Dec. 2005 kW | 31 Dec. 2006 kW | 31 Dec. 2007 kW |
|--------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Off-grid domestic | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 955 | 1 101 | 1 136 | 1 148 | 1 212 | 1 884 |
| Off-grid non-domestic | 15 260 | 19 170 | 23 260 | 29 360 | 35 890 | 44 900 | 52 300 | 56 200 | 63 000 | 66 227 | 71 692 | 77 792 | 83 109 | 85 909 | 87 376 | 88 266 |
| Grid-connect ed distributed | 1 220 | 2 300 | 5 130 | 10 820 | 20 500 | 43 100 | 77 750 | 149 000 | 263 770 | 383 086 | 561 295 | 777 830 | 1 044 846 | 1 331 951 | 1 617 011 | 1 823 244 |
| Grid-connect ed centralized | 2 370 | 2 600 | 2 600 | 2 900 | 2 900 | 2 900 | 2 900 | 2 900 | 2 900 | 2 900 | 2 900 | 2 900 | 2 900 | 2 900 | 2 900 | 5 500 |
| Total | 19 000 | 24 270 | 31 240 | 43 380 | 59 640 | 91 300 | 133 400 | 208 600 | 330 220 | 452 813 | 636 842 | 859 623 | 1 131 991 | 1 421 908 | 1 708 499 | 1 918 894 |

Table 2 The cumulative installed PV power in 4 sub-markets

National support framework for residential PV system was completed in FY 2005 and the market of residential PV system has shifted to a self-supported market driven by the market mechanism. PV system for housing became standard equipment by major pre-fabricated housing manufacturers, which was developed from actions for reducing CO₂ emissions and promoting all-electrification housing. This movement has been spreading from a few major housing manufacturers to a large number of housing manufactures as well as local housing developers. Intensive introduction of PV systems in residential estates by developers has also been increasing. As a new movement in residential application, introduction of PV system to collective housings has started. Some local authorities continued subsidy programs to prop up dissemination of residential PV systems.

Introduction of PV systems to public, industrial and commercial facilities has been promoted with the support of METI. PV systems for public facilities have been installed at a steady pace every year, under "Field Test Project on New Photovoltaic Power Generation" and "Project for Promoting the Local Introduction of New Energy". Major locations of installation include kindergartens, schools, government office buildings, hospitals, welfare facilities, libraries, parks, community centers and water purification plants, with the systems sized between 10 kW and 1 000 kW. Recently, local authorities have been active in PV system installation and they are expected to continue such efforts.

Introduction of PV systems for industrial and commercial uses has been promoted mainly by "Field Test Project on New Photovoltaic Power Generation" and "Project for Supporting New Energy Operators". Demand for PV systems for industrial and commercial uses increased from 6.2 % in 2006 to 9,3 % in 2007 of the overall demand due to increasing introduction of PV systems by companies who are proactive in tackling environmental issues. Industrial PV systems with the size of 10 kW to 5 000 kW were installed on the roofs and rooftops of facilities such as plants, warehouses and laboratories. Commercial PV systems with the size of 10 kW to 300 kW were installed on the rooftops, roofs, exterior walls and parking lots of facilities such as companies' headquarters, sales offices, plants and large-scale commercial facilities. PV systems were also installed at service stations, agricultural facilities, facilities for truck delivery as well as railroad facilities. The first installation of PV system was made at a balancing reservoir. New buildings are equipped with building-integrated PV (BIPV) systems consisting of light-weight PV modules, light-through PV modules and flexible PV modules on roofs, rooftops, exterior walls, canopies, blind louvers and eaves. Following the trend from FY 2006, large-scale PV systems were installed including a 2-MW PV system and 1-MW PV systems in FY 2007 on roofs and facilities of plants. Latest trend is represented by an increasing number of introducing PV systems over 100 kW. Installation of large-scale PV systems is the fledgling trend of these days.

In FY 2007, under "Verification of Grid Stabilization with Large-Scale PV Power Generation System" project by the national government, construction of two grid-connected centralized PV systems started, one each in Wakkanai City of Hokkaido Prefecture and Hokuto City of Yamanashi Prefecture. Both of the systems started a partial operation, which contributed to increasing introduction volume of grid-connected centralized type PV systems. Under this project, total capacity will be 5 MW in Wakkanai City, and 2 MW in Hokuto City.

Utilities are also supporting dissemination of PV systems through purchasing excess electricity, management of Green Power Fund and implementation of quota under RPS Law.

2.3 Major projects, demonstration and field test programs

Main field test and dissemination programs implemented in FY 2007 were "Field Test Project on New Photovoltaic Power Generation Technology", "Project for Promoting the Local Introduction of New Energy", "Project for Supporting New Energy Operators" and "Eco-School Promotion Pilot Model Project" (See also Table 1 in Annex C). In addition, support for disseminating PV system and model projects of introduction of PV system under the countermeasures for CO₂ reduction are implemented by the Ministry of the Environment (MoE).

(1) Field Test Project on New Photovoltaic Power Generation Technology

This field test program started in FY 2003 as a successor program of Field Test Project on Photovoltaic Power Generation Systems for Industrial and Other Applications, aiming at adopting new technologies into PV systems for public and industrial facilities and accelerating further development. The object of the program is to promote further introduction of middle- and large-scale PV systems, improve the performance and reduce the cost by adopting new technologies. Under the FY 2007 program, four system types are defined as the models adopting new technologies as follows: 1) PV system with new type modules (next generation PV modules with solar cells using new materials and new type PV modules with improved functions and performance, total generation capacity: 10 kW and more); 2) PV system with building material integrated (BIPV) modules (BIPV modules such as roof-integrated, wall-integrated PV modules, etc., which have function of building materials, total generation capacity: 4 kW and more (from FY 2006, previously 10 kW or more)); 3) PV system with new control system (PV system with storage equipment and PV system adopting balance of system (BOS) with improved performance and functions compared to the conventional ones, total generation capacity: 10kW and more) and 4) PV system aiming at higher efficiency (PV system with higher system efficiency by improving components, design and installation method by modifying conventional PV systems, total generation capacity: 10kW and more).

Eligible applicants for the projects are private businesses, local authorities and organizations. As co-researchers, they collect performance data of the PV system for 4 years and demonstrate the performance of the PV system. 50% of the installation cost is subsidized.

Under the Field Test, 148 PV systems totaling 4 480 kW were installed in FY 2003, 262 PV systems totaling 7 161 kW in FY 2004, 435 PV systems totaling 11 608 kW in FY 2005, and 661 PV systems totaling 21 420 kW in FY 2006.

In FY 2007, total 457 PV systems accounting for 17 449 kW were installed. The numbers of projects by type of PV system are: 8 for new type modules (125 kW in total), 19 for BIPV modules (374 kW in total), 7 for new control system (270 kW in total) and 423 for higher efficiency (16 680 kW in total). This project will be continued until FY 2010. Cumulative installed capacity of PV systems introduced by these Field Test Programs between FY 1992 and FY 2007 is expected to exceed 88 700 kW.

(2) Project for Promoting the Local Introduction of New Energy

This project aims at accelerating new energy introduction by supporting the regional projects established by local governments for introduction of new energy and nonprofit projects for introducing new energy systems by nonprofit organizations (NPOs). The project was started in FY 1997.

Eligible new and renewable energies are PV power generation, wind power generation, use of solar thermal energy, differential temperature energy, natural gas co-generation, fuel cells, biomass power generation, thermal utilization of biomass, biomass-derived fuel production, thermal utilization of ice and snow, clean energy vehicles, small- and medium-sized hydroelectric power generation and geothermal power generation. Although the term of subsidy is one year in principle, the recipients of subsidy under this program are allowed to install the system up to 4 years, so that new energy system can be introduced in multi-fiscal years, depending on the process of the project. PV systems with 10 kW output and over are eligible for the subsidy. Up to half or one third of system installation cost is subsidized for the project of new energy introduction, depending upon the status of each case. For PV systems, the lower amount of half or one third of installation cost or 340 000 JPY or 220 000 JPY will be applied. Also, fixed amount (up to 20 MJPY for multi-fiscal year and 5 MJPY for single fiscal year) is subsidized to the projects for enlightenment and introduction activities.

Recipients of the subsidy are required to report the utilization status of the system such as generated electricity for at least 4 years after the start of the full-scale operation of the system.

In FY 2007, 119 projects were newly selected. Among them, 49 PV systems (945 kW in total) were subsidized and installed at city halls, water treatment plants, primary and junior high schools,

kindergartens and so on. The accumulated capacity of PV systems installed and to be installed from FY 1998 to FY 2010 will be 24 623 kW by 310 PV systems in total.

(3) Project for Supporting New Energy Operators

This project started from 1997 with the aim of accelerating new energy introduction by supporting the businesses who introduce new energy such as PV power generation, wind power generation, utilization of solar thermal energy, differential temperature energy, natural gas co-generation, fuel cells, thermal utilization of ice and snow, biomass power generation, thermal utilization of biomass, biomass-derived fuel production, small- and medium-sized hydraulic power generation, thermal power generation, etc. from the viewpoint of energy security and global environmental protection. Among these new and renewable energies, output capacity of eligible PV system is designated as 50 kW or more. In case of multiple installations of different types of energy, PV system with 10 kW or more capacity is also eligible.

Eligibles for the subsidy or the guaranteed debt are private businesses that set about new energy introduction. Maximum one third of the system installation cost is subsidized (maximum subsidy for a PV system is 1 billion JPY) and 90% of the debt is guaranteed. The term of a subsidized project is maximum 4 years.

Between FY 1998 and FY 2006, 385 projects were newly selected. Among them, 14 PV projects, totaling 986 MW were approved. While PV systems were mainly introduced to factories under the Project, some PV systems were installed at all-electrified condominiums.

(4) Eco-school Promotion Pilot Model Project

This project was initiated in FY 1997 through the partnership between METI and the Ministry of Education, Culture, Sports, Science and Technology (MEXT). In FY 2002, Agriculture, Forestry and Fisheries Ministry (MAFF) joined the partnership, followed by the Ministry of the Environment (MoE) in FY 2005.

The project aims at implementing pilot model projects to promote introduction and demonstration of environmental-friendly schools, providing students with environmental education and improving school facilities.

Eligible projects are 1) PV power generation, 2) utilization of solar thermal energy, 3) new energy utilization including wind power generation, geothermal energy and fuel cells, 4) energy conservation and resource saving, 5) symbiosis with nature (greening of buildings), 6) utilization of wood building materials, 7) recycling of resources and 8) others (natural lighting and ventilation).

The MEXT provides the fixed amount of subsidy for investigation of basic planning, half of cost for new construction of the school and one third of cost for rebuilding or retrofitting of school buildings. In case of PV system installation at the time of new construction and renovation of schools, METI's subsidies described above will be applied.

688 schools were selected as eco-school between FY 1998 and FY 2007. Total 439 schools were approved to install PV systems; 51 schools in FY 2007, 45 in FY 2006, 59 in FY 2005, 53 in FY 2004, 68 in FY 2003, 49 in FY 2002, 38 in FY 2001, 36 in FY 2000, 16 in FY 1999, 11 in FY 1998, and 13 in FY 1997.

(5) PV support programs implemented by the Ministry of the Environment

Besides various PV support programs implemented by METI, The Ministry of Environment (MoE) is promoting PV support programs and model projects under the projects for CO_2 emission reduction, mainly supported by the special account for energy measures. MoE established a plan of "Solar Promotion Program", a package of programs for introduction of PV system in 2005 and officially started full-implementation of the program from FY 2006.

The major subprograms for dissemination of PV system under "Solar Promotion Program" are 1) Town-wide CO_2 20% reduction projects (2 projects were selected in FY 2006 and PV power generation was introduced in one project), 2) Model project for shared use of MW-scale solar (3 sites were selected for 3-year PV installation projects in FY 2006. Total 3 MW of PV systems will be installed), 3) Model project for advanced introduction of renewable energy (2 model regional projects for CO₂ reduction were selected in FY 2005 (1 050 kW of PV systems were installed), new 2 projects are selected in FY 2006 (100 kW in total)) (PV systems with the capacity of 50 kW or more are eligible), 4) Project of environment-friendly renovation of schools (10 schools were selected in FY 2005, and 6 schools were selected in FY 2006), 5) Solar mileage club project (for dissemination and enlightenment for PV-related activities and provision of information on a community level) and 6) Project for pioneering introduction of PV system by local governments (total 38 projects and 2 027 kW between FY 2003 and FY 2006).

