**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 2012

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## Definitions, Symbols and Abbreviations

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

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

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

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

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

CPV: Concentrating PV

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

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

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

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

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

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

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

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

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

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

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

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

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

PV support measures:

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

| | |
|---|---|
| Investment funds for PV | share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends |
| Income tax credits | allows some or all expenses associated with PV installation to be deducted from taxable income streams |
| Net metering | allows PV customers to incur a zero charge when their electricity consumption is exactly balanced by their PV generation, while being charged the applicable retail tariff when their consumption exceeds generation and receiving some remuneration for excess electricity exported to the grid |
| 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 23 participating countries are Australia (AUS), Austria (AUT), Belgium (BEL), 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, the US Solar Energy Industries Association and the Copper Alliance are also members. Thailand is a pending member.

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 Korean National Survey Report for the year 2012. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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

# 1 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 was mainly due to the limited FIT scheme which played an important role in the PV market expansion. However, new installation of 230 MW was recorded in 2012 due mainly to the newly introduced RPS scheme in 2012 with mandated PV requirement in RPS.

In spite of the continued difficult global environment surrounding PV industry which led to the halt of PV production of several companies and the bankruptcy of many companies, the Korean government continued to support strongly the PV deployment, R&D, infrastructure building and market promotion.

## 1.1 Installed PV power

The cumulative installed power of PV system in Korea increased to 959,2 MW by the end of 2012, nearing 1 GW capacity. Annual installed power in 2012 has reached 230 MW, which is about 47% more than the installation capacity of 156 MW in 2011. The share of grid-connected centralized system is 77% of the total cumulative installed power, and the grid-connected distributed system accounts for 23% 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 0,6% of total cumulative installed power.

## 1.2 Costs & prices

The average PV module price was 1 000 KRW/W in 2012, which is about 29% 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 2 400 KRW/W to 3 000 KRW/W. The price of the 3 kW rooftop system was 3 000 KRW/W in 2011, which is 25% lower than 4 000 KRW/W in 2011.

## 1.3 PV production

In 2012, the PV production covered entire value chain from raw materials to BOS & system installation with a focus on upstream sectors. Two companies produced about 40 000 tons of polycrystalline silicon feedstock with an annual capacity of 57 000 tons, and seven companies were involved in the silicon ingot and wafer production domestically. Total five companies produced about 1 000 MW crystalline silicon solar cells with a total capacity of 1 490 MW domestically. Eighteen companies produced about 1 700 MW of crystalline silicon PV module with a total production capacity of 2 670 MW domestically.

## 1.4 Budgets for PV

In 2012, the total budget for PV was at least 577 838 million KRW which is 3% more than that of 561 221 million KRW in 2011.

The budget for R&D (demonstration projects are included) in 2012 was 133 286 million KRW (28% more than 2011). Three regional (Chungcheong, Honam and Daegyeong regions) PV test-bed projects have been launched in 2011, thus newly added to the budget for 2012.

The budget for market incentives was 434 467 million KRW (12% less than 2011).

# 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 2012 statistics if the PV modules were installed between 1 January and 31 December 2012, although commissioning may have taken place at a later date**.

## 2.1 Applications for photovoltaics

In Korea, photovoltaic system is mainly applied to the electric power generation.

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 was mainly due to the limited FIT scheme which played an important role in the PV market expansion. However, new installation of 230 MW was recorded in 2012 due mainly to the newly introduced RPS scheme in 2012 with mandated PV requirement in RPS. At the end of 2012, the total installed capacity is about 959,2 MW, among them the grid-connected centralized system accounted for 77% of the total cumulative installed power. The grid-connected distributed system amounted to 23% of the total cumulative installed PV power. On the other hand the share of off-grid non-domestic and domestic systems has continued to decrease to about 0,6% of total cumulative installed PV power.

The total capacity of 959,2 MW corresponds to 1,17% of total electricity generation capacity of about 81,806 GW, and the installed PV power of 230 MW in 2012 accounts for 4,46% of total power generation capacity newly installed in 2012, 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 2012.

The annual installation data was obtained from the total capacity of the PV systems approved to install in the year of 2012 by the NREC (New & Renewable Energy Centre) at KEMCO (Korea Energy Management Corporation). However, some small scale installations for off-grid domestic and non-domestic applications are not accurately monitored by the NREC, introducing some errors in the data in the tables. The author divided the raw data into four applications depending on the individual deployment programs. The electricity statistics data were taken from the 'KEPCO (Korea Electric Power Corporation) in Brief 2012,' published on December, 2012. The 2012 data for actual PV electricity production is still not available, thus the estimation was made assuming a linear extrapolation of the data of 2011 using constant (1 258) kWh/kW value in 2011. Official statistics from NREC differs from Korean NSR 2011 report, thus official value is represented in parentheses of 2011 & 2012 data in Table 2 and used in this report.

**Table 1: PV power installed during calendar year 2012 in 4 sub-markets**

| Sub-market/ application | off-grid domestic | off-grid non-domestic | grid-connected distributed | grid-connected centralized | Total |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| PV power installed in 2012 (MW) | | | 59,9 | 170,1 | 230 |
| *Amount of CPV in the above (MW)* | | (…) | (…) | (…) | 0 |
| *Amount of PV in hybrid systems (MW)* | (…) | | | | 0 |

## Table 2a: PV power and the broader national energy market

| Total national (or regional) PV capacity (from Table 2) as a % of total national (or regional) electricity generation capacity* | New (2012) PV capacity (from Table 1) as a % of new electricity generation capacity** | Total PV electricity production as a % of total electricity consumption*** |
|---|---|---|
| 1,17 | 4,46 | 0,26 |

*Total national electricity generation capacity is 81,806 GW in 2012 (KEPCO in Brief, December, 2012).

