

**International Energy Agency**

**CO-OPERATIVE PROGRAMME**

**ON**

**PHOTOVOLTAIC POWER SYSTEMS (IEA-PVPS)**

**Task 1**

Exchange and dissemination of information on PV power systems

**National Survey Report of  
PV Power Applications in Korea  
2007**

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## ***i Foreword***

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the organisation for Economic Co-operation and Development (OECD), which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

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

The 21 participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia, Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey, the United Kingdom (GBR) and the United States of America (USA). The European Commission and the European Photovoltaic Industry Association are also members.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (tasks) is the responsibility of Operating Agents. Eleven tasks have been established and currently seven are active. Information about these tasks can be found on the public website [www.iea-pvps.org](http://www.iea-pvps.org).

The objective of Task 1 is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems.

## ***ii Introduction***

This 2007 National Survey Report gives an overview of the key developments and achievements in the field of photovoltaics (PV) in Korea during the year 2007. All the information in this report was provided by various organizations involved in the photovoltaic power systems in Korea. These organizations include industry, government organizations, research institutes and academia. This report is prepared every year for information dissemination and for International Survey Report (ISR) on PV power applications.

## ***iii Definition, symbols and abbreviations***

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

Demonstration Programme: Programme to demonstrate photovoltaic (PV) electricity production to various potential users/owners.

Field Test Programme: Programme to test the performance (eg yield and reliability) of photovoltaic (PV) systems/components in real conditions.

Final annual yield: Total photovoltaic (PV) electricity delivered to the load during the year per kW of rated PV power installed.

Grid-connected centralized PV system: Power production system performing the function of a centralized power plant. 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.

Grid-connected distributed PV system: System installed to provide electricity 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 customer (demand) side of the electricity meter, on public and commercial buildings, or simply in the built environment. They may be specifically designed for support of the utility distribution grid.

Market deployment initiative: Set of means to encourage the market deployment of PV through the use of market instruments such as green pricing, feed-in tariffs, tax credits, capital subsidies etc. These may be implemented by government, the finance industry, utilities, etc.

Off-grid domestic PV system: System installed to provide power mainly to a household or village not connected to the (main) electricity 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 'micro-grid', often as a hybrid with another source of power.

Off-grid non-domestic PV 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 system'.

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 rated PV power.

Photovoltaic (PV) module manufacturer: An organisation carrying out the encapsulation of PV cells in the process of the production of PV modules.

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

Photovoltaic (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 (if any) and all installation and control components with a PV power capacity of 40 W or more.

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

Rated power: Available power delivered by a PV module or array under standard test conditions (STC), written as W.

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 telecommunications system in a remote area are excluded).

KERI: Korea Electrotechnical Research Institute\_

KEMCO: Korea Energy Management Corporation

KEPCO: Korea Electric Power Corporation

KIER: Korea Institute of Energy Research

KPVDO: Korean Photovoltaics Development Organization

KRW: Korean Currency, Korean Won. One thousand KRW approximately corresponds to 1 USD.

MOCIE: Ministry of Commerce, Industry and Energy

KATS : Korea Agency for Technology and Standards

MOST: Ministry of Science and Technology

NRSE: New and Renewable Sources of Energy

## **1 Executive summary**

Korea has been making a strong effort to increase the renewable energy portion of “energy mix” to achieve the goal that was announced in December 2003. Korea’s renewable energy is targeting to take 5% of the total energy consumption by 2011. Currently the renewable energy estimated to account for about 2,26% of total energy. The special feature in Korean PV applications during 2007 was the remarkable increase in the amount of grid-connected systems installed, especially grid-connected centralized one, whereas there was no increase in the installed PV power of off-grid domestic and non-domestic sectors in comparison to the previous year. This means the main market for PV in Korea has been moving toward the grid-connected applications and the Korean national PV programme favors the installation of grid-connected PV. The Korean PV programme has strongly supported the area of installation, R&D investment, standards and accreditation. In 2007, some Korean companies entered into crystalline Si cell manufacturing business newly with the production capacity of a few tens MW and one company also began to construct a Si thin film PV module line.

- Installed PV power

The cumulative installed power of PV system in Korea tremendously increased to 77,6 MW by the end of 2007. Annual installed power in 2007 has reached 42,9 MW, which was more than two times higher than that achieved in the previous year.