"Solar Promotion Program" additionally included the research on CDM/JI commercialization through dissemination programs including PV power generation and moved into to the 2nd stage. MoE, to make these projects more effective, will integrate some of the projects by purpose of business and scheme with a view to reestablishing a framework through t the new business.

In addition, MoE implements "A Community Model Project of a Virtuous Circle for Environment and Economy" aiming at achieving city planning including introduction of PV system, developed by local communities. Under this program, 3-year projects are supported. The numbers of selected projects so far are 10 in FY 2004, 10 in FY 2005 and 1 in FY 2006, 7 in FY 2007, 28 in total.

2.4 Highlights of R&D

In the end of FY 2005 (March, 2006), 3 R&D projects; "Development of Advanced Solar Cells and Modules", "Development of PV System Technology for Mass Deployment" and "Investigation for Innovative Photovoltaic Power Generation Technology", conducted under "5-Year Plan for Photovoltaic Power Generation Technology Research and Development (FY 2001 – FY 2005)" by New Energy and Industrial Technology Development Organization (NEDO) were completed. In FY 2006, new "4-Year Plan for Photovoltaic Power Generation Technology Research and Development (FY 2006 - FY 2009)" was launched, based on a roadmap for technological development of the PV system, "PV Roadmap toward 2030 (PV2030)". Under the 4-Year Plan, 2 new projects, "R&D for Next Generation PV systems" and "PV System Technology for Mass Deployment, Phase II" were started as successive projects. In addition, "PV systems Advanced Practical Technology" to be completed in FY 2007 was continued during 2006. As for new demonstrative research projects a couple of new 5-year projects, "Verification of Grid Stabilization with Large-Scale PV Power Generation System" and "Development of an Electric Energy Storage System for Grid-connection with New Energy Resources", started in 2006. "Demonstrative Project on Grid-Interconnection of Clustered Photovoltaic Power Generation Systems" and "Demonstrative Project of Regional Power Grids with Various New Energies" were also continued in 2006.

R&D for Next Generation PV systems aims at establishing elemental technologies to achieve the target PV power generation cost set in PV2030: 14 JPY/kWh for 2020, 7 JPY/kWh for 2030. Based on the outcome of the previous project, "Development of Advanced Solar Cells and Modules" that finished in the end of FY 2005, development of 5 types of technologies and search for new seed technologies started in August 2006. The project covers following 5 technologies.

1) Technological development of high-performance thin-film CIS solar cells: main research topics are development of low temperature process of CIS solar cell with light-weight substrate and development of wide-bandgap material. The target conversion efficiency has 3 categories: 18% for sub-module (10 cm x 10 cm), 16% for larger sub-module (30 cm x 30 cm) and 16% for sub-module using light-weight substrate (10 cm x 10 cm).

2) Development of highly-efficient and high-productivity thin film Si solar cells: major results are large area and high-speed deposition process of of μ c-Si films (4 m²), high-quality wide-gap materials, narrow-gap materials and tandem solar cell. Targets are to achieve at least 15% of conversion efficiency with PV modules and to establish the process with > 2,5 nm/s of film deposition rate.

3) Development of low-cost dye-sensitized solar cells (DSCs): major research issues are new

dyes, tandem cell structure, and module process technology for high durability. Targets are 15% of conversion efficiency for small-sized cell and 8% for PV module (30 cm x 30 cm).

4) Development of next generation ultra-thin crystalline silicon solar cells: improvement of quality of multicrystalline silicon ingots, development of slicing technology of ultra-thin wafers and development of high-performance solar cell process using ultra-thin wafers are conducted to achieve 18% of conversion efficiency for 100-µm thick multicrystalline solar cell.

5) Development of organic thin-film solar cell: research for organic thin-film semiconducting materials for solar cell and devices using them are promoted aiming at 7% of conversion efficiency for small-sized cell (1 cm x 1 cm).

As for seed technology search, fundamental research for ultra-high performance solar cell and other technologies was started to achieve higher performance, further cost reduction and improvement in durability.

Development of PV System Technology for Mass Deployment, Phase II is a successor program of Development of PV System Technology for Mass Deployment (FY 2001 - FY 2005), aiming at developing technological infrastructure for extensive application and mass deployment of PV systems. Projects under this program started in June 2006. Projects to develop evaluation technologies for performance and reliability of PV cell/ module and electricity output were continued. In addition, as environmental technologies for manufacturing process of PV system and disposal of used PV modules, life cycle assessment (LCA) and development of recycling technology of solar cell are conducted.

PV systems Advanced Practical Technology is a 3-year program started to support industrial technology aiming at practical application of the results of R&D so far. In 2006, the middle year of the 3-year plan, following technological development were conducted: recycling technology of silicon feedstock for solar cell, manufacturing technology of spherical silicon solar cells, high-performance inverter and autonomous PV system technology.

Verification of Grid Stabilization with Large-Scale PV Power Generation System was newly started for development of PV system-related technologies. It aims at constructing MW-scale PV power plants, establishing stabilization technologies of output power for the MW-scale PV power plants and verifying effectiveness and usefulness of the developed technologies. The final goal of this research is verifying the technologies to make the business using future MW-scale PV power plants feasible. A 5-MW scale project in Wakkanai City of Hokkaido Prefecture and a 2-MW scale project in Hokuto City of Yamanashi Prefecture were selected and construction was launched in both sites.

Development of an Electric Energy Storage System for Grid-connection with New Energy Resources aims at developing high-performance, low cost storage systems with longer operating time for large-scale energy system including MW-scale PV power plants. In 2006, 11 subprojects on lithium secondary batteries and other batteries and storage system started.

Demonstrative Project on Grid-Interconnection of Clustered Photovoltaic Power Generation Systems aims at developing general purpose technologies to resolve restraint of power generation and influence to the grid caused by intensively and massively installed grid-connected PV systems with storage batteries. The specific research objectives are 1) development of technology to avoid restriction of PV system output by using storage batteries, 2) analysis and evaluation of higher harmonics, 3) analysis and evaluation of devices for mis-actuation function to prevent islanding operation, 4) development of applied simulations and 5) evaluation of characteristics of power generation and economical efficiency. Installation of 550 residential PV systems with storage batteries in the testing site (residential estate) in Ohta City of Gunma Prefecture was completed by the beginning of FY 2006. Operation test and evaluation of output control, evaluation of new devices for mis-actuation function to prevent islanding operation function to prevent islanding operation and so on were conducted. This project will be completed in FY 2007.

Demonstrative Project of Regional Power Grids with Various New Energies is conducted to intensively install various types of distributed power sources such as PV systems, fuel cells and wind power generators, etc. in one area, aiming at demonstrating various issues: ensuring quality of electricity, balance between supply and demand of electricity, stability, and studying economical

performance of distributed power sources. In FY 2003, 3 demonstrative sites were selected across the country: Aichi Prefecture (total 2 225 kW of distributed power generation systems including PV systems totaling 330 kW), Aomori Prefecture (total 714 kW of distributed power generation systems including an 80-kW PV system) and Kyoto Prefecture (total 850 kW of distributed power generation systems including a 50-kW PV system). Demonstrative operation of the power generation systems was started in FY 2005 and operation was continued in FY 2006. The power generation systems installed in the premises of the 2005 World Exposition (EXPO 2005), Aichi, Japan, were relocated to Central Japan Airport City in Tokoname City of Aichi Prefecture and the demonstrative research was resumed from August 2006. This research will be completed in FY 2007.

2.5 Public budgets for market stimulation, demonstration/field test programs and R&D

The FY 2007 budgets for PV systems are mainly based on the national budgets on R&D, demonstration programs and market incentives. The budget for R&D was allocated to "R&D for Next Generation PV systems", "PV System Technology for Mass Deployment, Phase II" and "PV systems Advanced Practical Technology", etc. The budget for demonstration was allocated for "Field Test Project on New Photovoltaic Power Generation Technology", "Verification of Grid Stabilization with Large-Scale PV Power Generation System" and "International Cooperative Demonstration Projects on PV Power Generation System". Installation of PV system is implemented under "Field Test Project on New Photovoltaic Power Generation System".

As for the budget for market initiatives, METI's "Residential PV system Dissemination Program" was completed and current major initiative is "Solar Promotion Program" by the Ministry of Environment (MoE). Moreover, PV systems can be installed using the budgets for introduction of new energy such as "Project for Promoting the Local Introduction of New Energy", "Project for Supporting New Energy Operators" and "Demonstrative Project of Regional Power Grids with Various New Energies". However, as these budgets include other new energies, they are not included in Table 3. Other ministries and agencies such as the Ministry of Land, Infrastructure and Transport (MLIT) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) are also promoting introduction of PV system, but the budget amounts are unknown.

The budgets of local governments are complementarily appropriated for market incentives, mainly for residential PV system. The number of local governments having complementary budgets is 344 in FY 2007. The amount of subsidy varies by municipalities (e.g. approximately 20 000 JPY/kW to 100 000 JPY/kW), and the total amount is unknown.

| | 2005 | | | 2006 | | | 2007 | | | |
|---------------------------------|------|------------------------|--------|------|------------------------|--------|------|------------------------|--------|--|
| | R&D | Demo/ Field Test | Market | R&D | Demo/ Field Test | Market | R&D | Demo/ Field Test | Market | |
| National ¹ (BJPY) | 4,1 | 10,59 | 2,6 | 3,17 | 13,6 | 4,145 | 4,58 | 14,6 | 4,8 | |
| Regional ² (BJPY) | - | - | NA | - | - | NA | - | - | NA | |

Table 3 Public budgets (in National Currency) for R&D, demonstration/ field test programmes and market incentives

¹: The figures in Table 3 shows budgets of METI and MoE. The budgets of other ministries and government agencies except METI are unknown.

²: 344 Municipalities are implementing additional subsidy program on residential PV systems.

3 Industry and growth

3.1 Production of silicon feedstock, ingot and wafer for solar cells

In Japan, 3 companies manufacture polycrystalline silicon (semiconductor grade) for the feedstock for solar cell: 1) Tokuyama (production capacity: 5 200 t/year), 2) Mitsubishi Materials (former Mitsubishi Materials Polycrystalline Silicon production capacity: 1 650 t/year) and 3) OSAKA Titanium technologies (former Sumitomo Titanium) production capacity: 1 300 t/year). Production volume of polycrystalline silicon for solar cell in 2007 was 1 200 t in total (Tokuyama: 1 000 t, Mitsubishi Materials: 200 t). In addition, several manufacturers conducted research and development (R&D) of solar grade silicon (SoG-Si): Tokuyama with vapor to liquid deposition (VLD) process, Chisso with Zn reduction process, Nippon Steel, etc.

Tokuyama has been conducting demonstration of VLD process using a 200-t/year pilot plant and announced enhancement of production capacity of the plant using conventional Siemens process, from 5 200 t/year to 8 200 t/year by 2009.

Chisso jointly established a new company, "Japan Solar Silicon (JSS)" with Nippon Mining Holdings and Toho Titanium in 2007, currently promoting joint development of SoG-Si aiming at commercialization of its Zn reduction process.

Nippon Steel established a manufacturing company "NS Solar Material" and started mass production with production capacity of 480 t/year. JFE Steel started production of silicon feedstock for solar cell with production capacity of 100 t/year and also decided to increase the capacity to 400 t/year. M.Setek started operation of polysilicon manufacturing plant and entered into the business of manufacturing polysilicon for solar cell.

M.Setek, SUMCO (former Mitsubishi Sumitomo Silicon) and JFE Steel are manufacturing Si ingots and wafers for solar cells. SUMCO decided to increase production of silicon ingot which has been produced at its subsidiary SUMCO Solar with electromagnetic casting process, at the headquarters plant. SUMCO plans add 300 MW/year production capacity to achieve total production capacity of 400 MW/year, aiming at expanding production to 1GW/year level after 2011. JEMCO, one of Mitsubishi Materials' group companies, decided to increase production of pillar-type crystalline silicon for solar cells around FY 2010. Space Energy and Shin-Etsu Film manufacture Si wafers for solar cells from purchased Si ingots. Besides these manufacturers, Kyocera manufactures Si ingots and wafers at its own manufacturing facilities.

With a dramatic expansion of the global demand for solar cell, an increasing number of companies are entering into manufacturing of Si ingots and wafers for solar cells. Thickness of Si wafers for solar cell has been rapidly reduced and the wafer with thickness of around 200 μ m has become the standard size. In addition to these trends, Clean Venture 21 started commercialization of spherical solar cell with lower silicon consumption unit.

Table 4 shows overview of manufactures of silicon feedstock, ingot and wafer for solar cell in 2007. Table 4a shows the process of each manufacturer. Table 4b shows process and technology of silicon ingot and wafer for solar cell. Table 4c shows new developments and products and Table 4d shows the expansion plan of the manufacturing capacity.

