

INTERNATIONAL ENERGY AGENCY CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS

Task 1

Exchange and dissemination of information on PV power systems

National Survey Report of PV Power Applications in Korea 2011

Prepared by

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Definitions, Symbols and Abbreviations

For the purposes of this and all IEA PVPS 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/m^2 , 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>CPV:</u> Concentrating PV

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

<u>Module manufacturer</u>: An organisation 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 gridconnected 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 system 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, electricity utility businesses etc.

<u>Final annual yield:</u> 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.

<u>Currency:</u> The currency unit used throughout this report is KRW(Korean Won).

| Enhanced feed-in tariff | an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh somewhat higher than the retail electricity rates being paid by the customer |
|---------------------------------------|---|
| Capital subsidies | direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed PV system cost |
| Green electricity schemes | allows customers to purchase green electricity based on renewable energy from the electricity utility business, usually at a premium price |
| PV-specific green electricity schemes | allows customers to purchase green electricity based on PV electricity from the electricity utility business, usually at a premium price |
| Renewable portfolio standards (RPS) | a mandated requirement that the electricity utility business (often the electricity retailer) source a portion of their electricity supplies from renewable energies |
| PV requirement in RPS | a mandated requirement that a portion of the RPS be met by PV electricity supplies (often called a set-aside) |

PV support measures:

| Investment funds for PV | share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends |
|--|---|
| Income tax credits | allows some or all expenses associated with PV installation to be deducted from taxable income streams |
| Net metering | allows PV customers to incur a zero charge when their electricity consumption is balanced by their PV generation, to be charged the applicable retail tariff when electricity is imported from the grid and to receive some remuneration for PV electricity exported to the grid |
| Net billing | the electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity account is reconciled over a billing cycle |
| Commercial bank activities | includes activities such as preferential home mortgage terms for houses including PV systems and preferential green loans for the installation of PV systems |
| Activities of electricity utility businesses | includes 'green power' schemes allowing customers to purchase green electricity, operation of large-scale (utility-scale) PV plants, various PV ownership and financing options with select customers and PV electricity power purchase models |
| Sustainable building requirements | includes requirements on new building developments (residential and commercial) and also in some cases on properties for sale, where the PV may be included as one option for reducing the building's energy foot print or may be specifically mandated as an inclusion in the building development |

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

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

Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to 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. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the Korea National Survey Report for the year 2011. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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

1 EXECUTIVE SUMMARY

Since the largest annual installation of 276 MW in 2008, the PV installation during following three years became stagnant, installing about 156 MW in 2011. This is mainly due to the limited FIT scheme which has played an important role in the PV market expansion.

In spite of the difficult global environment surrounding PV industry which led to the halt of PV production of several companies and the bankruptcy of some companies, the Korean government continued to support strongly the PV R&D and market promotion. In addition, the total PV production such as feedstock, wafer and module showed a big increase compared with the previous year.

1.1 Installed PV power

The cumulative installed power of PV system in Korea increased to 812 MW by the end of 2011. Annual installed power in 2011 has reached 156 MW, which is about 20% more than the installation capacity of 131 MW in 2010. The share of grid-connected centralized system is 77% of the total cumulative installed power, and the grid-connected distributed system accounts for 22% of the total cumulative installed power. On the other hand the share of off-grid non-domestic and domestic system has continued to decrease to about 0,7% of total cumulative installed power.

1.2 Costs & prices

The average PV module price was 1 400 KRW/W in 2011, which is about 42% off in comparison with in the previous year. Depending on the type of the installed PV system, the price of grid-connected systems varied from 3 150 KRW/W to 4 000 KRW/W. The price of the 3 kW rooftop system was 4 000 KRW/W in 2011, which is 21% lower than 5 060 KRW/W in 2010.

1.3 PV production

In 2011, the PV production covered a full value chain from raw materials to all system components with a focus on upstream sectors. Four companies produced about 40 000 tons of polycrystalline silicon feedstock with an annual capacity of 57 800 tons, and nine companies were involved in the silicon ingot and wafer production. Nine companies produced 1 030 MW crystalline silicon solar cells with a total capacity of 1 830 MW. Twenty one companies produced about 1 700 MW of crystalline silicon PV module with a total production capacity of 2 700 MW.