** New national electricity generation capacity in 2012 is 5,157 GW (KEPCO in Brief, December, 2012).

*** In 2012, estimated total national electricity consumption is 466 593 000 MWh, and estimated total PV electricity production is 1 206 674 MWh in 2012 (assuming 1 258 kWh/kW).

A summary of the cumulative installed PV Power, from 1992-2012, broken down into four sub-markets is shown in Table 3.

## Table 3: The cumulative installed PV power in 4 sub-markets

| | **Cumulative installed capacity as at 31 December** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sub-market** | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
| Stand-alone domestic | 0,2 | 0,2 | 0.2 | 0,3 | 0,3 | 0,3 | 0,5 | 0,6 | 0,6 | 0,6 |
| Stand-alone non-domestic | 1,5 | 1,6 | 1,8 | 2,1 | 2,4 | 2,9 | 3,1 | 3,6 | 4,0 | 4,4 |
| Grid-connected distributed | 0 | 0 | 0,1 | 0,1 | 0,3 | 0,3 (0,418) | 0,4 (0,549) | 0,5 (0,741) | 0,8 (0,816) | 1,0 (0,979) |
| Grid-connected centralised | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL (MW) | 1,7 | 1,8 | 2,1 | 2,5 | 3,0 | 3,5 (3,618) | 4,0 (4,149) | 4,7 (4,941) | 5,4 (5,416) | 6,0 (5,979) |

| | **Cumulative installed capacity as at 31 December** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sub-market** | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | |
| Stand-alone domestic | 0,7 | 0,9 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Stand-alone non-domestic | 4,6 | 4,8 | 5,0 | 5,0 | 5,0 | 5,0 | 5,0 | 5,0 | 5,0 | |
| Grid-connected distributed | 3,2 (2,994) | 6,5 (6,36) | 19,5 (19,311) | 36,0 (35,816) | 54,9 (52,36) | 79,0 (76,541) | 131,3 (110,847) | 177,3 (146,682) | 237,2 (206.582) | |
| Grid-connected centralized | 0,238 | 1,462 | 10,533 | 39,375 | 298,484 | 441.141 | 533,492 | 576,475 | 746,575 | |
| TOTAL (MW) | 8,5 (8,532) | 13,5 (13,522) | 35,9 (35,844) | 81,2 (81,191) | 357,6 (356,844) | 524,4 (523,682) | 655,6 (650,339) | 812,3 (729.157)* | 1 042,3 (959.157)* | |

*Official Statistics from NREC (2011 NRE Dissemination Statistics, NREC, December, 2012) show different figures in Table 2 when compared with figures reported in Korean NSR 2011. Thus the official figures are inserted in the table in parentheses, and these values are used to calculate the PV electricity production.

The increased new PV installation in 2012 was mainly due to the newly introduced RPS scheme in 2012 (FIT scheme was terminated at the end of 2011), with mandated PV requirement in RPS.

Korean government continued to support strongly the PV deployment, R&D, infrastructure building and market promotion which are described in the following sections.

Among these, the government-driven RPS scheme and R&D support played major role in boosting PV deployment and industry development.

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

The Ministry of Knowledge Economy (MKE), now called the Ministry of Trade, Industry and Energy (MOTIE) since 2013 by the newly elected Government, has been implementing, via the NREC, various deployment initiatives and programs for PV systems. In 2008, the "Third Basic Plan for the Promotion of Technological Development, Use, and Diffusion of New and Renewable Energy" based on the "First National Energy Basic Plan" was made public in order to enhance the level of self-sufficiency in energy supply, to meet the challenges of global warming and 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 is lower than the previously set value of 5% by 2012. Although the actual outcome of NRE deployment by 2012 was turned out to be 2,6%, falling far below the goal, PV still remains as one of the prioritized area. This plan includes the construction of "One Million Green Homes" and "200 Green Villages" until 2020. Also in this plan, the RPS (Renewable Portfolio Standards) scheme will replace the existing "Feed-in-Tariff" scheme from the year 2012. The RPS was launched in 2012 as planed and will be active until 2020.

- Home Subsidy Program (One Million Green Home Program): This program was launched in 2004 that merged the existing 100 000 rooftop PV system installation program, and it aims at the construction of one million green homes 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. In 2011, the number of households benefited was 45 530, and the installed capacity was about 37 MW. Until the end of 2012, about 122 MW capacity and about 141 000 households benefited from this program.
- RPS Program: The RPS is a mandated requirement that the electricity utility business source a portion of their electricity supplies from renewable energies. In Korea, electricity utility business companies exceeding 500 000 kW are required to supply

total 10% of their electricity from NRE source by 2022, starting from 2% in 2012. Before starting the formal RPS program from 2012, the Government initiated the RPS demonstration program for three years from 2009 until 2011. 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. The total capacity was fixed to be 101,3 MW. The six electricity companies constructed their own PV power plants or purchased PV electricity from the private source. In 2011, 31,7 MW was approved under this program. From the year 2012, the RPS (Renewable Portfolio Standard) scheme fully replaced the existing FIT scheme. Total thirteen companies including 6 electricity generation companies, electricity generation business companies and two other corporates have participated in the RPS since 2012. In order to expand the domestic market size and to boost the development, PV has its own set-aside amount in the RPS of total 1,2 GW for the four years covering 2012~2015. The original plan was for five years, but the Government decided to shorten one year, considering the difficult situation of Korean PV companies. In 2012, about 162 MW was installed under this program.