Table 4 Production and production capacity information for silicon feedstock, ingot and wafer manufacturers (2007)

| Manufacturer | Process & technology ¹ | Total Production | Maximum production capacity | Product destination |
|---|---|-------------------------------------|--|---------------------|
| Tokuyama Polycrystalline silicon for solar cell (Siemens process) | | ca. 1 000 t | 5 200 t/yr (including feedstock for semiconductor) | N.A. |
| Mitsubishi Materials | Polycrystalline silicon for solar cell (Siemens process) | 200 t | 200 t/yr ² | N.A. |
| | polysilicon | 191 t | | N.A. |
| M.Setek | sc-Si ingot (CZ process) | 1 029 t | 1 300 t/yr | N.A. |
| | sc-Si wafer | 88 MW | 150 MW/yr | N.A. |
| JFE Steel | Cast mc-Si ingot (Directional solidification process) | 1 000 t (Based on raw materials) | 1 500 t/yr | N.A. |
| | mc-Si wafer | 70 MW | 160 MW/yr | N.A. |
| SUMCO | sc-Si ingot ³ | ca. 150 t | - | N.A. |
| SUMCO | mc-Si wafer | 80 MW | ca. 100 MW/yr | N.A. |
| | Cast mc-Si ingot | 400 t | 700 t/yr | N.A. |
| Shin-Etsu Film | mc-Si wafer | 150 MW | 250 MW/yr | N.A. |
| Space Energy | sc-Si ingot⁴ | 53 t | 55 t | N.A. |
| Space Energy | sc-Si wafer | 60 MW | 60 MW/yr | N.A. |
| Kyocera | mc-Si wafer | NA | NA | In-house use |

¹: mc: multicrystalline, sc: single crystalline ²: Maximum capacity is 1 650 t including diversion of polysilicon for semiconductor

³: Capacity of sc-Si ingot for solar cell is influenced by the market status of Si for semiconductor

⁴: Excluded production by equity method affiliates (as of the end of September 2007)

| Manufacturer | Process & technology |
|----------------------|--|
| Tokuyama | - Polysilicon manufacturing using Siemens process |
| Mitsubishi Materials | - MG Silicon (98%) \rightarrow Siemens process \rightarrow High-purity Polysilicon |
| M.Setek | - Si feedstock (in-house production and purchased from the outside) → sc-Si ingot (CZ process ¹)→ sc-Si wafer |
| JFE Steel | - Si feedstock (purchased from the outside) → cast mc-Si ingot (directional solidification process) → mc-Si wafer |
| SUMCO | Si feedstock (purchased from the outside) → cast mc-Si ingot → mc-Si wafer |
| Shin-Etsu Film | Si feedstock (purchased from the outside) → cast mc-Si ingot (electromagnetic casting) → mc-Si wafer |
| Space Energy | sc-Si ingot (purchased from the outside) → sc-Si ingot (CZ process) → sc-Si wafer |
| Kyocera | - Si feedstock (purchased from the outside) $ ightarrow$ mc-Si wafer |

 Table 4a
 Process and technology for feedstock, ingot and wafer manufacturers (2007)

¹: Czochralski process

| Manufacturer | Product | Specification | | |
|---|-------------------------|--|--|--|
| Tokuyama | Polycrystalline silicon | N.A. | | |
| Mitsubishi Materials Polycrystalline silicon | | depends on agreement with each user | | |
| M Sotok | sc-Si wafer (P-type) | 125 mm x 125 mm, 0,5 - 2,0 Ωcm, 235 μm | | |
| WI.Selek | sc-Si wafer (N-type) | 125 mm x 125 mm, 0,5 - 3,0 Ωcm, 190 μm | | |
| IEE Stool | mc-Si ingot (P-type) | 850 mm x 850 mm, 1,0 Ωcm, max 250 mm | | |
| JFE Sleel | mc-Si wafer (P-type) | 180 µm | | |
| SUMCO mc-Si wafer | | 156 mm x 156 mm, 0,5 - 5,0 Ωcm, 180 - 220 µm | | |
| | mc-Si ingot (P-type) | 0,5 - 6,0 Ωcm, life time ≥ 5 µsec | | |
| Shin-Etsu Film | mc-Si wafer (P-type) | 156 mm x 156 mm, 0,5 - 6,0 Ωcm, 200 μm | | |
| | mc-Si wafer (P-type) | 125 - 126 mm x 125 - 126 mm, 0,5 - 6,0 Ωcm, 200 μm | | |
| | | 100 mm x 100 mm, 3,0 - 6,0 Ωcm, 200 μm | | |
| | Bture | 125 mm x 125 mm, 3,0 - 6,0 Ωcm, 200 μm | | |
| | г-туре | 125 mm x 125 mm, 0,5 - 3,0 Ωcm, 200 - 220 μm | | |
| Space Energy | | 150 mm x 150 mm, 0,5 - 2,0 Ωcm, 200 μm | | |
| | N type | 100 mm x 100 mm, 3,0 - 6,0 Ωcm, 200 μm | | |
| | м-туре | 125 mm x 125 mm, 3,0 - 6,0 Ωcm, 170 - 200 μm | | |

 Table 4b
 Specification of the products for feedstock, ingot and wafer Manufacturers (2007)

| - | |
|----------------------|--|
| Manufacturer | New product/ new development |
| Tokuyama | Conducting demonstration of VLD process to manufacture polysilicon |
| Mitsubishi Materials | - Nothing to report |
| M.Setek | - Polysilicon for solar cell |
| JFE Steel | - Nothing to report |
| SUMCO | - Nothing to report |
| Shin-Etsu Film | - Nothing to report |
| Space Energy | - Nothing to report |

Table 4c New products or new development of silicon feedstock, ingot and wafer manufacturers (2007)

| Manufacturer | Process & Technology | Production capacity in 2007 | Production capacity in 2008 | Production capacity from 2009 onwards |
|-------------------------|---|---|--------------------------------|--|
| Tokuyama | Silicon feedstock | 5 200 t/yr (including Si for semiconductor) | | 3 000 t/yr by the middle of 2009 (for semiconductor and solar cell) |
| Mitsubishi Materials | Polycrystalline silicon ¹ | 1 650 t/yr (including Si for semiconductor) | | 2 800 t/yr by 2010 (increase is mostly for semiconductor) |
| | sc-Si ingot | 1 300 t/yr | 2 400 t/yr | 3 000 t/yr |
| M.Setek | sc-Si wafer | 150 MW/yr | 336 MW/yr | 440 MW/yr (2009) |
| | Polysilicon | - | 3 000 t | 6 000 t (2010) |
| JFE Steel | mc-Si ingot | 1 500 t/yr | 1 500 t/yr | Not yet determined |
| | mc-Si wafer | 160 MW/yr | 160 MW/yr | Not yet determined |
| | sc-Si ingot ¹ | - | | |
| SUMCO | mc-Si wafer | ca. 100 MW/yr | | 400 MW/yr (2012) |
| Ohia Etau Eila | mc-Si ingot | 700 t/yr | | 1 000 t/yr (2010) |
| Shin-Eisu Film | mc-Si wafer | 250 MW/yr | 350 MW/yr | |
| | sc-Si ingot ² | 55 t/yr | | 500 t/yr (2009) |
| Space Energy | sc-Si wafer | 60 MW/yr | 230 MW/yr | |
| | Single crystalline cell | - | 3,5~7 MW/yr | |

Table 4dPlans for expansion of manufacturing capacity for silicon feedstock, ingot and wafer
manufacturers (2007)

¹: Excluded production by equity method affiliates (as of the end of September 2007)

3.2 Production of photovoltaic cells and modules

In 2007, 11 companies were listed as PV cell/ module manufacturers: Sharp, Kyocera, Sanyo Electric, Mitsubishi Electric (MELCO), Kaneka, Mitsubishi Heavy Industries (MHI), Hitachi, Fuji Electric Systems, Honda Motor, Showa Shell Sekiyu and Clean Venture 21. Among them, Hitachi manufactures bifacial silicon solar cell. Fuji Electric manufactures flexible a-Si PV modules while Honda Motor and Showa Shell Sekiyu manufacture CIGS PV modules. Clean Venture 21 manufactures spherical Si PV modules. Honda Motor established "Honda Soltec", which started production of PV modules at its Kumamoto Plant. Showa Shell Sekiyu started production at its 20-MW/year plant for CIGS solar cell in Miyazaki Prefecture and decided to construct No.2 plant with 60 MW/year capacity. As for module manufacturers, MSK is specialized in manufacturing PV modules. In 2006, MSK was acquired by Suntech Power Holdings, a major solar cell/ module manufacturers in China. Another manufacturer specialized in PV module, "YOCASOL" was established in 2007 through employment buyout (EBO). Former employees of MSK's Fukuoka Plant bought out the Plant to establish YOCASOL. Fujipream also manufactures PV module with its own technology such as double-glass light-through PV modules.

In 2007, production volume of solar cell in Japan decreased from the previous year, affected by the shortage of silicon feedstock.

Table 5 shows production and production capacity information on solar cell and PV module manufacturers. Table 5a shows PV module production processes of manufacturers in Japan. Table 5b shows PV module production processes of the manufacturers in Japan. Table 5c shows the technical data of typical modules for residential and power uses, which are typical in Japan. Table 5d shows the present status of PV module certification of module manufacturers. Table 5e shows new developments and products of PV cell and module manufacturers in Japan. Table 5f shows plans for future expansion in PV cell/ module production capacity. Table 6 shows typical module prices for residential use.

| Cell/Module | Technology ¹ | Total Produ | ction (MW) | Maximum production capacity (MW/year) | | |
|--------------------------------------|---------------------------|-------------|------------|--|------------------|--|
| manufacturer | | Cell | Module | Cell | Module | |
| Silicon wafer based manufacturers | | | | | | |
| Sharp | sc-Si | 146 | NA | 695 | NA | |
| Sharp | mc-Si | 196 | NA | 095 | NA | |
| Kyocera | mc-Si | 207 | 207 | 240 | 240 | |
| Sanyo Electric | a-Si/sc-Si (HIT) | 160 | -2 | 260 | 260 ³ | |
| Mitsubishi Electric | mc-Si | 121 | 121 | 141 | 141 | |
| Hitachi | sc-Si | 4 | 0,02 | 10 | 5 | |
| Clean Venture 21 | spherical Si | 0,02 | - | 1 | - | |
| Showa Shell Sekiyu | mc-Si | - | _4 | | | |
| MOK | sc-Si | - | 1,95 | - | 36,5 | |
| IVISK | mc-Si | - | 2,72 | - | 36,5 | |
| Fuji Pream | mc-Si | - | - | - | 12 | |
| Thin film manufacturers | | | | | | |
| Sharp | a-Si | 21 | 21 | 15 | 15 | |
| Sanyo Electric | a-Si⁵ | 5 | 5 | 5 | 5 | |
| Kaneka | a-Si a-Si/µc-Si hybrid | 45 | 45 | 55 | 55 | |
| Mitsubishi Heavy | a-Si | 12 | 12 | 15 | 15 | |
| Industries (MHI) | a-Si/µc-Si Tandem | 1 | 1 | 10 | 10 | |
| Fuji Electric Systems | a-Si | 1,15 | 1,15 | 12 | 12 | |
| Showa Shell Sekiyu | CIS | 3,0 | 3,0 | 20 | 20 | |
| Honda Motor ⁶ | CIGS | 0,7 | 0,7 | 27,5 | 27,5 | |
| MSK | a-Si | - | 0,26 | - | 0,27 | |
| Total | 922,87 | 421,8 | 1 506,5 | 897,7 | | |

Table 5 Production and production capacity information on each module manufacturer (2007)

¹: mc: multicrystalline, sc: single crystalline, a: amorphous, µc: microcrystalline

