

**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  
2006**

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

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. Nine tasks have been established, and currently six are active. Information about the active and completed tasks can be found on the IEA-PVPS website [www.iea-pvps.org](http://www.iea-pvps.org). The new task concerning urban-scale deployment of PV systems is now underway.

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 2006 National Survey Report gives an overview of the key developments and achievements in the field of photovoltaics (PV) in Korea during the year 2006. 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 Definitions, symbols and abbreviations***

For the purposes of the 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 kW/m<sup>2</sup>, cell junction temperature of 25°C, AM 1,5 solar

spectrum – (also see 'Peak power').

Peak 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.

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 in households and villages that are not connected to the utility grid. Usually a means to store electricity is used (most commonly lead-acid batteries). It is also referred to 'stand-alone PV power system'.

Off-grid non-domestic PV power system: System used for a variety of 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. It is also referred to 'stand-alone PV power system'.

Grid-connected distributed PV power system: System installed on consumers' premises usually on the demand side of the electricity meter. This includes grid-connected domestic PV systems and other grid-connected PV systems such as commercial buildings, motorway and sound barriers. These may be used for support of the utility distribution grid.

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

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 telecommunication systems 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, utilities etc.

NC: National Currency (KRW : Korean Won)

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.

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 be about 2,1% of total energy. Korean government increased the renewable energy budget steadily from 196 billion KRW in 2004, 324 billion KRW in 2005 and 409,5 billion KRW in 2006. In 2006, budget was allocated as 124,4 billion KRW for R&D, 137,5 billion KRW for deployment, 121,3 billion KRW for long-term loan and 26,3 billion KRW for feed-in Tariff program. As the third year implementing 10-year Plan, the Korean Photovoltaic Program has made a big progress in the areas of system installation, R&D investment, standards and accreditation. The feed-in Tariff (FIT) rate per kW-hr changed from 716,40 KRW to 677,38 KRW for systems larger than 30kW with a ceiling of cumulative 100 MW since Oct. 2006. Korean PV industry attracted international attention when DCC announced to jump into the polysilicon manufacturing business to tackle the silicon shortage issue.

- Installed PV power

The cumulative installed power of PV system in Korea tremendously increased to 34,7 MW at the end of 2006. After surpassing the 1 MW land mark with a figure of 4,99 MW in 2005 for the first time, annual installed power in 2006 reached 21,3 MW which was more than four times higher than that achieved in the previous year. The major increase came from PV power plants supported by feed-in Tariff and 3 kW residential roof-top application under the 100 000 solar roof program.

The share of grid-connected distributed system increased to 83 % of the total cumulative installed power from 58% in the previous year. In 2006, the annual installed power of this sector was 20,93 MW, representing over 98 % of the total Korean PV market.

After rapid increase of commercial PV power and residential roof-top installation, off-grid non-domestic and domestic sector is not interested by Korea PV industry and cumulative share is decreased year by year and occupied only 17 % of total cumulative installed power. For off-grid domestic application, a total of 130 kW was installed at island sites in 2006 supported by KEPCO, the largest Korean utility company. The share of this off-grid sector decreased to only 2% of the annual installed PV power in 2006.

- Cost & price

The PV module price fell in the range of 4 200 and 4 600 KRW/W depending on the manufacturing company and the order volume. The average PV module price of 4 400 KRW/W in 2006 was a little bit less than that of the previous year. Module price is strongly affected by Chinese product and price offer and this trend will seem to continue in the near future until domestic module manufacturers expand their production to meet Korean market growth. The price of grid-connected systems varied between 8 550 KRW/W and 5 800 KRW/W. The price of the 3 kW rooftop system was 8 550 KRW/W in 2006. Major source of price reduction came from grid-connected inverter area due to competition between domestic manufacturers and import dealers. Inverter price for residential roof-tops dropped to 530 KRW/W in 2006 and expects to decrease further in 2007.