**<Annual set-aside PV capacity requirement in RPS>**

| YEAR | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|
| Capacity (MW) | 220 | 330 | 330 | 320 | - |

- Feed-in Tariff Program: Until 2011, a total of 500 MW was installed under this scheme. In 2011 alone, 79 MW were installed. FITs in 2010 and 2011 were reduced by 10 to 15% compared with the previous year. For BIPV 10% bonus was given. A BIPV system larger than 1 MW is accounted as a ground installed system. The FIT scheme ended at the end of 2011.
- Building Subsidy Program (Formerly General Deployment Subsidy Program): The Government supports up to 50% 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 diffuse into the market. This is the "Test-period deployment subsidy program." In 2012, 115 PV systems with the total of 2,3 MW were installed by this program. Until the end of 2012, about 16 MW capacity and 690 PV systems benefited from this program. Various grid-connected PV systems were installed in schools, public facilities, welfare facilities as well as universities.
- Regional Deployment Subsidy Program: The government supports 50% of installation cost for PV systems owned and operated by local authorities. Until the end of 2012, about 60 MW benefited from this program with the subsidy of 284 900 million KRW.
- NRE Mandatory Use for Public Buildings: The new buildings of public institutions, the floor area of which exceeds 1 000 square meters, are obliged by law to use more than 10% of their total expected energy by the newly installed renewable energy resource systems. Public institutions include state administrative bodies, local autonomous entities, and state-run companies. The building energy mandate percentage is planned to increase up to 20% by 2020. In 2012 alone, approximately 32 MW was installed under this program, the cumulative total capacity reaching about 90 MW at the end of 2012.

- New & Renewable Energy Loans: This loan can be used for funding to construct facilities, production as well as working capital. In 2012, total 34 050 million KRW was used for PV loans.
- Convergence and Integration Subsidy Program for NRE: This is a new NRE subsidy program started in 2013. A consortium led by either local authority or public enterprise with NRE manufacturing companies and privates can apply for this subsidy program. This program is designed to diffuse the NRE into socially disadvantaged and vulnerable regions and classes such as islands, remote areas (not connected to the grid), long-term rental housing district, etc. Local adaptability is one of the most important criteria, thus the convergence between various NRE sources (PV, wind, electricity and heat) and the complex between areas (home, business and public) are primarily considered for this subsidy program.

## 2.4 Highlights of R&D

The Government budget for national PV R&D in 2010 reached 198,8 billion KRW for total 535 R&D projects, ranking world's three in the total budget amount. The PV R&D budget showed an average 36,9% increase over the last five years ('08~'12). About 75% of total R&D budget is governed by MOTIE (Ministry of Trade, Industry and Energy), which focuses on industry-oriented research and developments. About 18% of the budget is governed by MSIP (Ministry of Science, ICT and Future Planning) for mostly fundamental researches. Others are spent by many different organizations.

PV R&D budget governed by MOTIE is spent mainly by the R&D projects planned through KETEP (Korea Institute of Energy Technology Evaluation and Planning)'s NRE Convergent Core Technology Development program, KIAT (Korea Institute for Advancement of Technology)'s Expanded Economy Region Leading Industry Development program and KEIT (Korea Evaluation Institute of Industrial Technology)'s SME Development and Support program. Among them, KETEP is playing a leading role in Korea's national PV R&D programs since 2008. The KETEP's R&D budget tripled in 2008 (56 677 million KRW) compared with that of year 2007 (17 065 million KRW), and showed 25% increase in 2009 and another 20% increase in 2010 (peaking at 84 420 million KRW). Since 2011, KETEP's PV R&D budget is slightly decreasing and being flattened. The budget for year 2012 was 77 284 million KRW, which amounted to about half of the total budget from MOTIE.

**<The cumulative PV R&D budget of KETEP>**

| Year | | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|---|---|---|---|---|---|---|---|---|
| Number of Projects (ea) | Short-term | 9 | 26 | 46 | 63 | 67 | 49 | 260 |
| | Mid/Large Scale | 10 | 13 | 11 | 12 | 13 | 21 | 80 |
| | Total | 19 | 39 | 57 | 75 | 80 | 70 | 340 |
| Government Budget (Million KRW) | Short-term | 692 | 11,814 | 30,833 | 35,534 | 29,014 | 20,707 | 128,594 |
| | Mid/Large Scale | 16,373 | 44,863 | 39,806 | 48,886 | 47,759 | 56,577 | 254,264 |
| | Total | 17,065 | 56,677 | 70,639 | 84,420 | 76,773 | 77,284 | 382,858 |

Since 2009, MOTIE has invited a full-time PV R&D Program Director from academia for the two year term to strategically plan, launch and manage the PV R&D projects.

In 2012, numerous R&D projects have been initiated under the three R&D sub-programs categorized into "Strategic & Commercialization Technology Development", "Basic & Innovative R&D" and "Short-term Core Technology Development for SME (Small to Medium Size Enterprises)." First two sub-programs are classified as "Top-down Mid/Large Scale Program" (total 21 projects), while the last is classified as "Bottom-up Short-term Program" (49 projects).