The share of grid-connected distributed system increased to 92% of the total cumulative installed power from 83% in the previous year.

Whereas the grid-connected distributed system shows a sharp increase in the share of installation, the cumulative share of off-grid non-domestic and domestic system decreases to about 8% of total cumulative installed power because there is no increase in annual installed PV power of the off-grid systems in 2007.

- Cost & price

The module price was in the range of 3 900 to 4 100 KRW/W depending on the manufacturing company and the order volume. The average PV module price of 4 000 KRW/W in 2007 was about 10% off compared to that in the previous year. According to the type of the installed PV system, the price of grid-connected systems varied from 7 505 KRW/W to 9 083 KRW/W. The price of the 3 kW rooftop system was 8 400 KRW/W in 2007, slightly lower than 8 550 in 2006.

- PV production

During 2007, KPE, only one cell producer in Korea produced 25 MW of PV cells in a total annual production capacity of 36 MW. In 2008, however, new cell producers are expected to appear in Korea cell market. Hyundai Heavy Industry and Millinet Solar have been constructing the crystalline Si cell manufacturing line with 30 MW, respectively and will begin the production of PV cells within 2008. Korea Iron & Steel Co. also plans to produce Si thin film cell with annual production capacity of 20 MW in the second half of 2008. Nine companies produced only 52,9 MW of PV module with total annual production capability of 191 MW due to PV cell supply problem. It is expected that Korean module manufacturers will produce more than 100 MW next year. For module production, most of single and multi-crystalline silicon PV cells were imported from Japan and Germany.

- Budget for PV

The total budget for PV was 122 191 million KRW in 2007. The separate budget in 2007 for R&D, and market incentives were 17 065 million KRW and 105 126 million KRW respectively. The budget allocated for market incentives of rooftop PV system was 49 000 million KRW as in 2006.

## **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.

### **2.1 Applications for photovoltaics**

For the off-grid non-domestic and domestic systems, there was no increase in annual installation in 2007 and therefore the total cumulative shares of these sectors decreased sharply to 6.4% and 1.3%, respectively. Although the off-grid non-domestic sector has been major market in Korea until 2002, it is no longer an interesting area of major PV module manufacturers and system companies.

In 2007, under 100 000 roof-top program, 7 313 systems with a total capacity of 9 245 kW were installed for single-family houses and public rental apartments. Under the feed-in-tariff scheme, 119 new commercial PV power plants of 28 632 kW in total ranging 3 kW ~ 3 MW were operating. Among them large scale-PV systems exceeding 1 MW were 13. The largest one is 3- MW capacity which was set up and operated by Dongyang Energy PV power owned by Dongyang Energy Co.

Whereas the share of grid-connected distributed system decreased slightly from 52.5% in 2006 to 42% in 2007 of the total cumulative installed power. The share of grid-connected centralized one was raised to 50% in 2007 compared to 30.1% in 2006. The total installed power of these sectors were 14 236 kW and 28 632 kW, corresponding to 33% and 67% of the total annual PV market in 2007.

### **2.2 Total photovoltaic power installed**

The PV power installed in 4 sub-markets during 2007 should be entered in Table 1.

**Table 1 - The PV power installed in 4 sub-markets during 2007.**

Sub-market/application	off-grid domestic	off-grid non-domestic	grid-connected distributed	grid-connected centralized	total
PV power installed in 2007 (kW)	-	-	14 236	28 632	42 868

The total cumulative installed PV power for each sub-market as of the 31 December of each year from 1994 is shown in Table 1 and Figure 2.

The total installed power of PV systems in Korea was 77 601 kW by the end of 2007. The total PV power installed during 2007 was 42 868 kW, which is over two times higher than that achieved in the previous year (21 209 kW).