1.4 Budgets for PV

In 2011, the total budget for PV was 561 221 million KRW, which is 8% more than that of 517 543 million KRW in 2010. The budget for R&D(demonstration projects are included) in 2011 was 104 012 million KRW(24% more than 2010), and the budget for market incentives was 457 209 million KRW(5% more than 2010).

2 THE IMPLEMENTATION OF PV SYSTEMS

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries.

For the purposes of this report, **PV installations are included in the 2011 statistics if** the **PV modules were installed between 1 January and 31 December 2011**, although commissioning may have taken place at a later date.

2.1 Applications for photovoltaics

Since the largest annual installation of 276 MW in 2008, the PV installation during following three years became stagnant, installing about 156 MW in 2011. This is mainly due to the limited FIT scheme. As of end 2011, the total installed capacity is about 812 MW, among them the grid-connected centralized system accounted for 77% of the total cumulative installed power. The grid-connected distributed system amounted to 22% of the total cumulative installed power. On the other hand the share of off-grid non-domestic and domestic system has continued to decrease to about 0,7% of total cumulative installed power.

The total capacity of 812 MW corresponds to about 1 % of total electricity generation capacity of about 83,3 GW, and the installed PV power of 156,7 MW in 2011 accounts for 5,56% of total power generation capacity newly installed in 2011, as can be seen in Table 1a.

2.2 Total photovoltaic power installed

Table 1 shows the PV power installed in 4 sub-markets during 2011.

At the time of writing this report, the official installation data was not available. The annual installation data was assumed from the total capacity of the PV systems approved to install in the year of 2011 by the NREC (New & Renewable Energy Center). The author divided the raw data into four applications depending on the deployment programs. The electricity statistics data was taken from the 'KEPCO (Korea Electric Power Corporation) in Brief', Dec. 2012

| Sub-market/ application | off-grid domestic | off-grid non- domestic | grid- connected distributed | grid- connected centralized | Total |
|---|-------------------------------------|---------------------------|-----------------------------------|-----------------------------------|-------|
| PV power installed in 2011 (MW) | | | 46,0 | 110,7 | 156,7 |
| Amount of CPV in the above (MW) | | () | () | () | 0 |
| Amount of PV in hybrid systems (MW) | unt of PV in id systems () /) | | | | 0 |

 Table 1: PV power installed during calendar year 2011 in 4 sub-markets.

| Table 1 | 1a: | ΡV | power | and | the | broader | national | energy | market. |
|---------|-----|----|-------|-----|-----|---------|----------|--------|---------|
| Table | ıa. | ΓV | power | anu | uie | Dibauei | national | chergy | mainer |

| Total national (or regional) PV <u>capacity</u> (from Table 2) as a % of total national (or regional) electricity generation capacity | <u>New</u> (2011) PV capacity (from Table 1) as a % of new electricity generation capacity | Total PV <u>electricity</u> production as a % of total electricity consumption |
|--|--|--|
| 0,98 | 5,56 | 0,18 |

A summary of the cumulative installed PV Power, from 1994-2011, broken down into four sub-markets is shown in Table 2.

| | | Cumulative installed capacity as at 31 December | | | | | | | | |
|-----------------------------------|------|---|------|------|------|------|------|------|--|--|
| Sub- market | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | | |
| Stand- alone domestic | 0,2 | 0,2 | 0.2 | 0,3 | 0,3 | 0,3 | 0,5 | 0,6 | | |
| Stand- alone non- domestic | 1,5 | 1,6 | 1,8 | 2,1 | 2,4 | 2,9 | 3,1 | 3,6 | | |
| Grid- connected distributed | 0 | 0 | 0,1 | 0,1 | 0,3 | 0,3 | 0,4 | 0,5 | | |
| Grid- connected centralised | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| TOTAL (MW) | 1,7 | 1,8 | 2,1 | 2,5 | 3,0 | 3,5 | 4,0 | 4,7 | | |

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

| | | | Cumulative installed capacity as at 31 December | | | | | | | |
|-----------------------------------|------|------|---|------|------|------|-------|-------|-------|-------|
| Sub- market | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
| Stand- alone domestic | 0,6 | 0,6 | 0,7 | 0,9 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |
| Stand- alone non- domestic | 4,0 | 4,4 | 4,6 | 4,8 | 5,0 | 5,0 | 5,0 | 5,0 | 5,0 | 5,0 |
| Grid- connected distributed | 0,8 | 1,0 | 3,2 | 6,5 | 19,5 | 36,0 | 54,9 | 79,0 | 131,3 | 177,3 |
| Grid- connected centralized | 0 | 0 | 0 | 1,3 | 10,4 | 39,2 | 296,7 | 439,4 | 518,3 | 629,0 |
| TOTAL (MW) | 5,4 | 6,0 | 8,5 | 13,5 | 35,9 | 81,2 | 357,6 | 524,4 | 655,6 | 812,3 |

