New & Renewable Energy

National Survey Report of PV Power Applications in Korea 2014

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

PVPS

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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 member countries.

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 participating countries and organisations can be found on the www.iea-pvps.org website.

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 promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. 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 country National Survey Report for the year 2014. 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 INSTALLATION DATA

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. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, **PV installations are included in the 2014 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2014, although commissioning may have taken place at a later date**.

1.1 Applications for Photovoltaics

In Korea, photovoltaic system is mainly applied to the electric power generation.
Since the record-breaking year of 2008, that saw 276 MW of PV installations, the PV market remained stagnant in Korea during the next three years. This was mainly due to the limited FiT scheme which played initially an important role in the PV market expansion. However, 230 MW in 2012, 531 MW in 2013 and finally 926 MW in 2014, respectively, were installed, reaching the highest level of installations so far. Thanks mainly to the newly introduced RPS scheme (with PV set-aside requirement), the market started to react in 2013 and continued its development in 2014. At the end of 2014, the total installed capacity was about 2,5 GW, among those the grid-connected centralized system accounted for around 86% of the total cumulative installed power. The grid-connected distributed system amounted to around 14% of the total cumulative installed PV power. The share of off-grid non-domestic and domestic systems has continued to decrease and represents less than 1% of the total cumulative installed PV power. The total capacity of 2481,3 MW corresponds to 2,66% of total electricity generation capacity of about 93,216 GW, and the installed PV power of 926 MW in 2014 accounts for 14,8% of total power generation capacity newly installed in 2014, as can be seen in Table 3.

1.2 Total photovoltaic power installed

Table 1 show the PV power installed in four sub-markets during 2014.

The annual installation data was obtained from the total capacity of the PV systems approved to install in the year of 2014 by the NREC (New & Renewable Energy Centre) at KEA (Korea Energy Agency). Small scale installations for off-grid domestic and non-domestic applications are not accurately monitored by the NREC, introducing some errors in the data of the tables. In Korea, PV installation statistics is categorized into two sectors, PV for “business” or “self-use.” Thus in the tables, “grid-connected distributed” or “BAPV” is assumed as “self-use,” and “grid-connected centralized” or “ground-mounted” is assumed as “business.” Data for 2014 is the official value as of November 30th, 2015. The electricity statistics data were taken from the “KEPCO (Korea Electric Power Corporation) in Brief,” published on June 30th, 2015.

Table 1: PV power installed during calendar year 2014

AC			MW installed in 2014 (mandatory)	MW installed in 2014 (optional)	AC or DC
Grid-connected	BAPV	Residential	68,9 MW		
		Commercial			
		Industrial			
	BIPV (if a specific legislation exists)	Residential			
		Commercial			
		Industrial			
	Ground-mounted	cSi and TF	857,4 MW		
		CPV			
Off-grid		Residential			
		Other			
		Hybrid systems			
		Total	926,3 MW		

Table 2: Data collection process:

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	Data are reported in DC
Is the collection process done by an official body or a private company/Association?	Korea Energy Agency (KEA)/Korea Electric Power Corporation (KEPCO)/Korea Energy Economics Institute (KEEI)/Korea Photovoltaic Industry Association (KOPIA)/Korea Institute of Energy Technology Evaluation and Planning (KETEP)
Link to official statistics (if this exists)	www.energy.or.kr www.kepco.co.kr www.keei.re.kr www.kopia.asia www.ketep.re.kr
	Installation data are mainly collected from KEA; electricity data are mainly collected from KEPCO and KEEI; industry data are mainly collected by KOPIA; R&D data are mainly collected by KETEP

Table 3: PV power and the broader national energy market.

MW-GW for capacities and GWh-TWh for energy	2014 numbers	2013 numbers
Total power generation capacities (all technologies)	93 216 MW	86 969 MW
Total power generation capacities (renewables including hydropower)	10 941 MW	9 973 MW
Total electricity demand (= consumption)	477 592 GWh	474 849 GWh
New power generation capacities installed during the year (all technologies)	6 247 MW	5 163 MW
New power generation capacities installed during the year (renewables including hydropower)	968 MW	1,189 MW
Total PV electricity production in GWh-TWh	2 556 GWh	1,605 GWh
Total PV electricity production as a % of total electricity consumption	0,54	0,34