²: Production breakdown of module in- or outside of Japan is not available

³: Production capacity in Japan: 95MW/year, overseas: 165 MW/year

⁴: all the production volume of a-Si (5MW) is for application

⁵: About 4 MW of mc-Si PV module was purchased from outside

⁶: Production volume is reported by a subsidiary Honda Soltec (from October to December 2007)

| Cell/module manufacturer | Description of main steps in production process |
|--------------------------------------|---|
| Sharp | Purchase of sc-Si wafer → sc-Si cells → Modules Purchase of Si feedstock → sc-Si wafer → sc-Si Cells → Modules Purchase of mc-Si wafer → mc-Si cells → Modules Purchase of Si feedstock → mc-Si wafer → mc-Si Cells → Modules Purchase of gas → cells → modules |
| Kyocera | - Purchase of Si feedstock \rightarrow mc-Si wafer \rightarrow mc-Si cells \rightarrow Modules |
| Sanyo Electric | - Purchase of Si feedstock → sc-Si wafer → HIT cells → Modules |
| Mitsubishi Electric (MELCO) | - Purchase of mc-Si wafer \rightarrow mc-Si cells \rightarrow Modules |
| Hitachi | - Purchase of sc-Si wafer \rightarrow sc-Si cells \rightarrow Modules |
| Clean Venture 21 | Purchase of spherical Si feedstock → spherical Si solar cell → light-collecting spherical Si solar cell |
| MSK | - Purchase of mc-Si, sc-Si cells and a-Si cell $ ightarrow$ Modules |
| Fujipream | Cell inspection \rightarrow tab installation \rightarrow string \rightarrow lamination \rightarrow frame/terminal box installation \rightarrow measurement of module \rightarrow packaging |
| Showa Shell Sekiyu | - Integrated production : Glass substrate $ ightarrow$ forming CIS layer $ ightarrow$ module |
| Thin-film manufacturers | |
| Kaneka | - Purchase glass substrate \rightarrow forming a-Si layer \rightarrow module |
| Mitsubishi Heavy Industries (MHI) | Purchase of glass substrate → TCO process → formation of a-Si (a-Si/µSi) layer → back contact formation → PV module → packaging and shipment |
| Fuji Electric Systems | - Purchase of SiH ₄ \rightarrow film-based cell \rightarrow module |
| Honda Motor | - Metal material (Cu, In, Ga) + Se gas \rightarrow CIGS substrate \rightarrow module |

 Table 5b
 PV module production processes of manufacturers (2007)

| | | Typical m | odule da | | | | | |
|------------------------|------------------------|--------------------|--------------------|-----------------|--------------|------------|---------------------|--------------|
| Module Manufacturer | Cell technolo gy | W x L x D (mm) | Weig ht (kg) | Pma x (W) | Vop (V) | lop (A) | Residen tial use | Power use |
| | mc-Si | 1 165 × 990 × 46 | 14,5 | 153 | 20,30 | 7,54 | | \checkmark |
| | mc-Si | 1 200 × 802 × 46 | 12,5 | 132 | 26,40 | 5,00 | | \checkmark |
| | mc-Si | 1 165 × 990 × 46 | 14,5 | 142 | 19,92 | 7,13 | | \checkmark |
| | mc-Si | 1 200 × 802 × 46 | 9,9 | 100 | 20,38 | 4,91 | | \checkmark |
| | mc-Si | 1 512 × 330 × 34,9 | 8,8 | 52,5 | 10,70 | 4,91 | | |
| Sharp | mc-Si | 1 535 × 280 × 29.7 | 7.8 | 52.5 | 10.70 | 4.91 | | |
| [- | mc-Si | 1 640 × 994× 46 | 21.0 | 200 | 28.42 | 7 04 | | |
| | mc-Si | 1 323 × 1 004 × 46 | 16.5 | 167 | 22.98 | 7,01 | | |
| | a-Si | 1 129 ~ 929 ~ /6 | 19.0 | 90 | 19 30 | 1.83 | | N |
| | a-0i | 1 180,085 , 14 | 20.0 | 50 | 49,50 | 1,00 | | v |
| | | 1 100 005 07 | 39,0 | 50 | - | - | | |
| | a-01 | 1 180 × 985 × 27 | 63,0 | 58 | - | - | 1 | |
| Kyocera | mc-Si | 1 286 × 1 008 × 36 | 15,5 | 180 | 29,4 | 8,21 | V | 1 |
| | | 1 425 × 990 × 36 | 18,5 | 200 | 33,3 | 8,31 | | N |
| | | 1 319 × 894 × 35 | 14,0 | 200 | 55,8 60,0 | 3,59 | N | N |
| Sanyo Electric | нт | 1 424 × 894 × 35 | 15,0 | 210 | 41 3 | 5.09 | N N | |
| | a-Si | 1 370 × 012 × 03 | 10,0 | 210 | -1,0 | 0,00 | v | Y |
| | mc-Si | 1 271 × 827 × 37 | 13.0 | 134 | 19,4 | 6,91 | \checkmark | \checkmark |
| | mc-Si | 1 248 × 803 × 46 | 12,5 | 134 | 19,4 | 6,91 | \checkmark | \checkmark |
| Mitsubishi Electric | mc-Si | 1 657× 858 × 46 | 17,0 | 185 | 24,6 | 7,52 | \checkmark | \checkmark |
| (MELCO) | mc-Si | 1 658 × 834 × 46 | 17,0 | 190 | 24,7 | 7,71 | \checkmark | \checkmark |
| | mc-Si | 1 495 × 674 × 46 | 13,5 | 130 | 17,4 | 7,47 | \checkmark | \checkmark |
| | mc-Si | 1 338× 539 × 40 | 8,5 | 75 | 11,4 | 6,56 | \checkmark | \checkmark |
| | sc-Si | 868 × 1 120 × 9 | 19 | 102 | 22,3 | 4,6 | | \checkmark |
| Hitachi 1 | | 1010 001 5 | | 82 | 22,7 | 3,6 | | |
| | sc-Si | (max 40) | 16 | 125 | 42,5 42 3 | 5,2 4 0 | | \checkmark |
| | sc-Si | 903 × 930.1 × 33 | 10 | 85 | 18.8 | 4.54 | V | |
| | sc-Si | 1 262 × 327 × 49 | 5.8 | 42 | 8.7 | 4.85 | V | |
| MSK | a-Si (Hybrid) | 930 × 520 × 37,5 | 7,3 | 37,5 | 100 | 0,375 | 1 | |
| | a-Si | 950 × 980 × 10,5 | 23 | 38 | 58,6 | 0,648 | | \checkmark |
| Fujipream | mc-Si | 960 × 1 280 × 35 | 14,5 | 155 | 6,71 | 23,1 | \checkmark | \checkmark |
| | mc-Si | 827 × 1 271 × 37 | 13 | 134 | 19,4 | 6,9 | \checkmark | \checkmark |
| Showa Shall Sakiya | mc-Si | 1 012 × 1 290 × 36 | 16,5 | 175 | 23,6 | 7,4 | \checkmark | \checkmark |
| Showa Sheli Sekiyu | mc-Si ² | | | | | | | |
| | CIS | 641 × 1 235 × 35 | 12,4 | 70 | 37,6 | 1,9 | \checkmark | \checkmark |

Table 5c PV modules for residential and power uses (2007)(1/2)

¹: Upper line: surface, lower line: rear face ² : Mainly custom-made

| Modulo | | Posidontial | Power | | | | | |
|--------------------------------------|--------------------------|------------------------------|-------------------------|------------------------|------------------------|-------|--------------|--------------|
| Manufacturer | Cell technology | Weight (kg) | P _{max} (W) | V _{op} (V) | I _{op} (A) | USe | use | |
| Thin-film manufacturers | | | | | | | | |
| | a-Si | 960 × 990 × 40 | 13,7 | 60 | 67 | 0,90 | \checkmark | \checkmark |
| Kaneka | a-Si | 1 210 × 1 008 × 40 | 18,3 | 75 | 91,8 | 1,40 | \checkmark | \checkmark |
| | HB ¹ | $918 \times 350 \times 34^2$ | 4,6 | 17,5 | 97,2 | 0,181 | \checkmark | |
| | HB | 950 × 465 × 38 | 5,9 | 36,5 | 48,6 | 0,751 | \checkmark | \checkmark |
| Mitoubichi Hooyu | a-Si | 1 141 × 1 414 × 35 | 21 | 100 | 108 | 0,93 | \checkmark | \checkmark |
| Mitsubishi Heavy Industries (MHI) | a-Si∕ µc-Si tandem | 1 141 × 1 414 × 35 | 21 | 130 | 101 | 1,29 | \checkmark | V |
| Fuji Electric | a-Si | 525 × 3 885 × 15 | 15,7 | 92 | 319 | 0,288 | | \checkmark |
| Systems | a-Si | 460 × 3 399 × 1 | 1,57 | 92 | 319 | 0,288 | | \checkmark |
| Handa Mater | CIGS | 791× 1 417 × 37 | 14,3 | 125 | 280 | 0,66 | \checkmark | |
| Honda Motor | CIGS | 791× 1 417 × 37 | 14,3 | 115 | 278 | 0,64 | \checkmark | |

Table 5c PV modules for residential and power uses (2007) (2/2)

¹ : a-Si / poly-Si hybrid ² : working dimensions: 918 mm × 280 mm

| Module manufacturer | Certification of modules | Certification of plant |
|--------------------------------------|--|---|
| Sharp | IEC 61215 (VDE、JET, TÜV) IEC 61646 (JET) IEC 61730-1,-2 (VDE, JET, TÜV) UL1703 (UL) TÜV Safety Class II (TÜV) | IEC 61215 (VDE、JET、TÜV) ¹ IEC 61646 (JET) ² IEC 61730-1,-2 (VDE, JET, TÜV) ISO 9000-2000 (JACO) ISO 14001 (JACO) UL1703 (UL) |
| Kyocera | IEC 61215 IEC 61730 ISO 9000 UL 1703 | IEC 61215 IEC 61730 ISO 9000 UL 1703 |
| Mitsubishi Electric (MELCO) | IEC 61215 UL 1703 TÜV Safety Class II JET PVm | ISO 9000 ISO 14001 |
| Sanyo Electric | IEC 61215 (HIT module) ISO 9000 (HIT module) UL 1703 (HIT module) TÜV Safety Class II (HIT module) IEC 61730 (HIT)(HIT module) | IEC 61215 (HIT module) ISO 9000 (HIT module) UL 1703 (HIT module) TÜV Safety Class II (HIT module) IEC 61730 (HIT module) |
| Hitachi | IEC 61215 (JET PVm, sc-Si module) | IEC 61215 (JET PVm, sc-Si module) |
| Clean Venture 21 ³ | IEC 61215 (to be certified in 2008) | IEC 61215 (to be certified in 2008) |
| Showa Shell Sekiyu | IEC 61646 (CIS module certification) JET (CIS module certification) | |
| MSK | IEC 61215 IEC 61646 UL 1703 TÜV Spec TZE/2.57 2.09 | ISO 9000 (ISO 9001 for headquarters and Nagano Plant) |
| Fujipream | IEC 61215 application in progress | IEC 61215 application in progress |
| Thin film manufacturers | | |
| Kaneka | IEC 61215 IEC 61646 ISO 9000 UL 1703 TÜV Safety Class II JISC8991 | |
| Mitsubishi Heavy Industries (MHI) | IEC 61646 (JET, TÜV) | ISO 9000 |
| Fuji Electric Systems | IEC 61646 VDE certification in progress | |
| Honda Motor | IEC 61646 (to be certified in 2009 combined with 61730) ISO 9000 (to be certified in 2009) | IEC 61646 (to be certified in 2009 combined with 61730) ISO 9000 (to be certified in 2009) |

| Table 5d | Present status of certification of module manufacturers | (2007) |
|----------|---|--------|
|----------|---|--------|