2.3 PV implementation highlights, major projects, demonstration and field test programmes

The Ministry of Knowledge Economy (MKE) has been implementing, via the NREC, various deployment initiatives and programs for PV systems. In 2008, the "Third Basic Plan on New and Renewable Energy Sources R&D, D" based on the "National Basic Energy Plan" was made public in order to enhance the level of self-sufficiency in energy supply, to meet the challenging of climate change and to consolidate infrastructure of NRE industry. The goal of NRE deployment is to achieve 4,3 % share of total primary energy supply by 2015. This goal of share is lower than the previously set goal of 5% by 2012. PV still remains as one of the prioritized area. This plan includes the construction of "One Million Green Home" and "200 Green Villages" until 2020. It was also planned that the RPS (Renewable Portfolio Standard) will replace the existing "Feed-in-Tariff" scheme from the year 2012. This plan aims at the grid parity until 2020.

- One Million Green Home Program: This program that merged the 100 000 rooftop PV systems aims at the construction of one million green home utilizing PV as well as solar thermal, fuel cells, wind, bio-energy and geothermal until 2020. In general single-family houses and multi-family houses including apartments can benefit from this program. The government provides 60% of initial PV system cost for single-family and private multi-family houses, and 100% for public multi-family rent houses. The maximum PV capacity allowed for a household is 3 kW. Until the end 2011, about 85,2 MW capacity and about 95 900 households benefited from this program. In 2011, the number of households benefited was about 31 000 and the installed capacity was 19,1 MW.
- Feed-in Tariff Program: Since October 2008, the FIT rate was much reduced as seen in the table. The cap was increased from 100 MW to 500 MW. The beneficiaries can choose the period to be 15 years or 20 years. Until 2011, a total of 500 MW was installed under this scheme. In 2011, 79 MW were installed. FITs in 2010 and 2011 were reduced by 10 to 15% compared with the previous year. For BIPV 10 % bonus is given. A BIPV system larger than 1 MW is accounted as a ground installed system.

| ~ 30 Sep. | Location | Period | < 30 kW | > 30 kW | | | | | |
|-------------|----------------------|----------|---------|-------------------|------------------|----------------|-----------|--|--|
| 2008 | Location | 15 years | 711.25 | | 677.38 | | | | |
| 1 Oct. 2008 | | Period | < 30 kW | 30 kW ~ 200 kW | 200 kW ~ 1 MW | 1 MW ~ 3 MW | > 3 MW | | |
| ~ 2009 | - | 15 years | 646.96 | 620.41 | 590.87 | 561.33 | 472.70 | | |
| | | 20 years | 589.64 | 562.84 | 536.04 | 509.24 | 428.83 | | |
| | Ground | 15 years | 566.96 | 541.42 | 510.77 | 485.23 | 408.62 | | |
| 2010 | | 20 years | 514.34 | 491.17 | 463.37 | 440.20 | 370.70 | | |
| 2010 | Built Environment | 15 years | 606.64 | 579.32 | 546.52 | - | - | | |
| | | 20 years | 550.34 | 525.55 | 495.81 | - | - | | |
| | Cround | 15 years | 484.52 | 462.69 | 436.50 | 414.68 | 349.20 | | |
| 2011 | Ground | 20 years | 439.56 | 419.76 | 396.00 | 376.20 | 316.80 | | |
| 2011 | Built Environment | 15 years | 532.97 | 508.96 | 480.15 | - | - | | |
| | | 20 years | 483.52 | 461.74 | 435.60 | - | - | | |

Feed-in-Tariff (Fixed Price (Won/kWh)

- General Deployment Subsidy Program: The government supports 40% of installation cost for PV systems with a capacity below 50 kW. In addition, the government supports 80% of initial cost for special purpose demonstration and pre-planned systems in order to help the developed technologies and systems to advance into the market. This is the "Test-period deployment subsidy program". In 2011, a total of 1,4 MW was installed. Various grid-connected PV systems were installed in schools, public facilities, welfare facilities and universities.
- Regional Deployment Subsidy Program: The government supports 50% of installation cost for PV systems owned and operated by local authorities. In 2011, approximately 10,9 MW was installed under this program.