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

Sub-market/ application	31 Dec. 1994	31 Dec. 1995	31 Dec. 1996	31 Dec. 1997	31 Dec. 1998	31 Dec. 1999	31 Dec. 2000	31 Dec. 2001	31 Dec. 2002	31 Dec. 2003	31 Dec. 2004	31 Dec. 2005	31 Dec. 2006	31 Dec. 2007
	kW													
off-grid domestic	175	219	256	296	306	316	528	608	608	628	753	853	983	983
off-grid non- domestic	1 506	1 550	1 757	2 046	2 410	2 855	3 076	3 625	4 041	4 382	4 606	4 810	4 960	4 960
grid- connected distributed	0	0	100	133	266	288	356	524	761	971	3 175	6 551	18 323	32 559
grid- connected centralized	0	0	0	0	0	0	0	0	0	0	0	1 310	10 467	39 099
<b>TOTAL</b>	<b>1 681</b>	<b>1 769</b>	<b>2 113</b>	<b>2 475</b>	<b>2 982</b>	<b>3 459</b>	<b>3 960</b>	<b>4 757</b>	<b>5 410</b>	<b>5 981</b>	<b>8 534</b>	<b>13 524</b>	<b>34 733</b>	<b>77 601</b>

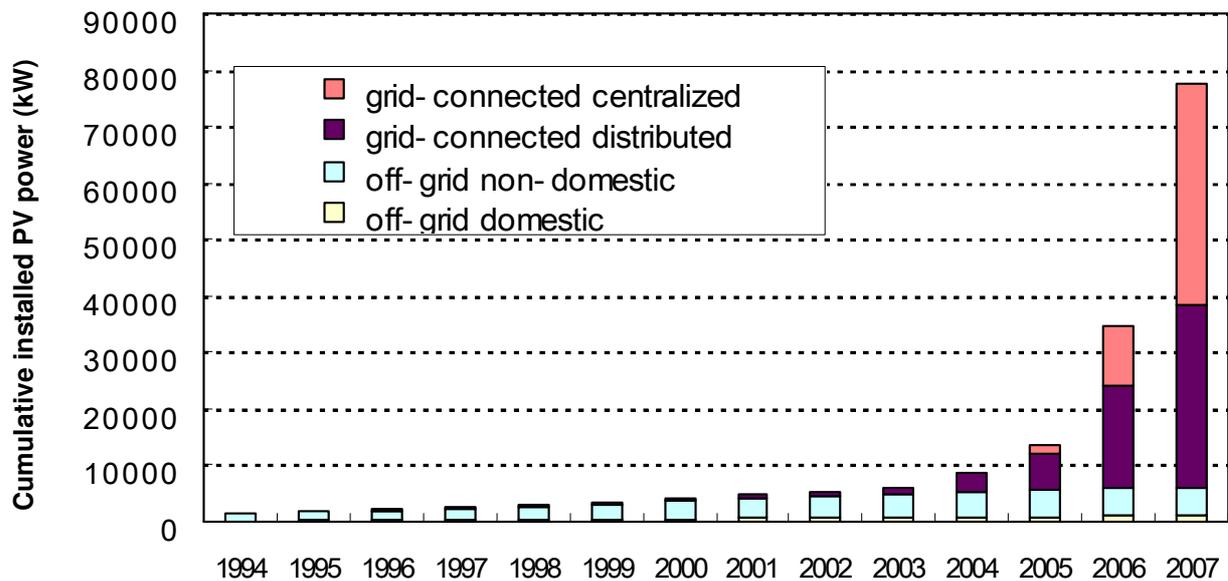


Figure 1 : The cumulative installed PV power in 4 sub-markets

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

The Ministry of Commerce, Industry and Energy (MOCIE) has been implementing, via KEMCO, demonstration and field test of various renewable energy technologies. In 2003, the 2<sup>nd</sup> 10-year basic plan for NRE RD&D was established 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 the plan is to achieve 3,0 % share of total primary energy supply with NRE by 2006 and 5,0 % by 2012. PV was selected as one three major areas as well as wind power and hydrogen & fuel cell. The government appointed Korea University as an organization for planning and managing PV R&D programs and established the Korea Photovoltaic Development Organization (KPVDO, President Donghwan Kim) in 2004. Korea plans to secure 7 % of world PV market share through utilizing the infrastructure and the resources of semiconductor and display industries where Korea has a world-class leadership and also has plans to install 1 300 MW of PV by 2012.

- **Rooftop Program:** The target of this program is to install 100 000 rooftop PV systems until 2012. The Government supports 60 % of total system price for single-family house and 100 % for public rent apartments. In 2007, 7 313 systems with a total capacity of 9 245 kW were for single-family houses and public rent apartments with a total budget of 49 000 million KRW.
- **Feed-in Tariff Program:** The Feed-in Tariff (FIT) rate per kW-hr was 677,38 KRW and 711,25 KRW for systems larger and smaller than 30 kW, respectively. This scheme has a ceiling of cumulative 100 MW since Oct. 2006 and is guaranteed for 15 years for the PV system over 3 kW. In 2007, a total of 28 632 kW was installed under this scheme, and the annual spending was 14 772 million KRW.