¹: Accredited by factory qualification by JET and TÜV, factory QA system is not included in IEC 61215
 ²: Accredited by factory qualification by JET, factory QA system is not included in IEC 61215
 ³: Business partner, Fujipream is to be qualified in 2007

| Table 5e | New developments and | products of manufacturers | (2007)(1/2) |
|----------|----------------------|---------------------------|--------------|
| | new acveropments and | products of manufacturers | (2007) (1/2) |

| Cell/Module | New developments an new products |
|-----------------------------------|---|
| Sharp | - [2007/07/17] Started sales of solar LED light "LN-LW3A1/LN-LS2A1" - [2007/04/27] Certified with Eco mark for all models of power conditioners for PV power generation equipped with colored electricity-monitoring system - [2007/01/24] Successfully developed a mass production technology of triple junction thin-film PV module - [2007/01/09] Certified with Eco mark as the first-certified power conditioner for PV power generation |
| Kyocera | Developed high-efficiency back contact solar cell (self-measured conversion efficiency: 18,5 %) |
| Sanyo Electric | Commercialized 210 W PV module using 104 pieces of HIT cell (104 mm x 104 mm) for domestic market Certified with Eco mark by Japan Environment Association for all models of PV modules and power conditioners for residential PV system for domestic market Achieved 22,3% of conversion efficiency of HIT solar cell (100 cm²) on laboratory level |
| Mitsubishi Electric (MELCO) | Achieved the world's highest¹ conversion efficiency² of 18,0 %³ (1,2 points higher than MELCO's existing products) with multicrystalline Si solar cell in a practical size (150 mm x 150 mm), through its own production process including low reflection of light-collecting surface (press release on May 31, 2007) As of May 31, 2007, investigated by MELCO Efficiency to convert optical energy of sunlight into electric energy (direct current) Confirmation results by Advanced Industrial Science and Technology (AIST), a public organization to certify conversion efficiency Launched "large-output PV module with lead-free soldering" for overseas markets on July 1, 2007 Achieved maximum module output of 190 W and launched 16 new models of "large-output PV modules with lead-free soldering" for overseas markets, including a model with improved durability against snow Launched "MX series" PV modules for domestic and residential use (press release on July 25, 2007) Achieved the industry's largest¹ output/module of 185 W for domestic use and launched 4 models of "MX series" PV modules for domestic and residential use, including a model which is durable against accumulated snow of 1,5 m and can be installed in regions with heavy snow². As of May 14, 2007, for nominal (authorized?) maximum output/module for domestic and residential use (for multicrystalline Si type on mass production level) |
| Hitachi | Improvement of output of bifacial PV cell Commercialized of single-glass PV module |
| Clean Venture 21 | Development of fixed light-collecting spherical solar cell Development of a mass production technology for spherical silicon spheres Establishment of a high-speed mass production technology for fixed light-collecting spherical solar cell |
| MSK | Roof material-integrated PV module for European markets Light-through module (crystalline laminated glass module) |
| Fujipream | Development of PV - storage hybrid system Development of a standard module for building material-integrated solar cells Development of HSP module |

| Table 5e | New develor | oments and | products o | of manufacturers | (2007) | (2/2) |
|----------|-------------|------------|------------|------------------|--------|-----------|
| | | | producto c | i manalaota ci S | (2001) | (- / - / |

| Cell/Module manufacturer | New developments an new products |
|---|--|
| Showa Shell Sekiyu | - PV system using CIS modules |
| Kaneka | - 12 % hybrid type solar cell - Large-scale amorphous type solar cell (module size: 1 210 mm × 1 008 mm × 40 mm) |
| Mitsubishi Heavy Industries (MHI) | Commercialization of a-Si/µc-Si tandem solar cell Thin-film Si solar cell with conversion efficiency ca. 1,5 times higher than a-Si solar cell, by placing amorphous Si as a top layer and µc-Si as a bottom layer (tandem structure) |
| Fuji Electric | - Development of steel plate-integrated solar cell (92 MW for domestic use, mass-produced at Kumamoto Plant) |
| Systems | - Development of film-type solar cell (92 MW for European markets, mass-produced at Kumamoto Plant) - Development of mass production technology for film-type large-scale solar cell |

| Manufacturer | Production capacity in 2007 (MW/yr) | Production capacity in 2008 (MW/yr) | Production capacity from 2009 onwards | Technology |
|---|--|--|--|----------------------------------|
| Silicon wafer based manufacturers | | | | |
| Sharp | 695 | Not announced | | mc-Si、sc-Si |
| Kyocera | 240 | | 500 MW/yr (by 2010) | mc-Si |
| Sanyo Electric | 260 | 350 | | mc-Si |
| Mitsubishi Electric (MELCO) | 150 | | 220 MW/yr | mc-Si |
| Hitachi | 10 | - | - | sc-Si |
| Clean Venture 21 | 1 | 15 | 90 MW/yr (by 2010) | Light-collecting spherical Si |
| MSK | 100 | | | mc-Si |
| (module only) | | | | a-Si |
| Fujipream (module only) | 12 | | 24 MW/yr (by 2009) | mc-Si |
| Thin film manufacturers | | | | |
| Sharp | 15 | 160 (by October) | 1 GW/yr (by March 2010) | a-Si |
| Sanyo | 5 ¹ | | | a-SI |
| Showa Shell Sekiyu ² | 20 (authorized capacity) | 20 (authorized capacity) | Start of 60-MW operation in 2009 Total 80 MW by the end of 2009 | CIS |
| Kaneka | 55 | 70 | | a-Si, a-Si/poly-Si hybrid |
| | 10 | 28 | | a-Si |
| Mitsubishi Heavy Industries (MHI) | 15 | | 100 MW/yr (by 2009) | a-Si/µc-Si tandem |
| Fuji Electric Systems | 12 | | 40 MW/yr (by 2009) | a-Si |
| Honda Motor | 27,5 | - | - | CIGS |

 Table 5f
 Plans for future expansion of production capacity

¹: For consumer products
 ²: Started manufacturing by a wholly-owned subsidiary, "Showa Shell Solar" in July 2007

| Year | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Price | 966 | 950 | 927 | 764 | 646 | 652 | 674 | 598 | 542 | 481 | 462 | 451 | 441 | 428 | 433 | 436 |

Table 6 Trends of typical module prices (JPY/W) for residential use

3.3 Manufacturers and supplies of other components

While several dozen companies manufacture inverters (power conditioners), over 10 companies manufacture inverters for PV systems in Japan. Most of them are PV manufacturers, manufacturers of power supply systems, electric appliances, electric components and general electric machines. 8 residential PV inverter manufacturers are registered to the voluntary certification program of Japan Electrical Safety and Environment Technology Laboratories (JET): Sharp, Sanyo Electric, Mitsubishi Electric (MELCO), Omron, GS Yuasa, Sanyo HVAC, Delta Electronics and Matsushita Electric Works Electric Control Equipment & Systems. Delta Electronics is the first non-Japanese manufacturer registered in the JET certification program. The capacity of commercialized inverters in distributed in the market ranges from 1,5 to 5,5 kW, mainly 3 kW, 4 kW, 4,5 kW and 5,5 kW. Standardization, mass production, size and weight reduction of inverters including islanding prevention system integrated into them for residential PV systems have been promoted as well as miniaturization and weight saving.

10 - 2 000 kW PV systems have been installed for public and industrial facilities. As NEDO promoted standardization of 10-kW inverters under the Field Test Project on Photovoltaic Power Generation Systems for Industrial and Other Applications and Field Test Project for Public Facilities, a large number of 10-kW inverters are supplied for this application area. 10-kW inverters are also accredited by JET, and four companies, GS Yuasa, Sanyo Denki, Mitsubishi Electric (MELCO) and Sanken Electric are registered. As under the Field Test Project on New Photovoltaic Power Generation Technology, capacity of the inverters is not specified, standardization of 100-kW scale inverters is advancing for larger PV systems. Sharp, GS Yuasa, Sanyo Denki, Meidensha, Matsushita Electric Industrial, etc. entered this area. Generally, 10-kW inverters are connected in parallel for PV installations ranging 10 to 100 kW. However, due to price reduction of 100-kW inverters, installation of 100-kW unit inverters is on the rise for PV systems with the capacity of 100 kW or more. Meidensha newly brought a 250-kW inverter onto the market, which started to be adopted for MW-level PV systems. In addition, recently, monitoring and control functions of inverters as well as parallel operation function and measurement function for PV system for public and industrial uses have been reinforced for PV system with larger capacity

In near future, PV system will be installed with storage batteries having longer lifetime, which has been developed recently, as PV systems can be installed network with improved autonomy using micro-grid or PV systems can correspond to linearization of electric load.

In Japan, currently, installations of stand-alone PV systems remain much less common than that of grid-connected PV systems, so that standardization of stand-alone system is less advanced. If micro-grid with storage batteries is realized along with further price reduction of solar cells, it is expected that standardization of inverters and storage batteries for those applications will be promoted.

Table 6a shows the prices of inverters sold for grid-connected PV application.

| Size of inverter | Average price per kVA in 2005 (JPY) | Average price per kVA in 2006 (JPY) | Average price per kVA in 2007 (JPY) |
|------------------|--|--|--|
| 10 - 100 kVA | 100 000 | 96 500 | 96 500 |
| > 100 kVA | 100 000 | 93 000 | 88 000 |

 Table 6a
 Price of inverter for grid-connected PV applications

3.4 System prices

Table 7 shows typical applications the price of PV systems by category. Table 7a shows the trends in system prices since 1993. The standardization of grid-connected systems has progressed with the growth of the PV market (mainly residential PV system market) in Japan, and the prices have been reduced. 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.

| Turnkey Prices of typical applications (2007) | | | | | | |
|---|---|--------------------------|--|--|--|--|
| Category / Size | Typical applications | Typical price (JPY/W) | | | | |
| Off-grid ¹ up to 1 kW | Telecommunications, lighting, traffic and road signs, ventilating fans, pumps, remote monitoring, navigation signs, clock towers, etc. | case by case | | | | |
| Off-grid > 1 kW | Agricultural facilities, communication facilities, disaster prevention facilities, mountain cottages, park facilities, remote area housing, lighthouses, etc. | case by case | | | | |
| Grid-connected up to 10 kW | Residences, park facilities, small public facilities, etc. | 696 JPY/W | | | | |
| Grid-connected | Plants, warehouses, commercial buildings, large-scale public facilities, road facilities, railway | 640 JPY/W | | | | |

| Table 7 | Turnkey Prices | of typical | applications | (2007) |
|---------|----------------|------------|--------------|--------|
|---------|----------------|------------|--------------|--------|

: Prices do not include recurring charges after installation such as battery replacement or operation and maintenance

Table 7a Trends in PV system prices (JPY/W)

facilities, etc.

| Year | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|
| Public & Industrial (>10 kW) | 3 400 | 2 800 | 2 400 | 1 500 | 1 300 | 1 190 | 1 040 | 1 010 | 850 | 840 | 770 | 770 | 732 | 802 | 640 |
| Residential (3 - 5 kW) | 3 500 | 1 920 | 1 510 | 1 090 | 1 062 | 1 074 | 939 | 844 | 758 | 710 | 690 | 675 | 661 | 683 | 696 |

3.5 Labor places

> 10 kW

Estimated labor places are as follows;

- a) Research and development (not including companies): about 500
- b) Manufacturing of PV systems components, including company R&D: about 6 500
- c) All other, including within electricity companies, sales and installation companies etc.: about 11 000

3.6 Business value

Table 8 shows business value of the domestic market of PV systems.

| Year | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|-------------------|------|------|------|------|------|------|------|------|------|
| Business value | 76,5 | 84,9 | 110 | 150 | 170 | 200 | 215 | 205 | 150 |

Table 8 Business value of PV system market (billion Yen)

4 Framework for deployment (Non-technical factors)

4.1 Support measures and new initiatives

a) Support measures

Table 9 shows measures and schemes for dissemination of PV system implemented in 2007.

| | Ongoing measures implemented by | Measures that commenced in 2007 |
|---------------------------------------|---|---|
| Enhanced feed-in tariffs | - | - |
| Direct subsidy | - 344 local governments | - |
| Green Power schemes | - Utilities (Green Power Fund, all over Japan) | - |
| PV-specific green electricity schemes | - | _ |
| Renewables Portfolio Standards (RPS) | - National government | Target amount of renewables usage was revised in 2007 to 16 billion kWh by FY 2014 Measures to double-count the amount of electricity generated by PV system were introduced |
| PV requirements in RPS | - | - |
| Funds for investment in PV | - | - |
| Tax credits | National Corporate bodies or individuals to introduce PV system (100 kW or more) are eligible for 3-year reduction of property tax (7/8) Individuals who apply blue return as well as corporate bodies are eligible for special deduction (7 %) or special depreciation (max. 30 %) | - |
| Net metering | - | - |
| Net billing | Voluntary purchase program for excess electricity by utilities (all over Japan) | - |
| Commercial bank activities | Low-interest loan Introduction of PV systems to company-owned buildings | - |
| Electricity utility activities | Voluntary buyback system for excess electricity by utilities (all over Japan) Introduction of PV systems to public and welfare facilities by Green Power Fund Introduction of PV systems for in-house use | - |
| Sustainable building requirements | - | - |

Table 9: PV support measures in 2007

While the Ministry of Economy, Trade and Industry (METI) continued following support programs: "Field Test Project on New Photovoltaic Power Generation Technology", "Project for Promoting the Local Introduction of New Energy", and "Project for Supporting New Energy Operators". METI did not start new initiatives in FY 2007.

The Ministry of the Environment (MoE) continued "Solar Promotion Program", a package of several projects to advance countermeasures against global warming through introduction of PV systems, and is currently implementing "A Community Model Project of a Virtuous Circle for Environment and Economy" for taking advantage of PV systems.

b) New plan of PV system introduction

METI will enhance and expand introduction of PV systems in non-residential facilities such as public, commercial and industrial facilities, where dissemination of PV systems has not been advanced compared to the residential market, utilizing "Field Test Project on New Photovoltaic Power Generation Technology". So far, the project has been applicable for PV systems with capacity of 10 kW or more, whereas in FY 2008, the project will also cover PV systems with capacity of 4 kW or more for new module type, building material-integrated type and new control method type, in order to promote introduction of PV systems by private businesses and various types of organizations. Starting in FY 2008, projects for smaller-sized multiple connection PV systems with capacity of 3 kW or less will also be covered, with a view to promoting installation of PV systems at collective housing.