- PV production

In 2006, KPE (former Photon Semiconductor Energy Company) completed the second manufacturing line of 30 MW which has a capability of handling both single and multi crystalline Si wafer with the size of 125 mm and 156 mm on May 2006 and had a total production capacity of 35 MW. Second cell manufacturer, Neskor Solar, with a 2 MW capacity, terminated its operation in 2006. KPE, now only one cell producer, produce 18 MW single crystalline Si cell in 2006. Eight companies produced only 16,9 MW of PV module with total annual production capability of 130 MW due to PV cell supply problem. In spite of limited operation of production line, Symphony energy and Hyundai heavy industries successfully entered into European module market in 2006 and these two companies will expect to increase their production in 2007. Korean module manufacturers plan to produce more than 60 MW in 2007. 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 74 627 million KRW in 2005. The separate budget in 2006 for R&D, demonstration & field test programs and market incentives were 18 785 million KRW, 263 million KRW and 96 694 million KRW respectively, totaling 115 479 million KRW. Especially, the budget allocated for market incentives of rooftop PV system was sharply increased to about 49 000 million KRW in 2006 compared to 16 000 million KRW in 2005.

## **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**

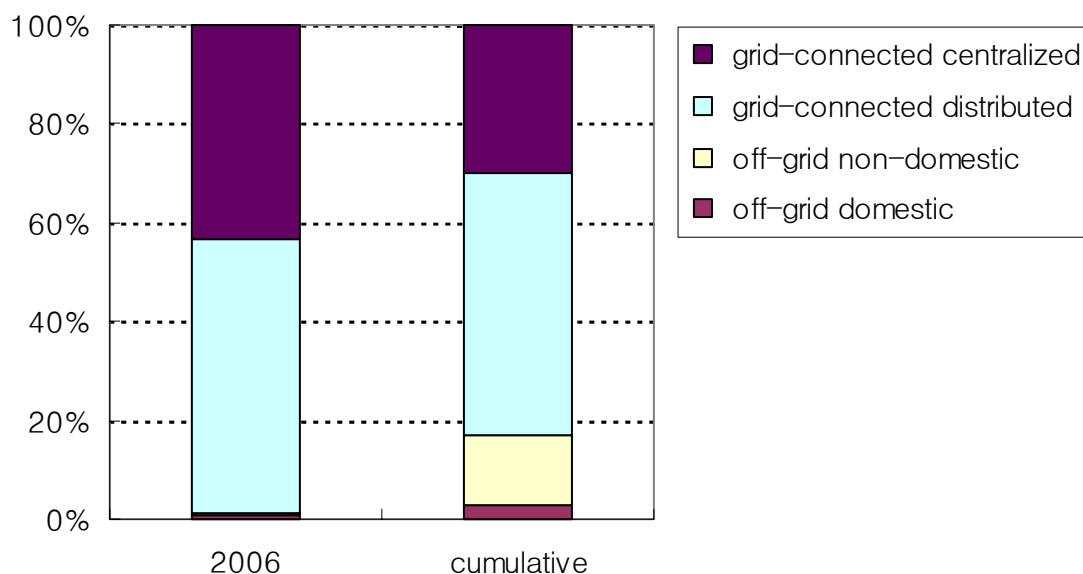
The off-grid non-domestic sector was major PV market until 2002. However, the cumulative share of this sector has been decreasing sharply 14,3 % in 2006 compared from 35 % in 2005 due to a large increase of grid connected distributed sector. Among the various off-grid non-domestic applications, only street-lighting was active in 2006. However, this application was minor sector with annual market size of 150 kW level. Therefore, major PV module and system companies were no longer interested in these areas.

For off-grid domestic application, 130 kW was installed at several island sites in 2006, which were financed by KEPCO. Two projects were Nulok island electrification of 45 kW and Gosa island of 45 kW. The share of this sector decreased again to about 2,8 % of the total cumulative installed PV power.

In 2006, under the 100 000 roof-top program, 2 452 systems with a total capacity of 6 469 kW were for single-family houses, the average capacity being 2,47 kW. In addition, 120 kW system for apartment with 550 households and 3 kW for public rental apartment with 2 962 households were installed. PV system application for multi-family apartment was new one in 2006 and this kind of installation will be more encouraged by Korean residential situation. For feed-in-tariff program, 52 commercial PV power plants of 9 157 kW in total ranging 3 kW ~ 1 MW were newly installed and operating. Four of 1 MW PV plant was installed such as Donghae PV power

owned by Dong seo utility, Young heung PV power owned by Namdong utility, Kangjin PV power owned by Namhae energy and Hanra PV power owned by Hanra Electric Co., LTD. The share of grid-connected distributed and centralized was raised to 52,5 % and 30,1% of the total cumulative installed power. In 2006, the total installed power of this sector was 11 772 kW and 9 157 kW, representing 55 % and 43% of the total annual PV market in 2006.