- RPS Demonstration Program : Before starting the RPS from 2012, the Government initiated RPS demonstration program for three years from 2009 until 2011. The total capacity was fixed to be 101,3 MW. Six electricity companies construct their own PV plants or purchase PV electricity from private. In 2011, 31,7 MW was approved under this program.
- NRE Mandatory Use for Public Buildings : The new buildings of public institutions, the floor area of which exceeds 3 000 sq meters, are obliged by law to use more than 5% of total construction budget in installing renewable facility. According to the newly revised regulation that took effect on the 1st. Jan. 2012, 10 % of total expected energy use of the new buildings larger than 1 000 sq. meters will have to be provided by the newly installed renewable energy resource systems. Public institutions include state administrative bodies, local autonomous entities, and state-run companies. In 2011, approximately 14,6 MW was approved under this program.

2.4 Highlights of R&D

The KETEP (Korea Energy Technology Evaluation and Planning) is playing a leading role in Korea's PV R&D program since 2008. The R&D budget tripled in 2008 compared with the year 2007, and showed 20% increase in 2009 and another 12% and 24% increase in 2010 and 2011, respectively.

In 2011, the 42 new and 51 continuous projects have been initiated under the four R&D sub-program categorized into "Commercialization Technology Development", "Strategic R&D", "Basic & Innovative R&D", "Short-term Core Technologies Development for Medium and Small industry". The R&D budget for 42 new projects amounts to 52,3 billion KRW. The sub-program "Basic & Innovative R&D" is led by the research institute or the university, and the other three sub-programs are led by the industry. The representative "Commercialization Technology Development" projects funded newly in 2011 is "Development of high-efficiency and large-area thin film PV modules" which focuses on CIGS and Si-based thin film technologies.

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

In 2011 the total budget for PV was 561 221 million KRW which is 8% more than that of 517 543 million KRW in 2010. The budget for R&D(demonstration projects are included) in 2011 was 104 012 million KRW(24% more than 2010), and the budget for market incentives was 457 209 million KRW(5% more than 2010).

The market incentives include the budget for FIT scheme and were offered to individuals and private companies that applied for the construction of PV systems through "one Million Green Home", "Deployment Aid Program", etc. The government also provided low-interest loans every year for renewable energy production or PV system application facilities, which were not included in the budget figures.

Table 3: Public budgets for R&D, demonstration/field test programmes and market incentives.

| R & D Demo/Field test Market incentives | |
|--|--|
|--|--|

| National/federal | 104 012 | | 417 638 |
|------------------------|---------|---------|---------|
| State/regional | | | 39 571 |
| Subtotal (Million KRW) | 104 012 | | 457 209 |
| Total (Million KRW) | | 561 221 | |

3 INDUSTRY AND GROWTH

3.1 Production of feedstocks, ingots and wafers

As can be seen in Table 4 and 5, the PV production covers from raw materials to all system components with a focus on upstream sectors. OCI has expanded its annual production capacity of poly-silicon feedstock up to 42 000 ton in 2011. A new company named 'Woongjin Polysilicon' started the production of poly-silicon feedstock in 2011. The production capacity and the total production of feedstock in 2011 were about 57 800 ton and 40 000 ton, respectively. Nine companies were involved in the silicon ingot and wafer production. The production capacity of ingot and wafer in 2011 were amounted to 3 270 and 2 840 MW, respectively. The wafer production was about 1 800 MW in 2011.