In FY 2006, METI started a project for demonstrative researches of a 5-MW PV plant in Wakkanai City of Hokkaido Prefecture and a 2-MW in Hokuto City of Yamanashi Prefecture, in the aim of validating technologies to deal with the peak demand as well as measures to stabilize grid connection of large-scale PV systems for power supply. In FY 2007, construction started at these two plants, part of which started operation.

The Ministry of the Environment (MoE) will introduce 1-MW scale PV system each in Saku City of Nagano Prefecture, lida City of Nagano Prefecture and Konan City of Kouchi Prefecture, respectively, as part of activities under Model project for shared use of megawatt solar under its Solar Promotion Program. Installation of these PV systems started in FY 2006, which will be advanced over several years, step by step. Each City will introduce the PV system into public, commercial and industrial facilities for power generation.

In addition, the Ministry of Land, Infrastructure and Transport (MLIT) continues to promote introduction of PV systems following "the Guidelines for Planning Environmentally-Friendly Government Building (Green Government Office Buildings)".

c) Utilities' perception of PV

Electric utilities has been supporting deployment of the PV system through 1) net billing system for surplus electricity generated by the PV system, 2) management of Green Power Fund, and 3) compliance of the Law on Special Measures Concerning New Energy Use by Electric Utilities (Renewables Portfolio Standard Law, RPS Law (Renewables Portfolio Standard Law (RPS Law)).

Electric power companies have consistently continued the net billing since 1992, and buying back surplus electricity generated by PV from their customers at the selling price of electricity across the country on a voluntary basis. Other initiatives, such as green pricing, rate-based incentives have not been studied in Japan. During FY 2006 (April 2006 to March 2007), the electric power companies purchased surplus PV electricity of 654,7 TWh. The volume of surplus electricity purchased by electric companies has been increasing year by year.

Moreover, the utilities introduced "Green Power Fund" to promote utilization of natural energy in October 2000. Electric power companies contribute to the Fund the same amount as the total sum collected on the basis of 500 JPY/month per share from their customers who support the purpose of "Green Power Fund". The Fund is utilized to introduce PV and wind power plants. By the end of FY 2006, 752 PV systems, 15 112 kW in total were installed mainly at public facilities such as schools and hospitals by Green Power Fund. In FY 2007, 122 projects, 1 716,9 kW in total were granted.

Electric utilities had achieved to purchase required amounts of electricity generated from new and renewable energy designated in FY 2003, under the Renewable Portfolio Standard (RPS) Law that was enforced from the same year. They archived the quota set by RPS in FY 2006 and

enhanced actions to expand usage of new energy to achieve the required purchase amounts in FY 2007. Usage volume of electricity generated by new energy by utilities in FY 2006 was 6 507 TWh in total, including 541 TWh from PV power generation. The accredited facilities for power generation using new energy under the RPS Law was 333 898 systems totaling 4 756 MW as of March 2007. Among them, PV systems are 332 852, accounting for 1 232 MW of generation capacity.

Hokkaido Electric Power Co., Inc. (HEPCO) started a demonstrative research of a 5-MW large-scale PV system. Electric Power Development Co., Ltd (J-POWER) started operation of a 1-MW PV plant in Kyushu region. These PV systems prove that large-scale PV plants have been promoted and utilized for practical applications in Japan. Kansai Electric Power Co., Inc. (KEPCO) also has a plan to construct a large-scale PV plant.

d) Changes in public perceptions of PV

Public perception of PV and awareness for introduction of PV system in Japan is getting more positive through active initiatives of PV introduction and promotion, as well as publicities via media such as television and newspapers year by year. Although the government-backed "Residential PV System Dissemination Program" ended in FY 2005, introduction of the residential PV system has continued without subsidies.

Furthermore, willingness to contribute to the environment by businesses is increasing. An increasing number of businesses such as Aeon group and Sagawa Express are facilitating systematic introduction of PV systems through "Field Test Project on New Photovoltaic Power Generation".

e) Local governments, businesses and others

Local governments have been taking an initiative in dissemination of residential PV system with their own support schemes for expanding dissemination. More local governments are formulating their own support schemes, such as subsidy according to the excess electricity output amount and green power certificate for electricity from PV systems for home consumption, in addition to subsidy according to installed volume (subsidy/kW).

Housing manufacturers, building material manufacturers, construction companies and power supply equipment manufacturers promote to develop products using PV systems, enhance their sales and began to play a role in PV deployment. In addition, local electric equipment stores, home electric appliances stores, building contractors, roofers, etc. promote sales and installation of PV systems for local communities, and the distribution chain of residential PV systems, from solar cell manufacturers to the end uses is established.

PV systems for public and commercial facilities are introduced mainly with the support of "Field Test Project on New Photovoltaic Power Generation". Introduction of PV systems is expanding among private businesses.

The government's effort for further introduction of new and renewable energy started to penetrate into the whole industries in Japan, and movement to recognize PV business as a future business opportunity is expanding. For dissemination and expansion of PV systems, it is necessary to incubate PV system integrators.

4.2 Indirect policy issues

a) International policies influencing the use of PV systems

In 2005, the government established the Kyoto Protocol Target Achievement Plan to fulfill the greenhouse gas reduction target designated by the Kyoto Protocol. Among the actions and the measures, the Plan recognizes that PV and wind power generation and biomass, etc. significantly contribute to measures against global warming and improvement of self-sufficiency ratio of energy supply. In addition, it is mentioned that microgrid utilizing PV and wind power generation, biomass, fuel cells and other types of new and renewable energy will be introduced to promote implementation, technological development and demonstration of advanced model projects, in order to facilitate multifaceted introduction of new and renewable energy and secure the flexibility

of energy.

In 2007, the Ministry of the Environment and the Ministry of Economy, Trade and Industry (METI) reviewed the Kyoto Protocol Target Achievement Plan, focusing on promotion of new and renewable energy as one of the major additional measures.

The national government approved the execution plan for measures against global warming at the Cabinet meeting. In the aim of reducing greenhouse gas emissions as an average of three years between FY 2010 and FY 2012 by 8 % from that of FY 2001, it was stipulated that energy conservation and introduction of new and renewable energy will be facilitated through such measures as introduction of PV systems and planting trees at office buildings of local governments. Headquarters to promote measures against global warming reported that PV systems with total capacity of 6 500 kW are expected to be introduced between FY 2010 and FY 2012 under the national government's plan to reduce greenhouse gas emissions.

The national government's headquarters to promote measures against global warming confirmed the initiatives to reduce greenhouse gas emissions including the followings: 1) installation of PV systems and green-planting on the rooftop of all the government office buildings applicable for introduction, 2) promotion of national campaigns mainly for commercial and residential sectors in which CO_2 emissions are expected to grow. Over 6 years up to FY 2012, the government decided to install PV systems which are effective for reducing CO_2 emissions and plant trees at government office buildings across the nation for the area of 1 000 m² or more, in principle. Furthermore, the government proposed a new long-term target to tackle global warming by "reducing the global greenhouse gas emissions by 50 % by 2050 from the current level". To achieve this target, the government announced "Cool Earth - Energy Innovative Technology Plan" and selected 20 themes for innovative technological development, on which the government places significant emphasis. One of the 20 selected themes is "innovative PV power generation", which aims to improve conversion efficiency of solar cells to over 40 % from the current level of 10 - 15 % and reduce power generation cost of solar cells to 7 JPY/kWh from the current level of 46 JPY/kWh. The project will start in FY 2008.

b) Favorable environmental laws and regulations

The Ministry of Economy, Trade and Industry (METI) enforced "the Law Concerning the Use of New Energy by Electric Utilities (Renewable Portfolio Standard (RPS) Law)" in April 2003 as a new measure to promote further dissemination of new and renewable energy. The RPS Law obliges electric power companies to expand the use of electricity generated from new and renewable energy. The target minimum ratio of renewable energy usage in FY 2010 is 12 200 GWh, which accounts for 1,35% of net sales energy demand. In FY 2006, METI started to work out a new target ratio for 2014 and in FY 2007, added 950 million kWh to each year on top of the 12 200 GWh target, making the ultimate target of 16 000 GWh. Regarding the PV system, METI took special measures to double-count the electricity generated from PV as RPS electricity, by improving management of the system. This will strongly accelerate dissemination and expansion of the PV system.

The Ministry of Land, Infrastructure and Transport (MLIT) established "Guideline for Planning Environmentally-Friendly Government Building (Green Building)" and has been advancing construction of green government buildings equipped with PV systems for the national governmental facilities such as the local branch offices of the national government. In order to reduce environmental burdens through the life cycle of government facilities, MLIT announced "FY 2007 Action plan to save CO₂ at the national government's facilities", which covers measures on which the Ministry focuses its efforts. The plan includes active utilization of green technologies such as PV power generation and double-layer glasses to establish environment-friendly facilities.

The Ministry of the Environment (MoE) is promoting projects to reduce CO2 emissions by the use of natural energy under "Law Concerning the Promotion of Measures to Cope with Global Warming" enforced in FY 1998. In addition, it implemented "Law on Promotion of Green Purchasing" in April 2001, and commodities procured by the national and local governments have to be replaced by environmental-friendly products, and specified PV systems as one of the special procurement products.

c) Environmental Tax (CO₂ Tax)

The Ministry of the Environment is taking the initiative for studying introduction of Environmental Tax. In the Kyoto Protocol Target Achievement Plan which was approved at the Cabinet meeting in April 2005, the national government defines Environmental Tax as "a challenge that needs to be carefully and comprehensively studied" and continues study by the entire government along with the plan. However, in the basic guidelines for tax systems, under which introduction of tax systems is decided, MoE's proposal to establish the Environmental Tax in FY 2007 was put on the shelf. Nevertheless, the Environmental Tax is positioned as the issue with the highest priority, and will be studied comprehensively with due considerations of the relations with existing tax systems and other issues. Effects of introduction of the Environmental Tax on dissemination of PV systems are unknown at this moment.

d) National policies and programs to promote the use of PV in non-IEA PVPS countries

PV power generation is an effective energy technology to improve living standards in developing countries and reduce greenhouse gas emissions. It also has a potential to become a promising technology option for the mechanisms of Kyoto Protocol such as CDM (Clean Development Program), JI (Joint Implementation) and emissions trading. The national government promotes international cooperative activities to disseminate PV system in the world, especially in East Asian region in order to play an active role concerning global warming issues, improvement of living standards in developing countries and contribution to energy security overseas to curb energy consumption overseas.

In cooperation with developing countries which have natural conditions and social systems that are not seen in Japan, New Energy and Industrial Technology Development Organization (NEDO) implemented International Cooperative Demonstration Project Utilizing Photovoltaic Power Generation Systems in Thailand, China, Malaysia, Vietnam, Nepal, Mongolia, Myanmar, Cambodia and Laos, in order to develop technologies for practical use of PV systems and promote introduction and dissemination. In 2007, NEDO conducted a joint demonstrative project in China. In addition, NEDO started "International Cooperative Demonstration Project for Stabilized and Advanced Grid connection PV Systems" in FY 2006, which is an international demonstration and development program using PV power generation. Aiming at stable supply of electricity by microgrid with higher usage ratio of the PV system, joint demonstrative projects have been conducted in China, Thailand, Indonesia and Malaysia.

JICA, Japan International Cooperation Agency implements inter-governmental technological cooperation projects based on requests from developing countries. JICA supports developing master plans for rural electrification using PV power generation through the study of development for rural electrification. In 2007, JICA conducted a survey to study a master plan to use PV energy in Nigeria. In addition, JICA makes efforts to cultivate human resources through PV volunteer training programs and to improve the framework for introduction of PV system.

JBIC, Japan Bank for International Cooperation also supports rural electrification projects using PV in developing countries through loan financed projects under its guideline for implementing economic cooperation overseas (FY 2005 - FY 2007), focusing on "establishment of foundation for sustainable growth", "support for the global issues" and "support to reduce poverty".

Other than these projects, as one of the e8 (an organization consisting of 9 electric utilities from 7 countries of G8 excluding the U.K.) projects, Kansai Electric Power Co., Inc. (KEPCO) constructed a 40-kW PV plant in Tuvalu, an island nation in the South Pacific, and connected it to the electricity grid in 2007. Under the project, KEPCO is transferring knowhow for installation and operation of the PV system to Tuvalu Electric Corporation, who is in charge of managing the facility.