A representative "Strategic & Commercialization Technology Development" project launched newly in 2012 is "The Development of Large Area (> 4 square meters) Commercial BIPV System for Building Exterior Applications Incorporating Design Ingredients," in which the developed BIPV system utilizes DSSC, CIGS and Si-based thin film BIPV modules. Crystalline Si related projects (total 7) still occupies the largest portion of the top-down PV R&D budget. OPV (Organic Photovoltaics), DSSC (Dye-sensitized Solar Cells) and non-vacuum processed CIGS thin film PV module commercialization projects were also included. Noticeably, two CPV (Concentrating PV) system development projects were first launched in the year 2012 as well as the MIC (Micro Inverter Converter) attached PV module and system optimization project. Organic and quantum-dot solar cell development projects were included as Basic & Innovative R&Ds.

Numerous Short-term R&D projects have also been implemented in 2012 in the area of high efficiency crystalline Si solar cell, Si-based thin film solar cell, CIGS thin film solar cell, etc.

KETEP has also launched the "Green, Energy-independent Islands" project in 2012, aiming at the diffusion of NRE with maximizing the local adaptability. The convergence of PV with other NRE sources and diesel fuel is attempted to provide energy-mixed electric power supply to grid-connected and stand-alone islands in south-western islands region.

Institutes for Region Program Evaluation have been established in 2013, which will conduct the evaluation and planning of regional programs including R&D programs, funded by MOTIE through KIAT. Three Institutes (Chungcheong, Daegyeong and Honam) will plan and manage the regional PV R&D programs. This PV R&D budget in 2012 was 56 002 million KRW. In 2012 total 31 top-down PV R&D projects are being implemented in the area covering the entire value chain of PV industry with special emphasis on the regional needs. Chungcheong Institute focuses on "Parts" in particular, Daegyeong Institute on "Equipment," and Honam Institute on "Materials" for the entire PV value chain.

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

In 2012, the total budget for PV was at least 577 838 million KRW which is 3% more than that of 561 221 million KRW in 2011.

The budget for national PV R&D (demonstration projects are included) in 2012 was at least 133 286 million KRW (28% more than 2011), since the national PV R&D budgets for KETEP and KIAT were 77 284 million KRW and 56 002 million KRW, respectively. PV R&D budgets allocated to KEIT, MSIP and other institutions are not included in the figure of Table 3 due to lack of accuracy in data. But, total about 200 billion KRW are estimated to be spent for national PV R&D in 2012.

Three regional (Chungcheong, Daegyeong and Honam regions) PV test-bed projects have been recently launched in 2011, thus newly added to Table 3. The budget for 2012 was 10 085 million KRW.

**<Roles and functions of three regional PV test-beds>**

| Region | Roles and Functions |
|---|---|
| **Chungcheong** | Performance certification test & evaluation (international certification standards), Trial production test of the prototype parts & materials for PV modules |
| **Daegyeong** | Trial production test of the parts & materials for crystalline Si PV cells and modules, Support for technology Commercialization |
| **Honam** | Characterization and evaluation service for analyzing trace impurities, rheological properties of materials and devices, and properties of wafers<br>Analysis, inspection and performance testing of second generation thin film solar cell materials, cells and modules |

The budget for market incentives was 434 467 million KRW (12% less than 2011). Market incentives in each category since beginning to 2012 are summarized below.

**<The cumulative market incentive budget for PV>**

(Unit: Million KRW)

| Program | ~2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|---|---|---|---|---|---|---|---|
| **Building Subsidy** | 57 599 | 10 136 | 3 171 | 1 995 | 4 590 | 3 968 | 81 459 |
| **Regional Subsidy** | 85 982 | 40 497 | 30 481 | 39 807 | 39 571 | 48 607 | 284 945 |
| **Home Subsidy** | 119 981 | 48 942 | 58 996 | 59 997 | 49 998 | 54 969 | 332 886 |
| **FIT Subsidy** | 18 407 | 112 875 | 240 217 | 292 675 | 323 479 | 292 873 | 1 280 526 |
| **Financing Subsidy** | 181 036 | 163 633 | 90 600 | 55 186 | 75 377 | 34 050 | 599 882 |
| **Total** | 463 004 | 376 083 | 423 466 | 449 660 | 493 016 | 434 467 | 2 579 698 |

Decrease in the market incentive budget in 2012 was caused mainly by the decrease in the Feed-in-Tariff subsidy amount. As stated earlier, FIT scheme ended at the end of 2011, and RPS scheme started since January, 2012.

**Table 4: Public budgets for R&D, demonstration/field test programmes and market incentives**

(Unit: Million KRW)

| | R & D | Demo/Field test | Market incentives |
|---|---|---|---|
| National/federal | 133 286 | 10 085 | 385 860 |
| State/regional | - | - | 48 607 |
| Total | 577 838 | | |

# 3 INDUSTRY AND GROWTH

## 3.1 Production of feedstocks, ingots and wafers

As can be seen in Table 4 and 5, the PV production in Korea covers entire spectrum of PV value chain from raw materials to system installation. The supply chain in crystalline silicon businesses is also firmly constructed.

Korean PV production is still focused on upstream sectors: OCI has expanded its annual production capacity of poly-silicon feedstock up to 42 000 ton in 2011 and ranked as world's top three in 2012. 'Woongjin Polysilicon' who started the production of poly-silicon feedstock in 2011 went bankrupt, and KCC(KAM) stopped production. Instead, Hanwha Chemicals and SMP (Joint Venture of Samsung Precision Chemicals and MEMC) completed the construction of new plants in 2012 and are expected to begin the productions in 2013. The production capacity and total production of poly silicon feedstock in 2012 remained about the same as in 2011 and were about 57 000 ton and 40 000 ton, respectively.