| Manufacturers (or total national production) | Process & technology | Total Production | Production capacity | Product destination | Price (if known) |
|---|----------------------------------|---------------------|---------------------|------------------------|---------------------|
| осі | Silicon feedstock | | 42 000 ton | | N.A. |
| HK Silicon | Silicon feedstock | | 4 800 ton | | N.A. |
| KCC(KAM) | Silicon feedstock | 40 000 ton | 6 000 ton | | N.A. |
| WoongJin | Silicon feedstock | | 5 000 ton | | |
| sul | ototal | 40 000 ton | 57 800 ton | | |
| Glosil | Ingot / wafers (MW) | | 100 / 70 | | N.A. |
| Elpion | Ingot / wafers (MW) | | - / 20 | | N.A. |
| LG Siltron | Ingot / wafers (MW) | | 150 / 150 | | N.A. |
| Neosemitech | Ingot / wafers (MW) | - | 200 / 100 | | N.A. |
| Woongjin Energy | Ingot / wafers (MW) | 1 800 MW | 1 000 / 500 | | N.A. |
| Nexolon | Ingot / wafers (MW) | | 1 500 /1 500 | | N.A. |
| OSung LST | OSung LST Ingot / wafers (MW) | | 100 / 300 | | N.A. |
| Lexor | Ingot / wafers (MW) | | 100 / 80 | | N.A. |
| SK Solmics | Ingot / wafers (MW) | | 120 / 120 | | N.A. |
| sul | ototal | 1 800 MW | 3 270/2 840 | | |

| Table | 4: Production | information | for | the | year | for | silicon | feedstock, | ingot | and |
|-------|---------------|-------------|-----|-----|------|-----|---------|------------|-------|-----|
| wafer | producers | | | | | | | | | |

3.2 Production of photovoltaic cells and modules

Total PV cell and module manufacturers together with production capacity information in 2011 is summarised in Table 5. In 2011, nine companies produced 1 030 MW crystalline silicon solar cells with a total capacity of 1 830 MW. Twenty one companies produced about 1 700 MW of crystalline silicon PV module with a total production capability of 2 700 MW.

There is no thin film module manufacturer in Korea. Two amorphous silicon thin film module manufacturers with a total capacity of 45 MW stopped their production in 2010.

| Cell/Module manufacturer (or total pational | Technolog y (sc-Si, mc-Si, a-Si, | Technolog y (sc-Si, mc-Si, a-Si,Total Production (MW) | | | Maximum production capacity (MW/yr) | | |
|---|--|--|--------|-------|-------------------------------------|--|--|
| production) | CdTe) | Cell | Module | Cell | Module | | |
| Wafer-based PV manufa | actures | | | | | | |
| 1 Hyundai Heavy Ind. | | | | 600 | 600 | | |
| 2 LG Electronics | | | | 330 | 330 | | |
| 3 Shinsung Solar Energy | | | | 350 | 150 | | |
| 4 KPE | | | | 90 | - | | |
| 5 Samsung SDI | | | | 150 | 30 | | |
| 6 Hanwha Chemical | | | | 30 | - | | |
| 7 STX Solar | | | 1,700 | 180 | 50 | | |
| 8 JES Solar | | | | 100 | - | | |
| 9 S-Energy | | | | | 350 | | |
| 10 Solar World Korea | | | | | 300 | | |
| 11 Symphony Energy | sc-Si mc-Si | 1,030 | | | 140 | | |
| 12 T & Solar | | | | | 70 | | |
| 13 Seoul Marrine (SDN) | | | | | 300 | | |
| 14 Kyungwon | | | | | 30 | | |
| 15 Bibong E & G | | | | | 10 | | |
| 16 Haesung Solar | | | | | 10 | | |
| 17 LS IS | | | | | 120 | | |
| 18 EOS Solar | | | | | 30 | | |
| 19 Topsun | | | | | 100 | | |
| 20 luxco | | | | | 50 | | |
| 21 GNR | | | | | 30 | | |
| Total | | 1,030 | 1,700 | 1,830 | 2,700 | | |

 Table 5: Production and production capacity information for 2011

3.3 Module prices

The average PV module price was 1 400 KRW/W in 2011, which is 42% off in comparison with the previous year as shown in Table 6.

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Standard module price(s): Typical (KRW/W) | 7 000 | 4 600 | 4 600 | 4 400 | 4 000 | 3 260 | 2 600 | 2 400 | 1 400 |
| Best price (KRW/W) | | | | | 3 900 | 3 020 | 2 400 | 2 000 | 1 200 |
| PV module price for concentration (if relevant) | | | | | | | | | |

 Table 6: Typical module prices for a number of years

3.4 Manufacturers and suppliers of other components

In 2011, several companies such as Hex Power Systems, Hyundai Heavy Ind., Willings, Dathtech, Hanyang Electric, LS IS, Hyosung and Sungho were involved in inverter production.

3.5 System prices

Depending on the type of the installed PV system, the price of grid-connected systems varied from 3 150 KRW/W to 4 000 KRW/W. The price of the 3 kW rooftop system was 4 000 KRW/W in 2011, which is 21% lower than 5 060 KRW/W in 2010.