Table 4: Other informations

	2014 Numbers :
Number of PV systems in operation in your country (a split per market segment is interesting)	Electricity Business : 857,4 MW Self-use : 68,9 MW (Residential : 22,06 MW, Public : 20,61 MW, Education : 13, 78 MW, Welfare : 4,66 MW, Industry : 0,82 MW, Commercial : 0,45 MW, Miscellaneous : 7,67 MW)
Capacity of decommissioned PV systems during the year in MW	Not monitored yet: Plan to keep track of decommissioned PV systems in Korea from 2016
Total capacity connected to the low voltage distribution grid in MW	
Total capacity connected to the medium voltage distribution grid in MW	
Total capacity connected to the high voltage transmission grid in MW	

Table 5: The cumulative installed PV power in 4 sub-markets.

Sub-market	Stand-alone domestic	Stand-alone non-domestic	Grid-connected distributed (Self-use)	Grid-connected centralized (Business)
~2002	0	0	5,416	0
2003	0	0	563	0
2004	0	0	2,315	0,238
2005	0	0	3,766	1,224
2006	0	0	13,251	9,071
2007	0	0	16,505	28,842
2008	0	0	16,555	259,110
2009	0	0	24,181	142,657
2010	0	0	34,295	92,350
2011	0	0	35,835	42,983
2012	0	0	62,180	232,978
2013	0	0	63,298	467,422
2014	0	0	68,910	857,353
TOTAL (MW)	0	0	347,070	2,134,228

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

A summary of typical module and system prices is provided in the following tables. Prices shown in Table 6 are the calculated average values. The price of grid-connected systems varied from 2 400 KRW/W to 3 000 KRW/W depending on the type and size of installations.

Table 6: Typical module prices for a number of years

Year	2003	2004	2005	2006	2007	2008
Standard module price(s): Typical (KRW/W)	7 000	4 600	4 600	4 400	4 000	3 260
Best price (KRW/W)					3 900	3 020
PV module price for concentration (if relevant)						
Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Standard module price(s): Typical (KRW/W)	2 600	2 400	1 400	1 000	974	974
Best price (KRW/W)	2 400	2 000	1 200	800	634	634
PV module price for concentration (if relevant)						

2.2 System prices

Table 7: **Turnkey Prices of Typical Applications – local currency**

Category/Size	Typical applications and brief details	Current prices per W
OFF-GRID Up to 1 kW		
OFF-GRID >1 kW		
Grid-connected Rooftop up to 10 kW (residential)	Grid-connected 3 kW Rooftop systems for residential applications	3 000 KRW
Grid-connected Rooftop from 10 to 250 kW (commercial)		
Grid-connected Rooftop above 250 kW (industrial)		
Grid-connected Ground-mounted above 1 MW		
Other category existing in your country (hybrid diesel-PV, hybrid with battery…)	Grid-connected Ground-mounted 30 kW systems for electricity business applications	2 400 KRW

Table 8: National trends in system prices (current) for different applications – local currency

Price/Wp	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Residential PV systems < 10 KW	14 300	13 700	12 000	9 800	8 550	8 400	6 662
Commercial and industrial							
Ground-mounted							
Price/Wp	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	
Residential PV systems < 10 KW	5 850	5 060	4 000	3 000	3 000	3 000	
Commercial and industrial (30 kW)						2 900	
Ground-mounted (99 kW)					2 400	2 120	

2.3 Cost breakdown of PV installations (optional)

2.3.1 Residential PV System < 10 kW

Table 9: Cost breakdown for a residential PV system – local currency

Cost category	Average (local currency/W)	Low (local currency/W)	High (local currency/W)
Hardware			
Module			
Inverter			
Other (racking, wiring…)			
Soft costs			
Installation			
Customer Acquisition			
Profit			
Other (permitting, contracting, financing…)			
Subtotal Hardware			
Subtotal Soft costs			
Total			

2.3.2 Utility-scale PV systems > 1 MW

Table 10: Cost breakdown for an utility-scale PV system – local currency

Cost Category	Average (local currency/W)	Low (local currency/W)	High (local currency/W)
Hardware			
Module			
Inverter			
Other (racking, wiring, etc.)			
Soft cost			
Installation Labor			
Customer acquisition			
Profit			
Other (contracting, permitting, financing etc.)			
Subtotal Hardware			
Subtotal - Soft cost			
Total Installed Cost			

2.4 Financial Parameters and programs (leasing…)

Table 11: PV financing scheme

Average Cost of capital per market segment	Not available
Description of a specific PV financing scheme (leasing, renting…)	Capital subsidy program (NRE loan) is aimed at tackling the up-front cost barrier, either for specific equipment for NRE use or facilities for NRE products, with low interest rate (typically 1.75% variable), grace period option (1 to 5 years) and amortization option. This subsidy loan can be used for financing facilities (installation, renovation, etc.), production funds as well as working capital. In 2014, total budget of 103 400 million KRW was allocated for NRE, and about 20 000 million KRW loan was provided for PV.