Seven companies were involved in the silicon ingot and wafer production. LG Siltron and Neosemitech stopped production, and Elpion was purchased to OCIS. The production capacity of ingot and wafer in 2012 were amounted to 2 920 and 2 590 MW, respectively. The wafer production was estimated to be about 1 800 MW in 2012.

**Table 5: Production information for the year for silicon feedstock, ingot and wafer producers**

| Manufacturers (or total national production) | Process & technology | Total Production | Production capacity | Product destination | Price (if known) |
|---|---|---|---|---|---|
| OCI | Silicon feedstock (CVD) | 40 000 ton | 42 000 ton | China, Taiwan, U.S.A., Japan, Domestic, etc. | N.A. |
| HK Silicon | Silicon feedstock (CVD) | | 15 000 ton | | N.A. |
| Subtotal | | 40 000 ton | 57 000 ton | | |
| Glosil | Ingot / wafers (MW) | 1 800 MW | 100 / 70 | Taiwan, U.S.A., Germany, Japan, China, Domestic, etc. | N.A. |
| OCIS | Ingot / wafers (MW) | | - / 20 | | N.A. |
| Woongjin Energy | Ingot / wafers (MW) | | 1 000 / 500 | | N.A. |
| Nexolon | Ingot / wafers (MW) | | 1 500 /1 500 | | N.A. |
| 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. |
| Subtotal | | 1 800 MW | 2 920 / 2 590 | | |

## 3.2 Production of photovoltaic cells and modules

Total PV cell and module manufacturers together with production capacity information in 2012 is summarised in Table 5.

In 2012, five companies produced about 1 000 MW (70% of the capacity) crystalline silicon solar cells with a total capacity of 1 490 MW. Eighteen companies produced about 1 700 MW of crystalline silicon PV modules with a total production capability of 2 670 MW.

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

**Table 6: Production and production capacity information for 2012**

| **Cell/Module manufacturer** (or total national production) | **Technology** (sc-Si, mc-Si, a-Si, CdTe) | **Total Production (MW)** | | **Maximum production capacity (MW/yr)** | |
|---|---|---|---|---|---|
| | | Cell | Module | Cell | Module |
| *Wafer-based PV manufactures* | | | | | |
| **1 Hyundai Heavy Ind.** | sc-Si mc-Si | 1 000 | 1 700 | 600 | 600 |
| **2 LG Electronics** | | | | 330 | 330 |
| **3 Shinsung Solar Energy** | | | | 350 | 150 |
| **4 Hanwha Chemicals** | | | | 30 | - |
| **5 STX Solar** | | | | 180 | 50 |
| **6 S-Energy** | | | | | 350 |
| **7 Solar World Korea** | | | | | 300 |
| **8 Symphony Energy** | | | | | 140 |
| **9 T & Solar** | | | | | 70 |
| **10 Seoul Marine (SDN)** | | | | | 300 |
| **11 Kyungwon** | | | | | 30 |
| **12 Bibong E & G** | | | | | 10 |
| **13 Haesung Solar** | | | | | 10 |
| **14 LS IS** | | | | | 120 |
| **15 EOS Solar** | | | | | 30 |
| **16 Topsun** | | | | | 100 |
| **17 Luxco** | | | | | 50 |
| **18 GNR** | | | | | 30 |
| Total | | 1 000 | 1 700 | 1 490 | 2 670 |
| *Thin film manufacturers* | | | | | |
| **1** | | | | | |
| *Cells for concentration* | | | | | |
| **1** | | | | | |
| **TOTALS** | | **1 000** | **1 700** | **1 490** | **2 670** |

Large portion of the produced cells and modules in Korea are exported to foreign countries. PV industry of Korea is export-oriented, and thus export occupies more than 70% of total sale.

LG Electronics introduced bi-facial crystalline Si module and was awarded in the Intersolar Expo & Conference in 2013. LG Electronics also set the world record in amorphous Si thin film solar cell with the cell efficiency of 13.4%.

Hanwha conglomerates (including Hanwha Chemicals and Hanwha Q-Cells) completed its vertical integration in the global context: Hanwha Q-Cells in China, Germany, U.S.A., Malaysia and Korea showed active overseas business activities with continued investments.

Hanwha, OCI and Shinsung Solar Energy expanded their downstream businesses and acquired large scale PV EPC projects from U.S.A. and other countries**.**

SK Innovation continued its investment on CIGS thin file solar cell developments in U.S.A. (Heliovolt).

Samsung SDI conducts nationally funded R&D to commercialize the large area CIGS thin film PV modules by two-step process using sputtering technique.

LG Innotek strives to commercialize the CIGS thin film PV modules using co-evaporation process.

Kolon Industries and LG Chemicals are developing OPV modules using polymers and small organic molecules, respectively.

Dongjin Semichem and Sangbo conduct nationally funded development to commercialize DSSC modules for niche market.

## 3.3 Module prices

The average PV module price was 1 000 KRW/W in 2012, which is 29% off in comparison with the previous year as shown in Table 6. Best price was 800 KRW/W.