Table 7a shows the price trends of a typical 3 kW-capacity residential roof-top system.

| Category/Size | Typical applications and brief details | Current prices per W |
|--|--|-------------------------|
| OFF-GRID Up to 1 kW | | |
| OFF-GRID >1 kW | | |
| GRID-CONNECTED Specific case | 3kW for roof-mounted system | 4 000 KRW |
| GRID-CONNECTED up to 10 kW | | |
| GRID-CONNECTED >10 kW | 30kW field-mounted system | 3 150 KRW |
| GRID – CONNECTED (centralized, if relevant) | | |

Table 7: Turnkey Prices of Typical Applications

Table 7a: National trends in system prices for 3 kW-capacity residential roof-top system

| YEAR | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|-----------------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|
| Price KRW/W: | 14 300 | 13 700 | 12 000 | 9 800 | 8 550 | 8 400 | 6 662 | 5 850 | 5 060 | 4,000 |

3.6 Labour places

a) Public research and development (not including private companies); 800

b) Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D; 9 300

c) All other, including within electricity companies, installation companies etc.; 1 200

The estimation of labour places in 2011 is not available. The above labour places were the same as in 2010.

Table 8: Estimated PV-related labour places in 2011

| Research and development (not including companies) | 800 |
|--|--------|
| Manufacturing of products throughout the PV value chain from feedstock to systems, including company | |
| R&D | |
| Distributors of PV products | |
| System and installation companies | 10 200 |
| Electricity utility businesses and government | 200 |
| Other | 100 |
| Total | 11 300 |

3.7 Business value

The value of PV business in Korea was estimated to be 2 693 325 million KRW. This value was calculated from the PV power installed to which PV products export was added. The export PV product export was estimated based on the total installation subtracted from the total module production. The value of export in 2011 represents 80% of PV business value, which remains at the similar level since 2008.

| Sub-market | Capacity installed <i>in</i> 2011 (MW) | Price per W (KRW) (from table 7) | Value (Million KRW) | Totals |
|-------------------------------|--|--|------------------------|-----------|
| Off-grid domestic | | | | |
| Off-grid non- domestic | | | | |
| Grid-connected distributed | 46,0 | 4 000 | 184 000 | |
| Grid-connected centralized | 110,7 | 3 150 | 348 705 | |
| | | | | 532 705 |
| Export of PV prod | lucts (including infor | mation from Table | s 4 & 5) | 2 160 620 |
| Change in stocks | s 4 & 5) | N.A. | | |
| Import of PV prod | N.A. | | | |
| Value of PV busines | 2 693 325 | | | |

Table 9: Value of PV business

4 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

Table 10 lists the main support measures for PV during 2011.

Table 10: PV support measures

| | On-going measures | Measures that commenced during 2011 |
|--|-------------------------|-------------------------------------|
| Enhanced feed-in tariffs (gross / net?) | Finished as of end 2011 | |
| Capital subsidies for equipment or total cost | V | |
| Green electricity schemes | | |
| PV-specific green electricity schemes | | |
| Renewable portfolio standards (RPS) | V | |
| PV requirement in RPS | V | |
| Investment funds for PV | | |
| Income tax credits | | |
| Net metering | | |
| Net billing | | |
| Commercial bank activities e.g. green mortgages promoting PV | | |
| Electricity utility activities | V | |
| Sustainable building requirements | V | |

Table 10a: PV financing scheme

PV financing scheme

4.1 Indirect policy issues

Considering that the energy sector is responsible for the major part of the greenhouse gas emissions in Korea, it is inevitable to accelerate the use of clean energy. Therefore, these issues will undoubtedly have a great impact on the promotion of PV market in near future. In particular, the PV emerges as one of the key sector for government's long-term vision in favour of "Low-carbon Green growth". In addition PV was designated as one of the most important new growth driving industry.

4.2 Interest from electricity utility businesses

Six Korean electricity generation companies have signed the 'RPA(Renewable Portfolio Agreement)' with the Government in order to increase the share of renewable energy electricity generation. From the year 2012, the RPS(Renewable Portfolio Standard) will replace the FIT scheme applicable until 2011. Before launching the RPS, the Government has been implementing 'RPS Demonstration' from 2009 until 2011 in order to further increase the PV market size and to prepare for the related regulation to RPS. Total thirteen companies including 6 electricity generation companies, electricity generation business companies and two other corporates are planned to participate at RPS.