- **General Deployment Program:** The government supports 60% of installation cost. In 2007, 159 PV systems with a total of 3 996 kW were installed. Various grid-connected PV systems with a power capacity of 5 ~ 200 kW were installed in schools, public facilities, welfare facilities and universities.
- **Public Building Obligation Program :** New public buildings larger than 3 000 sq meter must spend 5% of total construction budget in installing renewable facility. This program started in 2004. Up to November, 2006, a total of 349,1 kW PV systems was installed. In 2007, a total of 5 901 kW PV was installed. As the government pursues for “New Administration-Oriented City Plan” and “Plan for Public Enterprise Relocation”, new public buildings are planned all over Korea and thus this program will have to contribute a lot to the expansion of Korea PV market.
- **Local Deployment Program:** Under the local energy development project, a wide variety of PV systems were constructed including PV on public buildings of local authorities. Until the end of 2007, about 10 MW PV systems have been installed. This program aims at increasing public awareness on PV and developing PV as an indigenous renewable energy source for their region. The government supports 60 % of total system price, and the remaining 40 % is shared by local authorities and beneficiary. It is worthy to note that several local authorities finished “Green Village” projects which were mainly composed of PV, solar thermal, geothermal and wind power by the end of 2006. In 2007 several metropolitan cities such as Seoul, Daegu, Gwangju, Ulsan announced the plan to build the “Eco-friendly innovation cities” employing renewable technology.

## **2.4 Highlights of R&D**

Korea’s PV R&D program is led by the KPVDO since 2004. The Government commissioned the planning and management of R&D projects with KPVDO. Previously, Korea Energy Management Corporation (KEMCO) was playing the leading role. The program mostly consists of industry-oriented research works. Nineteen projects have been carried out by a lot of companies, national research institutes and universities and they was focusing on developing manufacturing technologies for solar cells, ingot & wafer, BIPV modules and power conditioning systems including inverter. Major R&D programs in 2007 were listed in Table 2a.

**Table 2a - R&D, infrastructure-establishment and demonstration/field test programs progressing in 2006**

Title	Period	Budget(Million KRW)	Contractor
Low cost, high efficiency bulk Si Solar cell Manufacturing	Sep.2004~Aug . 2007( 3years)	7 275	Samsung SDI
Low cost, high quality Solar grade Single crystalline Si wafer	Sep.2004~Aug . 2007( 3years)	4 800	LG Siltron
Poly Si manufacturing	Aug.2006~July 2009 (3years)	32 660	DCC

130-micron thick Si solar cell technology	Aug.2006~July 2009 (3years)	14 750	LG Chem
Dye-sensitized sub-module development	Dec.2006~Nov . 2009 (3years)	4 320	KIST
BIPV Module Manufacturing	Sep.2004~Aug . 2007( 3years)	5 387	KIER
Low cost, Stable ZnO electrode	Dec.2004~Dec . 2007( 3years)	2 009	Korea Univ.
100KW Bi-modal PCS	Aug.2006~July 2008 (3years)	2 151	Ewha Electric
Roof-integrated PV module	Dec.2004~Dec . 2007( 3years)	2 766	S-Energy
PV Power Standardization	Sep.2004~Aug . 2007( 3years)	272	KIER
Residential PV system optimization	Dec.2006~Nov . 2008 (2years)	1 068	KIER
1MW PV System Demonstration	Nov.2004~Oct. 2007( 3years)	9 978	Seoul Marine
Multi Si Ingot manufacturing	Dec.2005~Dec .2007(2years)	2 596	Glosil
CIGS thin film mini module	Dec.2005~Dec .2007(2years)	1 200	KIER
Transparent, Insulating BIPV Module for a-Si Cell	June.2007~Ju ne.2010(3year s)	1 687	Kolon Construction
Durability of Field aged Module	June.2007~Ju ne.2010(3year s)	1 450	KIER
Thin Film Si Module	Aug.2007~July .2010(3years)	8 947	LG Electronics
Spherical Si Cell	Nov.2007~Oct. 2009(2years)	1 600	TPS

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

The government budget in 2007 for R&D was 17 065 million KRW as shown in Table 3. The public budget allocated for market stimulation was 105 126 million KRW in 2007. Local authorities provided 6 012 million KRW for the implementation of PV Deployment Program. The incentives were offered to individuals and private companies that applied for the construction of rooftop or BIPV systems through Deployment Program. The government provided low-interest loans every year for renewable energy production or PV system application facilities.