4.3 Standards and codes

- Standards

As for the standards regarding PV power generation, industrial associations for electric appliances, The Japan Electrical Manufacturers' Association (JEMA) and Optoelectronic Industry And Technology Development Association (OITDA) map out draft standards and submit them to Japanese Standards Association (JSA), by which the standards are formulated as JIS (Japanese Industrial Standards) Standards. a large number of standards are formulated according to the standardization framework listed in Table 10. Although the standards basically comply with the international standards by International Electrotechnical Commission (IEC), some of them reflect unique circumstances of Japan. Recently, vigorous efforts have been made to establish standards for the entire PV system.

- Certification system

Japan Electrical Safety & Environment Technology Laboratories (JET) started a certification program of PV modules, "JETPVm certification" in October 2003. This is equivalent to TÜV certification system which is conducted mainly in Europe, covering non-concentrator type PV modules for terrestrial installation or crystalline and thin-film PV modules aimed at sales. Certification is made through product model certification and annual investigation of plants. Labels will be issued for the products which satisfies the standard. For crystalline PV modules, performance tests will be conducted in compliance with JIS C8990 (2004) (IEC61215 Ed.1 1993), and IEC61215 Ed.2 (2005). Furthermore, the following safety standards were added in 2006:

- TS C8992-1 (2006) (IEC61730-1 Ed.1 2004): Certification of safety conformity of PV modules - Part 1: Structure requirements

- TS C8992-2 (2006) (IEC61730-2 Ed.1 2004): Certification of safety conformity of PV modules - Part 2: Testing requirements

JETPVm certification system has a framework for mutual certification with other countries. Therefore, it is possible to utilize it for import and export of PV modules. At the end of 2007, the number of certified PV modules from 20 manufacturers is 136 types (751 types if similar types are included) for crystalline silicon and 24 types (149 types if similar types are included) for thin-film.

JET conducts a certification program for the performance and reliability of grid connection protecting unit (inverter) for small-sized PV systems with 10 kW or less capacity to connect to low-voltage grid. This certification program aims at smooth "technological preliminary discussions" at the time of connection to electricity grid of utilities. Similar to certification of PV modules, product models are certified and production plants are confirmed and certification labels are issued for the products which satisfy the standards. Certification standards are based on "testing method of equipment for grid connection of PV systems" stipulated by JET. The standards are based on "Electricity Enterprises Law", as well as METI's "Ordinance to set technological standards on electrical facilities", "Interpretation of technological standards on electrical facilities", "Guideline of Grid Connection Requirement (an instruction issued by the chief of public utility department of Agency for Natural Resources and Energy (ANRE) of METI in August 1986, revised in March 1998)" and so on. As of the end of 2007, 42 types of power conditioners by 12 companies (160 types if similar types are included) are listed as certified products.

| | | Category | JIS No. | Title | Note |
|-------------------|--------------------------|---------------------------|---|---|--|
| terms and symbols | | nd symbols | C 0617 C 8960: 2004 | Graphical symbols for diagrams Glossary of terms for photovoltaic power generation (incl. solar cells) | |
| | | | C 8905; 1993 | General rules for stand-alone photovoltaic power generating system | Under |
| | | | C 8906; 2000 | Measuring procedure of photovoltaic system performance | 00000000 |
| System | | | - | Design guide on electrical safety of residential PV system (tentative) | JIS proposed |
| | | | - | Measuring method of output power for photovoltaic system (tentative) | JIS Final Draft TR ¹ Final |
| | | | - | Structural design and installation for residential photovoltaic array (roof | Draft JIS proposed |
| | | | - C 8953: 2006 | mount type) | |
| | | | C 8910:2001 | Primary reference solar cells | |
| | | reference | C 8911; 1998 revised | Secondary reference crystalline solar cells | |
| | - | Solar simulator | C 8912; 1998 revised | Solar simulators for crystalline solar cells and modules | |
| Solar Cell | | C 8913; 1998 revised | Measuring method of output power for crystalline solar cells | | |
| | Crystalline solar | C 8915; 1998 revised | Measuring method of output power for crystalline solar cells | | |
| | - | C 8920; 2005 | Measuring method of equivalent cell temperature for crystalline solar cells by the open-circuit voltage | | |
| | alline | | C 8918; 1998 revised | Crystalline solar PV modules | |
| Crysta | - | C 8916; 1998 revised | Temperature coefficient measuring methods of output voltage and output current for crystalline solar cells and modules | | |
| | | - crystalline_solar | C 8914; 1998 revised | Measuring method of output power for crystalline solar PV modules | |
| olar Cell | PV modules | C 8917; 1998 revised正 | Environmental and endurance test methods for crystalline solar PV modules | | |
| | | - | C 8919; 1995 | Outdoor measuring method of output power for crystalline solar cells and modules | |
| 0) | | - | C8990; 2004 | Crystalline silicon terrestrial photovoltaic (PV) modules Design qualification and type approval | |
| _ | | reference cell/ | C 8931; 1995 | Secondary reference amorphous solar cells | |
| | | module Solar simulator | C 8932; 1995 | Secondary reference amorphous solar submodules | |
| | | Solar simulator | C 8933; 1995 | Solar simulators for amorphous solar cells and modules | |
| | ar Ce | amorphous solar – cell | C 8936; 1995 | Measuring methods of spectral response for amorphous solar cells and modules | |
| | Sol | | C 8939; 1995 | Amorphous solar PV modules | |
| | snouc | - | C 8937; 1995 | Temperature coefficient measuring methods of output voltage and output current for amorphous solar cells and modules | |
| | nor | amourphous | C 8935; 1995 | Measuring method of output power for amorphous solar modules | |
| | Ar | solar cell C 8938; 1995 | | Environmental and endurance test methods for amorphous solar cell modules | |
| | | | C 8940; 1995 | Outdoor measuring method of output power for amorphous solar cells and modules | |
| | | | C8991; 2004 | Thin-film terrestrial photovoltaic (PV) modules Design qualification and type approval | |
| | | | C 8951; 1996 | General rules for photovoltaic array | Under discussion |
| | | | C 8952; 1996 | Indication of photovoltaic array performance | Under discussion |
| 0 | arra | ау | C 8956; 2004 | Structural design and installation for residential photovoltaic array (roof mount type) | |
| omp | | | C 8954; 2006 | On-site measurements of crystalline photovoltaic array I-V characteristics | |
| bone | | | C 8953; 2004 C 8953: 2006 | On-site measurements of crystalline photovoltaic array I-V characteristics | |
| ents | | | C 8980; 1997 | Power conditioner for small photovoltaic power generating system | Under discussion |
| | ром | ver conditioner | C 8961; 1993 | Measuring procedure of power conditioner efficiency for photovoltaic systems | Under discussion |
| | | | C 8962; 1997 | Testing procedure of power conditioner for small photovoltaic power generating systems | Under discussion |
| | | | C 8971; 1993 | Measuring procedure of residual capacity for lead acid battery in photovoltaic system | |
| lea | lead acid battery for PV | | C 8972; 1997 | Testing procedure of long discharge rate lead-acid batteries for photovoltaic systems | |

Table 10 Standardization System for PV System

¹: TR: Technical Report (standard information)

Source: The Japan Electrical Manufacturers' Association (JEMA)

5 Highlights & Prospects

5.1 Highlights

In 2007, while dissemination and expansion PV systems have been developing around the world, Japan's PV system market was not able to maintain the growth which it pursed in the past years. Year 2007 was a tough year for the Japanese PV industry as it wasn't able to secure sufficient amount of silicon feedstock, nor expand the domestic residential PV market, as it shifted to the commercial-based one. However, a number of sectors including national and local governments, the PV industry, utilities, distributors and users of PV system worked on dissemination of the PV system, in pursuit of establishing a framework for a full-fledged dissemination of the PV system.

On the national government level, based on the "New National Energy Strategy" mapped out in 2006, the Revised Basic Energy Plan, which shows a basic direction of energy policy, was decided at a Cabinet meeting. New and renewable energy is positioned as "a complementary energy for the time being, but will be promoted with measures to make it a part of energy resources on a long-term basis. To achieve this objective, the government stressed that it will strategically tackle the issues of cost reduction, stabilization of grid connection and improvement of performances through collaboration in technological development among business, academic and governmental circles. To expand introduction of new and renewable energy, the government also included the following issues to focus, depending on the level of market growth: 1) support for starting technological development and demonstration researches, 2) creation of initial demand (model projects, support for installation of facilities), 3) introduction with the government's initiative (installation by public organizations at their affiliated facilities), 4) measures for market expansion (legal measures including Special Measures Law on Promoting Use of New Energy, etc., by Electric Enterprises (RPS Law)), 5) creation of industrial structure (promotion of entry by venture businesses, fostering of peripheral and related industries), 6) promotion and improvement of dissemination environment (dissemination and enlightenment, public relations, provision of information). Ministry of Economy, Trade and Industry (METI) decided to revise Special Measures Law on Promoting Use of New Energy, etc., by Electric Enterprises (RPS Law), setting a target of using 16 billion kWh of new and renewable energy in FY 2014. The Ministry also decided to take a favorable measure for PV by doubling the count of RPS electricity generated from PV system. Ministry of the Environment (MoE) implemented "Model Project for a Virtuous Circle for the Environment and the Economy" for promoting the use of PV system, while continuing "Solar Promotion Program" for dissemination and expansion of PV system. Local governments not only continued subsidy for residential PV system but also made active efforts to expand introduction of PV system in unique ways such as the start of establishing measures for installation of 1 000 MW of solar energy by Tokyo Metropolitan Government.

Utilities continued to support dissemination of PV systems with programs to purchase surplus electricity and Green Power Fund. In addition, Hokkaido Electric Power Co., Inc. (HEPCO) started a demonstration research of a 5-MW large-scale PV system. In the PV industry, many activities were conducted to strengthen a group of PV-related industries including the followings: 1) Capacity expansion and new entries by material and wafer manufacturers, 2) large-scale production capacity increase and extension of overseas production sites, in addition to improvement of solar cell performance by solar cell manufacturers who entered into the PV industry earlier, 3) start of production and production capacity increase by new entrant thin-film solar cell manufacturers, 4) burgeoning of PV system integrators, 5) production capacity increase and new entrants in solar cell components, 6) emergence of solar cell manufacturing equipment manufacturers, who deal with full turnkey systems for solar cell production lines. As for distribution of the PV system, efforts have been made by key prefabricated housing makers to install the PV system as standard equipment of housing, in line with the movement towards reduction of CO₂ emissions and all electrification. Supported by the enhanced dissemination measures for public and industrial use by the national government, the range of PV system users expanded from local governments and industry to installations of large-scale PV systems over 100 kW.

5.2 Prospects

Ministry of Economy, Trade and Industry (METI) is showing remarkable movements towards further dissemination of new and renewable energy, once again. In preparation for G8 Hokkaido Toyako Summit, scheduled in July 2008 in Toyako Town, Hokkaido, METI is addressing a drastic enhancement of the nation's policy on new and renewable energy in order to actively hammer out the energy and environmental policy of Japan. METI established New energy planning office in the aim of strongly forging ahead with further dissemination of new and renewable energy, and six strategic working teams on new and renewable energy as follows: 1) working team for dissemination of green energy, 2) working team for promoting introduction of electricity from new and renewable energy, 3) working team for dissemination of biomass energy, 4) working team for dissemination of photovoltaic (PV) power generation, 5) working team for housing with energy conservation and new and renewable energy, 6) working team for international cooperation and development. The mission of the working teams for dissemination of PV power generation is to study new measures to promote PV power generation. It is expected that the team will create promotional measures to revitalize the sluggish Japanese PV market. All concerned parties in the PV sector must collaborate and interact with this movement to establish a robust Japanese model for PV dissemination. In addition, METI will formulate a plan for technological innovation of energy towards 2050, with a long-term strategy to achieve a solar cell conversion efficiency of 40 % to promote research and development (R&D). Ministry of the Environment (MoE) places a high importance on strengthening efforts to establish a low-carbon society based on "a strategy for becoming a leading environmental nation in 21st century", which was decided at the Cabinet meeting in June 2007. With this, MoE will facilitate measures against global warming in all sectors including commercial and domestic sectors, though subsidy for introduction of new and renewable energy including PV systems. While continuing to provide subsidy for the existing "Mega Solar PV" systems. MoE will provide subsidy to projects supporting introduction of PV system and other types of renewable energy to housing, implemented by local governments. Ministry of Land, Infrastructure and Transport (MLIT) will not only significantly expand establishment of green government office buildings with introduction of PV systems and other items but also support introduction of technologies to reduce CO₂ emissions at housing and buildings through establishment of "a mode project to promote saving CO2 emissions". Local governments represented by Tokyo Metropolitan Government and Aichi Prefecture will promote their own plans to introduce large-scale PV systems. Utilities started construction of MW-level PV plants, in addition to support for introduction of PV systems through Green Power Fund.