Figure 1 shows the share of 4 sub-markets during the year 2006 and in total cumulative.



## 2.2 Total photovoltaic power installed

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 34 733 kW as of the end of 2006. The total PV power installed during the year 2006 was 21 209 kW, which is over four times higher than that achieved in the previous year (4 990 kW).

**Table 1 : 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
	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW
off-grid domestic	175	219	256	296	306	316	528	608	608	628	753	853	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
grid-connected distributed	0	0	100	133	266	288	356	524	761	971	3 175	6 551	18 323
grid-connected centralized	0	0	0	0	0	0	0	0	0	0	0	1 310	10 467
<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>

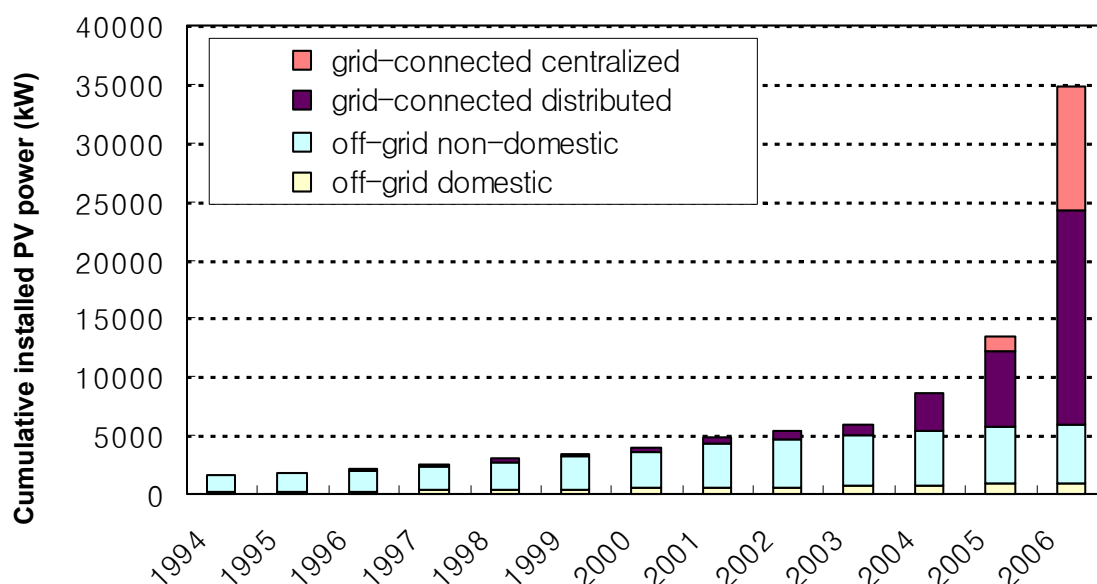


Figure 2 : The cumulative installed PV power in 4 sub-markets

### 2.3 Major projects, demonstration and 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.

- **General Deployment Program:** The government supports 70% of installation cost. In 2006, 77 PV systems with a total of 2 255 kW were installed. The installed capacity was not much changed compared to 71 PV systems with a total capacity of 2 025 kW in 2005. Various grid-connected PV systems with a power capacity of 5-200 kW were installed in schools, public facilities, welfare facilities and universities.
- **Rooftop Program:** In 2006, under the 100 000 roof-top program, 2 452 systems with a total capacity of 6 469 kW were for single-family houses, the average capacity being 2,47 kW. In addition, 120 kW system for apartment with 550 households and 3 kW for public rental apartment with 2 962 households were installed. PV system application for multi-family apartment was new one in 2006 and this kind of installation will be more encouraged by Korean residential situation. The beneficiary paid only 30 % of total system price of 8,55 million KRW per kW.
- **Feed-in Tariff Program:** The Feed-in Tariff (FIT) rate per kW-hr changed from 716,40 KRW to 677,38 KRW for systems larger than 30 kW with a ceiling of cumulative 100 MW since Oct. 2006 guaranteed for 15 years for the PV system over 3 KW. 52 commercial PV power plants of 9 157kW in total ranging 3 kW~1 MW were newly installed and operating. Four of 1 MW PV plant was installed such as Donghae PV power owned by Dongseo utility, Youngheung PV power owned by Namdong utility, Kangjin PV power owned by Namhae energy and Hanra PV power owned by Hanra Electric Co., LTD. Several projects of multi-MW scale in the planning stage with local government and local utilities or foreign companies. Annual spending for PV feed-in Tariff program was 3 478 million KRW and annual PV Power generation was 5 474 MWh in 2006.
- **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. As the Central government pursues for “New Administration-Oriented City Plan” and “Plan for Public Enterprise Relocation”, new public buildings are planned all over Korea and thus Program should 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 including off-grid domestic, non-domestic and grid-connected systems were constructed. In 2006, 27 PV systems of 1 831 kW were installed, two-fold increase compared to 24 PV systems of 883,7 kW in 2005. This program aims at increasing public awareness on PV and developing PV as an indigenous renewable energy source for their region. It is worthy to note that several local authorities finished 9 “Green Village” projects which were mainly composed of PV, solar thermal, geothermal and wind power until the end of 2006. In 2006 two new green village projects were accomplished, which are Buyeo of Chungchung nam-do province and Suncheon of Chunla nam-do province.