**Table 7: Typical module prices for a number of years**

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 1 000 |
| Best price (KRW/W) | | | | | 3 900 | 3 020 | 2 400 | 2 000 | 1 200 | 800 |
| PV module price for concentration (if relevant) | | | | | | | | | | |

## 3.4 Manufacturers and suppliers of other components

In 2012, several companies including 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 2 400 KRW/W to 3 000 KRW/W. The price of the 3 kW rooftop system was 3 000 KRW/W in 2011, which is 25% lower than 4 000 KRW/W in 2011.

A summary of typical system prices is provided in the following tables, and Table 7a shows the price trends of a typical 3 kW-capacity residential roof-top system.

**Table 8: Turnkey Prices of Typical Applications**

| 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 | 3 kW for roof-mounted system | 3 000 KRW |
| GRID-CONNECTED up to 10 kW | | |
| GRID-CONNECTED >10 kW | 30 kW field-mounted system | 2 400 KRW |
| GRID-CONNECTED (utility-scale plant, if relevant) | | |

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

| YEAR | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Price KRW/W | 14 300 | 13 700 | 12 000 | 9 800 | 8 550 | 8 400 | 6 662 | 5 850 | 5 060 | 4 000 | 3 000 |

## 3.6 Labour places

The labour places in PV manufacturing companies including company R&D was estimated to be 11 533 in 2012, excluding the labour places in foreign-based business units. In detail, there were labour places of 1 685 for poly silicon feedstock, 2 126 for ingot & wafer, 2 407 for solar cell, 2 671 for PV module, 1 573 for parts & materials, and 1 071 for equipment in Korea as of 2012. The foreign-based labour places was estimated to be about 15 004 in 2012 (4 626 for ingot & wafer, 4 507 for solar cell, and 5 871 for PV module), surpassing the domestic labour places, which is largely related with the Hanwha's business units in China, Malaysia, U.S.A. and Germany.

The estimation of labour places of 2012 in public R&D, distributors of PV products, system & installation companies, as well as labour places in electricity utility business & government is not available. The estimation of these labour places was taken from the data of 2010 and assumed not changed: 800 for public R&D, 900 for distributors of PV products and system & installation companies, 200 for electricity utility businesses and government, and 100 for others were used in Table 8, making the estimation in Table 8 more conservative.

**Table 9: Estimated PV-related labour places in 2012**

| | |
|---|---|
| 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 | 12 433 |
| Electricity utility businesses and government | 200 |
| Other | 100 |
| **Total** | 13 533 |

## 3.7 Business value

The annual PV industry sales amount was estimated to be 7 917 000 million KRW in 2011, and total export amount was about 4.6 billion US $ (5 060 000 million KRW, 64% of total sales).

In 2012, the total annual PV sales amount was estimated to be 9 802 700 million KRW (23.8% higher than the sales in 2011), and total export amount was 7 115 870 million KRW (72.6% of total sales and 40.6% higher that the exports in 2011). In more detail, 2 811 600 million KRW from poly silicon feedstock (export, 83%), 1 521 300 million KRW from ingot & wafer (export, 76%), 357 000 million KRW from solar cell (export, 57.4%), 3 364 000 million KRW from PV module (export, 68.1%), 1 189 200 million KRW from materials & parts (export, 68.6%), and 561 000 million KRW from equipment (export, 54.7%) are estimated in 2012 including sales from foreign-based business units.

**Table 10: Value of PV business**

| **Sub-market** | **Capacity installed *in 2012* (MW)** | **Price per W** *(from table 7)* | **Value** | **Totals** |
|---|---|---|---|---|
| **Off-grid domestic** | *X* | *Y* | *a = X x Y x 1 000 000* | |
| **Off-grid non-domestic** | | | | |
| **Grid-connected distributed** | **59,9** | **3 000** | *179 700* | |
| **Grid-connected centralized** | **170,1** | **2 400** | *408 240* | |
| | | | | *587 940* |
| **Export of PV products** *(including information from Tables 4 & 5)* | | | | *7 115 870* |
| **Change in stocks held** *(including information from Tables 4 & 5)* | | | | *N.A* |
| **Import of PV products** *(including information from Tables 4 & 5)* | | | | *N.A* |
| **Others** *(domestic sales of PV value chain products)* | | | | *2 686 830* |
| *Value of PV business (million KRW)* | | | | ***10 390 640*** |

# 4 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

Table 11 lists the main support measures (definitions at start of guidelines) for PV during 2012. Further details on these are to be provided on the following pages.

**Table 11: PV support measures**

| | On-going measures | Measures that commenced during 2012 |
|---|---|---|
| Feed-in tariffs (gross / net?) | Ended as of end 2012 | |
| Capital subsidies for equipment or total cost | V | |
| Green electricity schemes | | |
| PV-specific green electricity schemes | | |
| Renewable portfolio standards (RPS) | V | V |
| PV requirement in RPS | V | V |
| Investment funds for PV | | |
| Income tax credits | | |
| Net metering | | |
| Net billing | | |
| Commercial bank activities e.g. green mortgages promoting PV | | |
| Activities of electricity utility businesses | V | |
| Sustainable building requirements | V | |

If relevant, please provide a brief description of **one** interesting PV financing scheme currently operating in your country in Table 10a.