**Table 3 - Public budgets for R&D, demonstration/field test programs and market incentives in 2007.****(Million KRW)**

<i>currency name</i>	R & D	Demo/Field test	Market
National/federal	17 065 MKRW	-	99 114 MKRW
State/regional	-	-	6 012 MKRW
Total	17 065 MKRW	-	105 126 MKRW

### 3 Industry and growth

#### 3.1 Production of feedstocks and wafers

In 2007 there was no production of feedstock. The Dongyang Chemical Co., (DCC) is scheduled to start the commercial production of polycrystalline silicon feedstock in 2008, with an annual capacity of 5 000 tons. The basic procedure of polycrystalline silicon production is as follows ; Raw material Feed (MG-Si) → Silane Production → TCS Purification → CVD Reactor → Polysilicon. The quality of silicon is to be purer than 9 nine. DCC will expand its production capacity to 15 000 tons per year in 2008.

Woongjin Energy established through a joint venture with Woongjin Group and US- based Sunpower started single crystalline silicon ingot production in 2007.

In wafer area, LG Siltron which has set up 10 MW pilot production line in 2006 using electronic-grade ingot off-spec. produced 4 MW single crystalline silicon wafers.

In addition, several small size companies such as REXOR, Glosil, Neosemitch, etc. entered into silicon ingot and wafer production in 2007, as can be seen in Table 4.

**Table 4 - Production and production capacity information for the year for silicon feedstock, ingot and wafer producers**

Manufacturer	Process & technology	Total Production	Maximum production capacity	Product destination	Selling Price
DC Chemical	Silicon feedstock	-	5000 ton	-	-
Woongjin Energy	sc-Si ingots	N.A.	1400 ton	N.A.	N.A.
REXOR	sc-Si ingots	80 ton	80 ton	N.A.	N.A.
Glosil	mc-Si ingots	-	43 ton	-	-
Neosemitch	sc-Si ingots/wafers	N.A.	120 MW	N.A.	N.A.
Smart Applications	sc-Si ingots/wafers	N.A.	30 MW	N.A.	N.A.

Qualiflow Naratech	mc-Si ingots/wafers	3 ton	15 MW	N.A.	N.A.
LG Siltron	sc-Si wafers	4 MW	10 MW	N.A.	N.A.

### **3.2 Production of photovoltaic cells and modules**

In 2007, the KPE was still the only one solar cell producer in Korea. This company produced 25 MW of PV cells with an annual production capacity of 36 MW, and its technology is based on single crystalline silicon wafer with an average cell efficiency of 16.5 %. This company is expected to expand its production capacity focusing on polycrystalline silicon solar cells. In 2008, there will be more cell producers. The Hyundai Heavy Industry and Millinet Solar, Shinsung Eng. have been constructing the crystalline Si cell manufacturing line with 30 MW, 30 MW and 50 MW, respectively, and will begin their production in 2008. The Korea Iron & Steel plans to produce amorphous Si thin film cell with annual production capacity of 20 MW in the second half of 2008.

Nine companies produced 52,9 MW of PV module with an annual production capacity of 188 MW. Due to PV cell supply shortage, the production was far below the production capacity. For module production, most of single and multi-crystalline silicon PV cells were imported from Japan and Germany. Korean module manufacturers will produce more than 100 MW in 2008.

The S-Energy manufactured several types of conventional modules with a peak output of 80 to 200 W and special BIPV modules for façade and atrium applications. This company is a leading PV system integrator and installer. This company installed large sized laminator for the manufacturing of large sized modules with the R&D program on roof-integrated PV modules with construction material manufacturer.

The Hyundai Heavy Industries and Symphony Corp. were very active to export market development and made several supply contracts with foreign customers in 2007. In order to export, some companies have obtained certificate from foreign organization such as TUV.