#### **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. Twenty five projects have been formulated with the participation of 35 companies, 8 national research institutes and 21 universities. The national budget was about 19 billion KRW in 2006. Two projects initiated in 2006 are noteworthy : polysilicon manufacturing project and 130-micron thick Si solar cell technology development. Of the demonstration program, a 1 MW system was installed in Suncheon City in 2006.

Major programs in 2006 were listed in Table 2-1.

**Table 2-1: 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
Solar Cell Test infrastructure	Sep.2004~Aug . 2006( 2years)	844	KIER
PV System monitoring	Sep.2004~Aug . 2006( 2years)	533	KIER
BIPV System field test	Sep.2004~Aug . 2006( 2years)	883	KIER
Residential PV system optimization	Dec.2006~Nov . 2008 (2years)	1 068	KIER
Building PV System field test	Sep.2004~Aug . 2006( 2years)	506	KERI

1MW PV System Demonstration	Nov.2004~Oct.2007( 3years)	9 978	Seoul Marine
Electrode for high efficiency bulk Si Solar cell	Oct.2005~Jul.2008( 3years)	1,452	Neskor Solar
Standardization of PV concentrator	Oct.2005~Jul.2006 (1year)	70	KILT
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

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

The government budget in 2006 for R&D and demonstration/field test program was 18 785 million KRW and 263 million KRW respectively as shown in Table 2-2.

The public budget allocated for market stimulation was 96 694 million KRW in 2006. Local authorities provided 13 289 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. Especially, the budget allocated for market incentives of rooftop PV system was sharply increased to about 49 000 million KRW in 2006 compared to 16 000 million KRW in 2005. Budget for "General Deployment Program" was 21 433 million KRW, and budget for "Local Deployment Program" was 22 863 million KRW.

**Table 2-2: Public budgets for R&D, demonstration/field test programs and market incentives in 2006. (Million KRW)**

	R & D	Demo/Field test	Market
National/federal	18 785	263	83 405
State/regional	-	-	13 289
Total	18 785	263	96 694

## **3 Industry and growth**

### **3.1 Production of feedstocks and wafers**

There was no production of feedstocks but single crystalline wafers were produced by Siltron

Corp. which has 10MW pilot production line using electronic-grade ingot off-spec. in 2006. For polysilicon area, Dongyang Chemical Co., (DCC) announced to invest for 3 000 ton annual production facility scheduled for commercial production in 2008. In wafer area, Woongjin established a joint venture, Woongjin Energy, with US- based Sunpower for single crystalline silicon ingot production.

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

In 2006, KPE (former Photon Semiconductor Energy Company) completed the second manufacturing line of 30 MW which has a capability of handling both single and multi crystalline Si wafer at the size of 125 mm and 156 mm on May 2006 and had a total production capacity of 35 MW. Second cell manufacturer, Neskor Solar, with less than 5 MW capacity, terminated its operation in 2006. KPE, only one cell producer, produce 18 MW single crystalline Si cell in 2006.

Eight companies produced only 16,9 MW of PV module with total annual production capability of 130 MW, due to PV cell supply problem. In spite of limited operation of production line, Symphony energy and Hyundai heavy industries successfully entered into European module market in 2006 and these two companies will expect to increase their production in 2007. Korean module manufacturers plan to produce more than 60 MW in 2007. For module production, most of single and multi-crystalline silicon PV cells were imported from Japan and Germany.