**Table 10a: PV financing scheme**

| PV financing scheme |
|---|
| |

## 4.1 Indirect policy issues

Korea's energy consumption has increased sharply since the mid-1970s due to rapid economic growth propelled by the heavy and chemical industries. Total primary energy consumption, which stood at 43,9 million toe in 1980, increased more than six-fold to 277,7 million toe in 2012 (ninth-largest energy-consuming nation in the world). Korea's energy consumption per capita also increased dramatically form 1,1 toe in 1980 to 5,786 toe in 2012. With poor indigenous energy resources, Korea has to rely almost entirely on imports to satisfy the nation's energy demand. In 2011, the dependency rate on imported energy, including nuclear energy, was 96,4%. The cost for imported energy amounted to 172,5 billion US$, which accounted for 32,9% of total inbound shipment. Korea's energy resources are limited to low-quality anthracite, which accounted for less than 1% of total primary energy supply. Energy security with ever-increasing energy demand is one of the Korea's upmost concerns. Importantly, Korea has experienced severe shortage in electricity in the

last two years (2011-2012) with a rolling black-out on September 15, 2011 in the capital city of Seoul.

Considering that the energy sector is responsible for the major part of the greenhouse gas emissions in Korea, the Government has adopted "Low-carbon Green Growth" as the nation's major agenda, holding campaigns to reduce economy's dependence on oil and gas imports and tackle greenhouse gas emissions.

The total budgets for PV programs amounts 799,2 billion KRW in 2012. Korean government released the "Green Energy Strategy Roadmap 2011" to strategically steer the development of green energy industry. It is the second version, following of the first version in 2009. According to the plan, Korea aims to expand its green energy industry to occupy the global market share up to 18%, and reach 328 trillion KRW in exports by 2030. Strategies of the 2011 roadmap newly include the nurturing of world-class small and mid-sized enterprises, putting more efforts on the technology convergence, and strengthening the role of the public sector.

All the above will undoubtedly make a great impact on the promotion of PV market in the near future. In particular, the PV emerges as one of the key sector for the Government's long-term vision in favour of "Low-carbon Green growth." PV industry was designated as one of the nation's most important "New Growth Engine Industries."

In 2012, the Government has adopted two market-based regulations - the Renewable Portfolio Standards (RPS) and the Emission Trading System (ETS). The RPS scheme, already in operation, will require power producers with a capacity greater than 500 MW to generate 2% of their total power from renewable energy sources and raise it to 10% by 2022. "The Enforcement Decree of Allocation and Trading of Greenhouse Gas Emissions Allowances Act (the ETC Act)" was passed in the Cabinet meeting on November 13, 2012. MOE (Ministry of Environment) will be responsible for the overall governance of the scheme, and the ETS master plan will be published by the end of 2013, which will serve as a legal basis of the scheme. The master plan will be revised every five years and provide a 10-year plan for the operation of the market.

The Government is also strengthening the regulations on building energy efficiency, introducing building's Energy Efficiency Ratings. New building's NRE mandate percentage will increase continuously up to 20% by 2020.

A study on the externalities and hidden costs of conventional energy and nuclear electricity generation when compared to renewable energy has started in 2012 by KEEI (Korea Energy Economics Institute).

KETEP (Korea Institute of Energy Technology Evaluation and Planning) is preparing the Vision Roadmap for PV in 2013, which will provide a picture on future strategy to reach the Grid Parity with proper policy measures.

KISTEP (Korea Institute of Science & Technology Evaluation and Planning) and KISTI (Korea Institute of Science and Technology Information) are conducting projects to analyse all the nationally funded PV research in order to steer the national PV R&D more productive. KISTEP will publish the "PV Technology Investment Map" in 2013, while KISTI will construct a web-based "PV Technology Information Analysis Platform," in 2013.

The MOFA (Ministry of Foreign Affairs) is operating the GECC (Global Energy Cooperation Centre) to support overseas activities of Korean green energy enterprises, and the KOICA (Korea International Cooperation Agency) is continuing its PV power plant construction projects for developing countries as a mean of economic cooperation.

Since the launch of the new government in 2013, the Government announced "The Sixth Basic Plan for the Long-term Electricity Supply and Demand" and is currently preparing "The Second Energy Basic Plan" together with the "The Fourth Basic Plan for the Promotion of Technological Development, Use, and Diffusion of New & Renewable Energy." The MOTIE has recently prepared "The Comprehensive PV Industry Development Plan," too.

All these plans have a vision to strengthen the NRE industry development and expand the NRE deployment. Concrete plans with detailed goals will be available by the end of 2013.

## 4.2 Interest from electricity utility businesses

From the year 2012, the RPS (Renewable Portfolio Standards) began to replace the FIT scheme applicable until 2011. Total thirteen companies including 6 electricity generation companies, electricity generation business companies and two other corporates have participated in the RPS in the first fiscal year of RPS.

In 2012, only 64.7% of the first year's RPS duties were attained, while 95.7% of RPS PV set-aside amounts were attained. This caused the cost of REC (Renewable Energy Credit) for PV drop significantly. The electricity utility businesses would like to have more PV to replace the non-PV RPS to lower the cost and fulfil their duties.

In RPS scheme, REC weighting factor is introduced to balance the utilization/dissemination and promotion of technology development. In determining the PV REC weighting factors, considerations were given to address the following four issues: 1. Influence on environment, technology development and industry revitalization, 2. Cost in electricity generation, 3. Potential amount, 4. Effect on greenhouse gas emission reduction. In practice, however, there exist some mismatches and conflicts to hinder the RPS participants from fulfilling their duties. Some regions with large potential PV source have either low REC weighting factor or under strict regulation. The first year's RPS practice revealed many of these problems encountered by the electricity utility businesses.