For PV, obligatorily allocated capacity is 1,2 GW for five years covering 2012~2016.

| YEAR | 2012 | 2013 | 2014 | 2015 | 2016 |
|------------------|------|------|------|------|------|
| Capacity (MW) | 220 | 230 | 240 | 250 | 260 |

4.3 Interest from municipalities and local governments

Several municipalities and local authorities are actively implementing 'Regional Deployment Subsidy Program' mentioned in paragraph 2.3, and some local authorities provide separate incentives for 'One Million Green Home Program'.

4.4 Standards and codes

Korea has been adopting IEC TC 82 standards as Korean Standards under the responsibility of KATS(Korea Agency for Technology and Standards). The KATS and KNREC have been working together to prepare guidelines and regulations for massive dissemination of PV system.

The certification program for inverter and crystalline silicon PV module has been implemented since 2005. Under the IECEE scheme, the KNREC is designated as NCB(National Certification Body) and KTL(Korea Testing Laboratory) and KIER(Korea Institute of Energy Research) are as CBTL(Certification Body Testing Laboratory) for inverters and crystalline PV modules. For the government-supported PV systems the use of certified products is obligatory.

5 HIGHLIGHTS AND PROSPECTS

Since the largest annual installation of 276 MW in 2008, the PV installation during following three years became stagnant, installing about 156 MW in 2011. This is mainly due to the limited FIT scheme. In comparison the Korean government's expenditure on PV R&D and market promotion continued to grow. From the year 2012 when the RPS implementation will be launched, the PV market will be at least larger than 200 MW size

In accordance with global PV boom and the government's strong drive policy, many companies have entered into the PV industry until 2010. Due to the current difficult global environment surrounding PV industry, several PV companies shut down its operation, delayed further investment and some of them became bankrupt in 2011. Nonetheless the PV feedstock, wafer and module production showed a big increase compared with the previous year.

ANNEX A: 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 (http://cyber.kepco.co.kr/)

Household (low voltage less than 3 kW)

| Fixed rate (KRW/hou | Electricity rate per kWh(KRW/kWh) | |
|--------------------------|-----------------------------------|--------|
| less than 100kWh | 390 | 57,30 |
| 101~200 kWh | 860 | 118,40 |
| 201~300 kWh | 1 490 | 175,00 |
| 301~400 kWh | 3 560 | 258,70 |
| 401~500 kWh | 6 670 | 381,50 |
| More than 500kWh | 12 230 | 676,60 |

Commercial A (contracted power less than 300 kW)

| | | Basic rate per kW | Electricity rate per kWh (KRW/kWh) | | | | |
|--------------|-----------|----------------------|------------------------------------|-------------------------------|----------------|--|--|
| | | (KRW/kW) | Summer 7~8 | Spring Autumn 3~6, 9~10 | Winter 11~2 | | |
| Low Voltage | | 5 610 | 96,40 | 60,10 | 83,30 | | |
| High | Option I | 6 470 | 105,00 | 65,50 | 92,60 | | |
| Voltage A | Option II | 7 430 | 101,30 | 61,70 | 87,80 | | |
| High | Option I | 6 470 | 103,10 | 64,50 | 89,90 | | |

| Voltage | Option II | 7 430 | 98,30 | 59,70 | 85,10 |
|---------|-----------|-------|-------|-------|-------|
| В | | | | | |

Low, standard voltage : 220~380 V, High A : 3 300~66 000 V, High B > 154 000 V

- 2) typical household electricity consumption (kWh) : about 5 240 kWh/year (KEPCO in Brief, Dec. 2011)
- 3) typical metering arrangements and tariff structures for electricity customers (for example , interval metering? time-of-use tariff?) : one month-of-use tariff
- 4) typical household income (NC) : 46 Million KRW per year (http://kosis.kr/)
- 5) typical mortgage interest rate : 5,5%/yr
- 6) voltage (household, typical electricity distribution network) : 220 Volt (household)
- 7) electricity industry structure and ownership : generation and transmission & distribution are separated. The generation part consists of six companies.
- 8) price of diesel fuel (NC) : 1 500 KRW per liter (http://www.kesis.net)
- 9) typical values of kWh / kW for PV systems in parts of your country. : 1 180 (annually) (New & Renewable Energy Statistics 2010, KEMCO, Nov. 2011)