S-Energy (a spin-off from Samsung Electronics Co.) manufactured several types of modules with a peak output of 80 to 170 W. This company is a leading PV system integrator and installer with a market share of about 20% in Korean market and finished 1 MW PV project in 2006 for Donghae Thermal power for the first 1 MW PV project. 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.

Symphony completed a 1MW PV Power plant for Namhae Energy in Kangjin, Chunlanam-do with internally made module and foreign inverters.

Hyundai Heavy Industries and Symphony Corp. was very active to export market development and made several supply contracts with Spanish customers in 2006.

Unison, a market leader in wind power, joined PV module manufacturing and system installation business in 2006.

More than sixty companies are participating in installation business and KEMCO selected 20 PV system installers for roof-top market for subsidy allocation. In 2007, KEMCO announced new installation price with different application. Standard price for fixed PV system is 8,68 million KRW per kW, 10,64 million KRW per kW for tracking system and 12,73 million KRW per kW for BIPV system. Higher price setting is expected to activate BIPV market combined with Public Building Obligation Program.

The module price was in the range of 4 200 to 4 600 KRW/W depending on the manufacturing company and the order volume. The average PV module price of 4 400 KRW/W in 2006 was a little less than that in the previous year as shown in the Table 4-2

**Table 4-1: Production amount and production capacity**

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW)	
		Cell	Module	Cell	Module
1. Neskor Solar Co.	sc-Si			2.0	
2. Photon Semiconductor & Energy Co.	sc-Si	18		35	
3. Symphonyenergy	sc-Si, mc-Si		6,5		30
4. S-Energy Co.	mc-Si		2,2		20
5. Hyundai Co.	mc-Si		4,5		10
6. LS Industrial Systems			0,5		10
7. Solar Tech Co.	sc-Si, mc-Si		0,2		10
8. KD Solar	sc-Si, mc-Si		2		20
9. Unison	sc-Si, mc-Si		1		10
10. Haesung Solar	sc-Si, mc-Si		N.A.		10
<b>Total</b>		<b>18</b>	<b>16,9</b>	<b>37</b>	<b>130</b>

**Table 4-2: Average module prices between 1994 and 2006** Unit :Thousand KRW/W

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Module price	9,4	8,2	8,5	9,2	7,5	7,1	7,2	7,2	7,0	4,6	4,6	4,4

### **3.3 Manufacturers and suppliers of other components**

In 2006, several new company entered grid-connected inverter market with leading company

- Hex Power Systems. Active new companies were Willings, Hanyang Electric, Hyundai Heavy Industries and Dattech. Due to new suppliers and imported products from SMA, Fronius, price of PV inverters decreased very sharply in 2006 as listed in table 4.3. This trends expects to continue in 2007. Domestic manufactures supplied mainly for residential PV systems less than 10kW and foreign companies were active over 100 kW for PV power system by feed-in Tariff program. SMA was a leading supplier for larger inverters in Korean market.

**Table 4-3: Price of inverters for grid-connected applications.**

Size of Inverter	<1 KVA	1-10 KVA	10-100 KVA	>100 KVA
Average Price per kVA (1 000 KRW)	N.A.	530	800	600

### **3.4 System price**

Depending on the system type, the price ranged between 18 000 and 20 000 KRW/W in the case of stand-alone systems, as shown in Table 5. The price is 20 000 KRW/W for a street lighting system with a unit power capacity of 200 W. The price of grid-connected systems was 8 550 KRW/W which was reduced from 9 800 KRW/W of the previous year.

Table 5a shows the price trends of a typical 3 kW-capacity PV rooftop system.

**Table 5: Turn-key Prices of Typical Applications**

Category/Size	Typical applications and brief details	Current prices per W in KRW
OFF-GRID Up to 1 kW	Forest fire warning, Street lighting 200 W	20 000
OFF-GRID >1 kW	Remote island	18 000~ 20 000
GRID-CONNECTED Specific case	3 kW roof-mounted system	8 550
GRID-CONNECTED Up to multi-hundred kW	Multi-family apartment	7 000
GRID-CONNECTED > multi-hundred kW	Centralized PV Power plant (MW level)	5 800

**Table 5a: National trends in system prices for 3 kW-capacity residential rooftop system.**

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

### **3.5 Labor sites**

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

- a) Research and development (not including companies); 122
- b) Manufacturing of PV system components, including company R&D; 249
- c) All other, including within electric companies, installation companies etc.; 262

### **3.6 Business value**

The value of PV business in Korea was estimated to be 140,9 billion 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.