The module price was in the range of 3 900 to 4 100 KRW/W depending on the manufacturing company and the order volume. The average PV module price of 4 000 KRW/W in 2007 was about 10% off compared to that in the previous year as shown in Table 6.

**Table 5 - Production and production capacity information for the year for each manufacturer**

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW)	
		Cell	Module	Cell	Module
KPE	sc-Si	25		36	
Hyundai Heavy Industry	sc-Si		20		30
Symphony Energy	sc-Si/mc-Si		11		70
S-Energy	sc-Si		9.5		30

KD Solar	mc-Si		6		20
Unison	sc-Si		3		10
LS Industrial Systems	sc-Si		2.5		10
Hae Sung Solar	sc-Si		0.5		10
Solar Tech	sc-Si		0.36		5
ETA Solar	sc-Si		0.005		3
TOTALS		25	52.9	36	188

Table 6 – Typical module prices for a number of years

Unit :Thousand KRW/W

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Standard module price(s): Typical	9,4	8,2	8,5	9,2	7,5	7,1	7,2	7,2	7,0	4,6	4,6	4,4	4,0
Best price													3,9

### 3.3 Manufacturers and suppliers of other components

The Hex Power Systems is a leading company in grid-connected inverter business. Since 2006, several new companies such as Willings, Hanyang Electric and Dathtech have entered grid-connected inverter market. Due to new suppliers and imported products from SMA, Fronius, price of PV inverters have decreased continuously in 2007 as listed in Table 6a. Domestic manufactures supplied mainly for residential PV systems less than 10 kW and foreign companies were active in inverters for over 100 kW PV power system. SMA was a leading supplier for larger inverters in Korean market.

Table 6a - Price of inverters for grid-connected applications.

Size of Inverter	<1 KVA	1-10 KW	10-100 KW	>100 KW
Average Price per	N.A.	560	470	400

kVA (1 000 KRW)				
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### 3.4 System price

During 2007, no off-grid systems were installed in Korea. The price of 3 kW-capacity grid-connected systems was 8 400 KRW/W which was slightly reduced from 8 550 KRW/W of the previous year.

Table 7a shows the price trends of a typical 3 kW-capacity PV rooftop system.

For general deployment program, the KEMCO offers the standard installation prices of grid-connected PV systems smaller than 50 kW depending on system applications. In 2007, the standard price is 9,55 million KRW per kW for fixed PV system, 11,7 million KRW per kW for tracking system and 14 million KRW per kW for BIPV system. Higher price setting is expected to activate BIPV market combined with Public Building Obligation Program.

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

Category/Size	Typical applications and brief details	Current prices per W (to one decimal point)
OFF-GRID Up to 1 kW	-	-
OFF-GRID >1 kW	-	-
GRID-CONNECTED Specific case	3 kW roof-mounted system	8 400
GRID-CONNECTED (distributed) Up to 10 kW	PV Power plant, roof-mounted system	9 083
GRID-CONNECTED (distributed) >10 kW	PV Power plant, Public building, Multi-family apartment	8 113
GRID-CONNECTED (centralized) >100 kW	Centralized PV Power plant	8 194

GRID- CONNECTED (centralized) >1000 kW	Centralized PV Power plant	7 505
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**Table 7a: National trends in system prices for 3 kW-capacity residential rooftop system.**

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2005	2006	2007
Price : (KRW/W)	18 000	16 700	15 700	14 700	14 300	13 700	12 000	9 800	9 800	8 550	8 400

### **3.5 Labor places**

The estimated full-time labor place equivalents in PV related activities are as follows:

- Public research and development (not including private companies); 150
- Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D; 1 166
- All other, including within electric companies, installation companies etc.; 300

### **3.6 Business value**

The value of PV business in Korea was estimated to be 305 126 million KRW. This value was calculated from the module shipment plus PV power installed to which PV cell export was added and from which PV cell and module import was subtracted.