Meanwhile, it is assumed that the PV manufacturers will enhance their efforts for full-scale dissemination of PV Systems by working on 1) further cost reduction of the PV system, 2) detailed product development suitable for each application area, and 3) development of new application area, through technological development, enhancement of production capacity and collaboration with other industries using PV Systems. Thus, in addition to these efforts by the national government and industry, and with support from users of PV Systems, including other ministries, agencies, local authorities, private companies and individuals, further deployment of PV Systems in Japan will continue into the future.

Annex A Method and accuracy of data

The work was performed in collaboration with PV modules and BOS components manufacturers, housing manufacturers, government agencies running PV programs/projects. The data were collected by hearing and questionnaires.

As regards off-grid sector, some of these systems implement PV modules that have a capacity lower than 40 W. In this report they are included because it is very difficult to distinguish the application types and rated voltages.

The accuracy of data is $\pm 10\%$ for cumulative installed PV power, $\pm 10\%$ production and production capacity.

Annex B Country information

This information is simply to give the reader some background about the national environment in which PV is being deployed. It is not guaranteed to be 100 % accurate nor intended for analysis, and the reader should do their own research if they require more detailed data.

1) Retail electricity prices (NC) - household, commercial, public institution

Typical electricity price is the total of basic fees depending on contract size of ampere and the charge for the volume of usage.

| Household: | < 120 kWh/month: | 16,05 JPY/kWh |
|------------|----------------------|---|
| | 120 - 300 kWh/month: | 21,04 JPY/kWh |
| | > 300 kW/month: | 22,31 JPY/kWh (type B, typical ampere for general household: 10 - 60 A) |

Three-phase pricing system with prices varying depending on the volume of usage

(Source: Tokyo Electric Power Co., Inc. (TEPCO), April 1, 2007)

- Commercial: 12,00 JPY/kWh (summer), 10,90 JPY/kWh (other seasons) (high-voltage, business use) (Source: Tokyo Electric Power Co., Inc. (TEPCO), April 1, 2007)

- Industry, high-voltage, ≥ 500 kW : 10,69 JPY/kWh (summer), 9,72 JPY/kWh (other season)
- Industry, high-voltage, < 500 kW : 11,84 JPY/kWh (summer), 10,76 JPY/kWh (other season) (Source: Tokyo Electric Power Co., Inc. (TEPCO), April 1, 2007)
- 2) Typical household electricity consumption

304,7 kWh/month (2005 average)

(Source: The Japan Atomic Energy Relations Organization (JAERO), February2007)

- 3) Typical metering arrangements and tariff structures for electricity customers (for example, interval metering, time-of-use tariff)
 - Interval Metering (30 minutes)
 - Time-of-use tariff is available

(Source: websites of electric utilities)

- 4) Typical household income (NC)
 - 5 638 million JPY (2006)

(Source: The National Livelihood Survey, The Ministry of Health, Labour and Welfare)

- 5) Typical mortgage interest rate
 - 3,40 to 3,73 % (minimum rate and maximum rate from January to December 2007, standard) (Source: Japan Housing Finance Agency (former People's Finance Corporation))
- 6) Voltage (household, typical electricity distribution network)
 - Household: 100 V
 - Distribution network: single phase 3 lines 100/200 V

- 7) Electricity industry structure and ownership
 - All the utilities are investor-owned; generation, transmission and distribution are vertically integrated
 - Independent power producers (IPPs) also generate electricity
 - Electricity industry Regulator: Agency for Natural Resources and Energy (ANRE) of the Ministry of Economy, Trade and Industry (METI)
- 8) Retail price of diesel fuel (NC)
- High-octane gasoline: 140 167 JPY/litter (January to December 2007, including 5 % consumption tax)
- Regular gasoline: 129 156 JPY/litter (January to December 2007, including 5 % consumption tax)
- Diesel oil: 109 134 JPY/litter (January to December 2007, including 5 % consumption tax)

(Source: The Oil Information Center)

9) Typical values of kWh/kW for PV systems

1 000 to 1 100 kWh/kW/year

| Project name | Field Test Project | on New Photovoltaic Power Generation Techr | ology (2003 -) | | |
|---|--|--|--|-----------------------|--|
| Technical data/ Economic data | Objectives | Main accomplishments until the end of 2007/ problems and lessons learned | Funding | Project Management | Remarks |
| Grid connected (4 kW and over) Industrial facilities, such as factory and warehouse, public facilities such as government building, hospital and schools, commercial building such as restaurant. Eligible systems 1) PV system using New modules (≥ 4 kW) PV modules with improved functions compare to the conventional ones The next generation PV module using solar cell made from new material 2) PV system using building material (≥ 4 kW)integrated modules PV modules with functions as building material such as roofing materials 3) PV system using storage equipment aiming at disaster or peak cut PV system using BOS with improved function or performance compared to conventional ones such as snow melting function or string voltage adjustment function 4) the PV system aiming at higher efficiency (≥ 10 kW) PV system with improved efficiency by modifying the standard system with design, installation method and equipments | Collection and dissemination of operational data of middle and large scale PV system (≥ 4 kW) Cost reduction of PV systems for public and industrial facilities Standardization of those PV systems Demonstration of new type PV system, PV systems using new material and technologies | In 2007, 376 PV systems totaling 21 049 kW were installed in factories, ware houses, laboratories, commercial buildings, school, etc.: PV system using new modules: 53 cases (1 529 kW), PV system using BIPV modules: 18 cases (356.5 kW), PV system using new control system: 204 cases (16 556 kW), PV system aiming at higher efficiency: 101 cases (2 607 kW) 2003: 148 cases, 4 480 kW, installed 2004: 262 cases, 7 161 kW, installed 2005: 457 cases, 17 672 kW, installed 2006: 662 cases, 21 716 kW, installed 2006: 662 cases, 21 716 kW, installed Total installed capacity between FY 2003 and FY 2007 was 1 905 cases and 72 078 kW (number of selected cases for FY 2007) Industrial sector began to understand the value of introduction of PV system Cost of PV system for public and industrial facilities (≥ 10kW) reduced to 750 000 JPY/kW Better understanding of PV by local residents Diversification of PV systems using new technologies, materials and control system, etc. has been promoted | - ANRE, METI - Budget: 2003: 3 496 MJPY 2004: 5 026 MJPY 2005: 9 230 MJPY 2006: 11 800 MJPY 2007: 10 800 MJPY (NEDO budget: 7 860 MJPY for PV) | - NEDO | Total budget FY 2003 to FY 2007 was 37 400 MJPY. After FY 2007, implemented as part of Field Test Project on New Photovoltaic Power Generation (other than PV, high-level utilization of solar thermal heat, wind power generation, biomass thermal utilization are also covered) |

Annex C: Table 1: Summary of major projects, demonstration and field test programs (1/4)

| Project name | Project for Promoting the Local Introduction of New Energy (1997 -) | | | | |
|---|---|--|---|-----------------------|--|
| Technical data/ Economic data | Objectives | Main accomplishments until the end of 2007/ problems and lessons learned | Funding | Project Management | Remarks |
| New energy in general Eligible PV systems: grid-connected (10 kW and over) Subsidy for PV: lower amount of 50% or one third of installation cost or 340 000 JPY (or 220 000 JPY) Eligible: Local governments, Non-profit organizations, NPOs | Enhancement of promotion of new energy to public facilities Education and promotion of new energy to local inhabitants | 78 systems (9 995 kW) were installed in from 1998 to 2002. 70 PV systems (8 301 kW) out of 101 qualified systems in 2003. 45 PV systems (3 433 kW) out of 71 qualified systems in 2004. 33 PV systems (870 kW) out of 103 qualified systems in 2005. 35 PV systems (1 078,8 kW) out of 111 qualified systems in 2006. 49 PV systems (945,4 kW) out of 119 qualified systems in 2007. 310 PV systems totaling 24 623 kW will be installed during 1998 - 2010. Planned installation of multiple numbers of PV systems in local governmental offices, schools, libraries, water purification plants, kindergartens etc., which NPOs operate, can be implemented. Qualification of larger-scale PV systems with more than 100 kW output was started. | - ANRE, METI - Budget: 1997: 2 430 MJPY 1998: 4 379 MJPY 1999: 6 760 MJPY 2000: 6 430 MJPY 2001: 11 520 MJPY 2002: 12 720 MJPY 2003: 12 710 MJPY 2004: 11 031 MJPY 2005: 7 620 MJPY 2006: 5 181 MJPY 2007: 4 500 MJPY | - NEDO | Total budget from FY 1997 to FY 2007 is 85,227 BJPY |

Annex C: Table 1 Summary of major projects, demonstration and field test programs (2/4)

| Project name | Project for Supportin | g New Energy Operators (1997 -) | | | |
|---|---|---|--|--|---|
| Technical data/ Economic data | Objectives | Main accomplishments until the end of 2007/ problems and lessons learned | Funding | Project Management | Remarks |
| New energy in general Eligible PV systems: grid-connected (≥ 50 kW) (≥ 10 kW PV system is also eligible in case of multiple installation of renewable energy system) Subsidy: one third of installation cost or guaranteed debt | Support of private industries who introduce new energy Encouragement of introduction of new energy by private industries | 4 PV systems out of 155 qualified systems were installed in a commercial building (118 kW), a distribution center (100 kW) and a tourist hotel (25 kW) and an ironworks (140 kW) from 1997 to 2002. 2 PV systems out of 39 qualified systems were installed to a factory (200 kW) and a wind power plant (17 kW) in 2003. 3 PV systems out of 67 qualified systems was installed to a wind farm (10,8 kW), factories (70 kW) and a condominium building (66,5 kW) in 2004. 3 PV systems out of 90 qualified systems was installed to golf course (17 kW), wind farm (10,2 kW) and a condominium building for rent (53,38 kW) in 2005. 2 PV systems out of 54 qualified systems was installed to a condominium (93,64 kW), and a rental housings (66,71 kW) in 2006. | - ANRE, METI - Budget: 1997: 1 123 MJPY 1998: 5 393 MJPY 1999: 10 340 MJPY 2000: 11 490 MJPY 2001: 14 040 MJPY 2002: 23 618 MJPY 2003: 38 818 MJPY 2004: 48 255 MJPY 2005: 34 540 MJPY 2006: 35 272 MJPY 2007: 31 600 MJPY | - NEDO (-2002) - METI (2003 -) - METI, NEDO (2007 -) | The total budget from FY 1997 to FY 2006: 254,453 BJPY |

Annex C: Table 1 Summary of major projects, demonstration and field test programs (3/4)

| Project name | Eco-school Mode | Promotion Pilot Project (1997 -) | | | |
|---|--|--|---|--|---|
| Technical data/ Economic data | Objectives | Main accomplishments until the end of 2007/ problems and lessons learned | Funding | Project Manageme nt | Remarks |
| New energy use school (PV, solar thermal, etc.) energy efficient school etc. Eligible Energy: New energy including PV Subsidy: Investigation; fixed cost (METI's subsidy is available for PV system installation) Eligible: Local government | Demonstration and promotion of environment-fri endly school Environmental education to students | PV systems were qualified to 163 schools in 1997 to 2002. PV systems were qualified to 68 schools in 2003. PV systems were qualified to 53 schools in 2004. PV systems were qualified to 59 schools in 2005. PV systems were qualified to 45 schools in 2006. PV systems were qualified to 51 schools in 2007. Larger number of schools introduced PV systems. Students understanding PV systems was heightened. Environmental education was implemented and enhanced. | METI: METI's subsidy is available for PV systems installed under Eco-school Infrastructure Promotion Pilot Project (Reference) Budget of MEXT¹: 1998: 28 MJPY 1999: 28 MJPY 2000: 28 MJPY | - MEXT ¹ - ANRE ² /ME TI - MAFF ³ - MoE ⁴ | - Under supplementary budget in FY 1998, 85 schools, 3 590 kW in total were installed at national universities, national high schools, etc. |

Annex C: Table 1 Summary of major projects, demonstration and field test programs (4/4)

¹: MEXT: Ministry of Education, Culture, Sports, Science and Technology

²: ANRE: Agency of Natural Resources and Energy under Ministry of Economy, Trade and Industry (METI)

³ : MAFF: Ministry of Agriculture, Forestry and Fisheries

⁴ : MoE: Ministry of the Environment