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

### **4.1 New initiatives**

- Utility perception of PV

The Feed-in Tariff (FIT) rate per kW-hr changed from 716,40 KRW to 677,38 KRW for systems larger than 30 kW with a ceiling of cumulative 100 MW since Oct. 2006 guaranteed for 15 years for the PV system over 3 kW. FIT rate will be decreased 4% per year after 2009 and installation limit of 3 MW per project was removed .

- 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). Donghae Utility Company completed one MW PV system under this program

- Installation mandate of renewable energy product for new public building



New public buildings over 3 000 m<sup>2</sup> should have renewable energy facility corresponding to 5% of the construction budget. However, geothermal was main application because of architecturer's low acceptance for PV system.

#### **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. Additionally accreditation program for inverter and crystalline module was implemented in 2005 and 16 inverters were listed as the accredited products until the end of 2006 including imported inverters from SMA. 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**

The year 2006 was a year that the annual installed capacity exceeded 20 MW. In 2007 annual PV market will increase to about 50 MW based on government dissemination budget and PV power plant under feed-in Tariff program.

Under the new Korea's national PV plan, the goal increased to 100 000 roofs and 70 000 buildings for a total capacity of 1,3 GW by the year 2012. An explosive market growth is expected between 2006 and 2012. The foundation for mass deployment was set into place in the year 2006 especially for roof-top and feed-in tariff market. In the future BIPV market is expected to play an important role due to the "New Administration-Oriented City" and "Many Innovation Cities" programs under which Korean government will construct public buildings throughout Korea until year 2012. The Korean government recognizes that PV industry will grow and take up to 10 % of the world market by the year 2012 with the export amounting to 3 billion USD and employing 50 000 people. The strategies for promoting the distribution of PV systems are described below. The whole program will be managed and monitored by the experts group organized solely for the PV technology distribution.

- Establish the foundation for mass distribution through developing PV systems for distributed electricity system. During 2001-2006, focus on developing the standardized systems for residential homes and for commercial buildings that have large potential demands.
- Set up the test sites and villages for demonstration. Establish more "green villages" throughout Korea starting from Daegu and Gwangju. For new buildings, encourage the installation of 10 kW PV systems and multi-hundreds kW PV systems for factory buildings with removal of administrative and legal barriers.

- Maximize the subsidy program that has a strong short-term effect. Further promotion should be pursued by “green pricing” and other tax incentives.

To fuel the plans and strategies mentioned above, Korea will have to spend about 2,3 billion USD during 2004-2012. The fund will be provided by the Government. As the PV world market rapidly grows, investment from industry is expected to increase accordingly.

### **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. From the year 2005 quite a lot of small-sized installers appeared in the PV system construction. Therefore module manufacturers were not able to provide us the information about the detailed application of the modules, etc. Therefore, it seems that there must be a bit of data missing or some error in counting the date of construction completion, etc. The accuracy of data is  $\pm 7\%$  for the installed PV capacity and  $\pm 2\%$  for the cell/module production. Data on RD & D funding are correct. The number of labor sites was estimated from the information collected from many sources.

**Table 6: Value of PV business**

Sub-market	Capacity installed in 2006 (kW)	Price per W (KRW/W)	Value (NC) (MKRW)	Totals (NC) (MKRW)
Off-grid domestic	130	18 000	2 340	
Off-grid non-domestic	150	20 000	3 000	
Grid-connected distributed	11 772	8 550	100 650	
Grid-connected centralized	9 157	5 800	53 110	
				159 100
<b>Export of PV products</b>				76 200
<b>Change in stocks held</b>				N.A.
<b>Import of PV products</b>				94 400
<b>Value of PV business</b>				140 900

MKRW : Million Korean Won  
2006 Average Exchange Rate: 1 US\$ = 960 KRW

### **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) : 1 130 KRW per liter
- 9) typical values of kWh / kW for PV systems in parts of your country. : 1 200 (annually)