Electricity utility businesses in general are still hesitant to participate aggressively in the PV deployment and are asking for more support from the Government. Complementary measures are under preparation in 2013 to resolve some of the issues surfaced in 2012.

## 4.3 Interest from municipalities and local governments

Many 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'.

The Capital city, Seoul has been campaigning "One Less Nuclear Power Plant for Seoul" since 2011 and is conducting many programs to reduce the electricity demand and increase the amount of NRE usage. In this plan, total 320 MW of PV power will be supplied in Seoul by 2014. Seoul recently revived a modified type of FIT scheme to facilitate the PV deployment.

Chungbuk Province's slogan is "A Land of Life and Sun." In this province, more than 50% of Korean-made PV modules are produced. This province has a goal of installing 170 MW of PV power by 2013 and constructing a PV R&D hub in the province. KIER (Korea Institute of Energy Research) is located in the neighbouring metropolitan city, Daejeon.

The metropolitan city, Daegu is advocating "Solar City" as its slogan, and hosting many world renowned international meetings, conferences and expos. Recently, Daegu hosted "Solar City Congress," and has been regularly hosting IGEEC (International Green Energy Expo and Conference) every year. In 2013, the "22nd World Energy Congress" will be held in Daegu.

Solar Cell/Module RIC (Regional Innovation Centre) is located in Yeungnam University in the neighbouring Gyeonbuk province which also emphasizes Green Energy Industry as its new growth engine industry. Daegyeong PV test-bed located at GERI (Gumi Electronics & Information Technology Research Institute) also resides in Gyeonbuk Province.

Jeonnam Province selected "NRE Industry" as one of its major leading industries of the region and has invested its resources to promote PV industry development and PV deployment. Jeonnam province has the best sun-light source in Korea. Honam PV test-bed at Jeonnam technopark and KITECH (Korea Institute of Industrial Technology) Jeonnam Branch are both located in the neighbouring city, Gwangju. SRIGET (South-western Research Institute of Green Energy Technology) is also located in the neighbouring city, Mokpo.

## 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 designated as CBTL (Certification Body Testing Laboratory) for inverters and crystalline PV modules. The use of certified products is obligatory for the government-subsidized PV systems.

KNREC governs the "NRE Standardization Programs" and provides service on "Certification of NRE Systems" and "Certification of Buildings Using NRE."

# 5 HIGHLIGHTS AND PROSPECTS

Since the largest annual installation of 276 MW in 2008, the PV installation during following three years became stagnant, installing only about 156 MW in 2011. However, from the year 2012, the RPS implementation became in effect, and the PV market resumed its capacity to 230 MW.

The Korean government's expenditure on PV R&D and market promotion continued to grow in the past five years, and as a result, a sound supply chain in crystalline Si PV industry is constructed domestically. Development and commercialization efforts on second generation thin film solar cells are also actively pursued by the major companies in Korea. Efforts on the infrastructure building such as test-beds, certification and standardization and human resource development are systematically continued.

In accordance with the global PV booming and the Government's strong drive policy, many companies have entered into the PV industry until 2010. Due to the last two years of difficult global environment surrounding PV industry, several PV companies shut down its operation, delayed further investment, and some of them became finally bankrupt in 2011 and 2012. Nonetheless, the PV feedstock, wafer and module production showed a big increase, and thus total PV sales increased significantly compared with the previous year. Export is still the main workforce in PV industry.

With the upcoming fourth NRE development plan, Korea will continue its strong initiatives in developing PV industry as the nation's second semiconductor industry.

## 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/ as of January 14, 2013)

Household (low voltage less than 3 kW)

| **Fixed rate per home (KRW/household)** | | **Electricity rate per kWh (KRW/kWh)** |
|---|---|---|
| less than 100 kWh | 400 | 59,10 |
| 101~200 kWh | 890 | 122,60 |
| 201~300 kWh | 1 560 | 183,00 |
| 301~400 kWh | 3 750 | 273,20 |
| 401~500 kWh | 7 110 | 406,70 |
| More than 500 kWh | 12 600 | 690,80 |

Commercial A (contracted power greater than 4 kW and less than 300 kW)

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

| | | **Basic rate per kW (KRW/kW)** | **Electricity rate per kWh (KRW/kWh)** | | |
|---|---|---|---|---|---|
| | | | **Summer 7~8** | **Spring Autumn 3~6, 9~10** | **Winter 11~2** |
| Low Voltage | | 5 720 | 76,80 | 57,90 | 74,30 |
| High Voltage A | Option I | 6 200 | 84,50 | 63,90 | 83,80 |
| | Option II | 7 140 | 80,00 | 59,40 | 78,00 |
| High Voltage B | Option I | 5 740 | 83,40 | 62,80 | 82,40 |
| | Option II | 6 600 | 79,00 | 58,30 | 76,70 |

2) Typical household electricity consumption (kWh): about 5 221 kWh/yr (KEPCO in Brief, December, 2012)

3) Typical metering arrangements and tariff structures for electricity customers: one month-of-use tariff

4) Typical household income: 48.5 Million KRW/yr (http://kosis.kr/, February, 2013)

5) Typical mortgage interest rate: 4,6%/yr

6) Voltage (household, typical electricity distribution network): 220 Volt a.c. (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: 1 806 KRW per liter (KEEI Monthly Energy Trend, August, 2013)

9) Typical values of kWh / kW for PV systems in parts of your country: 1 258 (annually) (New & Renewable Energy Statistics 2012, KEMCO, December, 2012)