**Table 8 – Value of PV business**

Sub-market	Capacity installed in 2007 (kW)	Price per W (KRW/W)	Value (MKRW)	Totals (MKRW)
Off-grid domestic	-	-	-	
Off-grid non-domestic	-	-	-	
Grid-connected distributed	14 236	8 400	119 582	
Grid-connected centralized	28 632	7 781	222 786	
				342 368
Export of PV products				92 865
Change in stocks held				N.A.
Import of PV products				130 107
				<b>Value of PV business</b>
				305 126

## **4. Framework for deployment (Non-technical factors)**

#### **4.1 Support measures and new initiatives**

**Table 9 – PV support measures**

	Ongoing measures	Measures that commenced during 2007
Enhanced feed-in tariffs	V	
Capital subsidies for equipment or total cost	V	
Green electricity schemes		
PV-specific green electricity schemes		
Renewable portfolio standards (RPS)		
PV requirement in RPS		
Funds for investment in PV		
Income tax credits		
Net metering		
Net billing		
Commercial bank activities eg green mortgages promoting PV		
Electricity utility activities eg network support		
Sustainable building requirements		

- Utility perception of PV

The Feed-in Tariff (FIT) rate per kW-hr was 677,38 KRW and 711,25 KRW for systems larger and smaller than 30 kW, respectively. This scheme has a ceiling of cumulative 100 MW since Oct. 2006 and is guaranteed for 15 years for the PV system over 3 kW. This scheme will be revised in 2008 because the ceiling of 100 MW will be reached sooner or later.

- Renewable Portfolio Agreement (RPA)

Utility companies are asked to adopt renewable energy in their total power supply. The program is not mandatory as is the case with the renewable portfolio standard (RPS). In 2007, Korea Western Power Co. completed one 2 MW system in Miryang city, and Korea Hydro & Nuclear Power Co. completed one 1,25 MW system in Yeonggwang under this program.

#### **4.2 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.

#### **4.3 Standards and codes**

There are 17 Korean Standards (KS) related to the qualification of PV components such as solar cells and modules, batteries, and power conditioners. One of them is related to the

performance evaluation of stand-alone systems. The certification program for inverter and crystalline silicon PV module has been implemented since 2005. For the Government-supported PV systems the certified products should be obligatory used. New standardization and codes are under investigation basically for matching the global standards such as IEC TC 82 under the responsibility of Korea Agency for Technology and Standards (KATS). KATS and NREC have been working together to prepare guidelines and regulations before starting the massive dissemination of PV system.

## **5     *Highlights and prospects***

During 2007, the annual installed capacity exceeded about 40 MW, which was mainly due to the tremendous growth of grid-connected PV market. The 100 000 rooftop and feed-in-tariff programmes played a major role. It is expected that the Korean Government will continue to support the PV R&D and dissemination programmes in order to attain the cumulative deployment target of 1,3 GW by the year 2012.

In accordance with global PV boom, many companies are preparing to enter into PV cell and module production. The Korean PV community is expecting the concrete and massive investment of large companies, which have a good technological background in semiconductor and display industry.

**Annex A    *Method and accuracy of data***

All data on installed power, industry status and budgets were obtained from manufacturers, installers, the government and local authorities. To manufacturers and installers a questionnaire was sent. The accuracy of data is  $\pm 7\%$  for the installed PV capacity and  $\pm 5\%$  for the cell/module production. Data on RD & D funding are correct. The number of labor places was estimated from the information collected from many sources.

**Annex B Country information**

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

Please provide the following, including a short reference as to the source of the information (for example, author's estimate, electricity supply association etc):

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

Household

Fixed rate per home		Electricity rate per kWh
less than 100kWh	370 KRW	55,10 KRW
101~200 kWh	810 KRW	113,80 KRW
201~300 kWh	1 430 KRW	168,30 KRW
301~400	3 420 KRW	248,60 KRW
401~500	6 410 KRW	366,40 KRW
More than 500kWh	11 750KRW	643,90 KRW

- 2) typical household electricity consumption (kWh) : about 300
- 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) : 36 Million KRW/ per year
- 5) typical mortgage interest rate : 6~8%/yr
- 6) voltage (household, typical electricity distribution network) : 220 Volt (household)
- 7) electricity industry structure and ownership (eg vertically integrated or separate generation, transmission, distribution?; retailers and network businesses – integrated or separate?; state owned or municipal or private etc?; electricity industry regulator?) : generation and transmission & distribution are separated. The generation part consists of several companies.
- 8) price of diesel fuel (NC) : 1 260 KRW per liter
- 9) typical values of kWh / kW for PV systems in parts of your country. : 1 200 (annually)