2.5 Additional Country information

Table 12: Country information

Retail Electricity Prices for an household (range)	124,49 KRW/kWh on the average
Retail Electricity Prices for a commercial company (range)	126,11 KRW/kWh on the average
Retail Electricity Prices for an industrial company (range)	105,05 kRW/kWh on the average
Population at the end of 2014 (or latest known)	50 424 000 as of 2014
Country size (km^2)	100 266 as of 2013
Average PV yield (according to the current PV development in the country) in kWh/kWp	1 258 kWh/kWp
Name and market share of major electric utilities.	KEPCO (100%)

3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of PV. Direct support policies have a direct influence on PV development by incentivizing or simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

3.1 Direct support policies

Table 13: PV support measures (summary table)

	On-going measures	Measures that commenced during 2014
Feed-in tariffs (gross / net?)	Ended as of 2012F	
Capital subsidies for equipment or total cost	√	
Green electricity schemes		
PV-specific green electricity schemes		
Renewable portfolio standards (RPS)	√	
PV requirement in RPS	√	
Investment funds for PV	√	
Income tax credits		
Prosumers' incentives (self-consumption, net-metering, net-billing…)		
Commercial bank activities e.g. green mortgages promoting PV		
Activities of electricity utility businesses	√	
Sustainable building requirements	√	

3.2 Direct Support measures

3.2.1 Support measures existing in 2014

3.2.1.1 Description of support measures excluding prosumers, BIPV, and rural electrification

Various incentives have been used to support PV development. In 2014, the "Fourth Basic Plan for the Promotion of Technological Development, Use, and Diffusion of New and Renewable Energy" based on the "Second Basic National Energy Plan" was issued. This plan has the NRE target of 11% on primary energy basis by 2035 and NRE electricity target of 13.4% by 2035. In particular, among new and renewable energy sources, the portion of waste energy will decrease from 68.4% in 2012 to 29.2% in 2035, while PV will increase from 2.7% in 2012 to 14.1% in 2035 and wind power will increase from 2.2% in 2012 to 18.2% in 2035. To achieve this ambitious goals, this plan includes many new subsidy measures including the development of "Eco-friendly Energy Towns," "Energy-independent Islands," and "PV Rental Programs." The RPS scheme launched in 2012 will be active until 2024 with the final NRE supply goal of 10% by the obligators.

<Subsidy Programs for Power Business Facilities>

RPS Programme

The RPS is a mandated requirement that the electricity utility business sources a portion of their electricity supplies from renewable energies. In Korea, 14 obligators (electricity utility companies with electricity generation capacity of more than 500 MW) are required to supply 10% of their electricity from NRE (New and Renewable Energy) sources by 2024, starting from 2% in 2012. The PV set-aside requirement is set to be 1,5 GW by 2015. The PV set-aside requirement plan was shortened by one year in order to support the local PV industry. In 2014 alone, about 865 MW (cumulative 1 437 MW) was installed under this programme. In a cumulative amount, about 58% of the total PV installations in Korea was made under RPS scheme, while total 500 MW (about 20%) was installed under FiT programme which ended in 2011. The RPS is expected to be the major driving force for PV installations in the next few years in Korea with improved details such as boosting the small scale installations (less than 100 kW size) by adjusting the REC and multipliers, and unifying the PV and non-PV markets.

<Subsidy Programs for Privately-owned Facilities>

Home Subsidy Programme

This programme was launched in 2004 that merged the existing 100 000 rooftop PV system installation programme, and it aims at the construction of one million green homes utilizing PV as well as solar thermal, geothermal small-size wind, fuel cells and bio-energy until 2020. In general, single-family houses and multi-family houses including apartments can benefit from this programme. The Government provides 60% of the 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 2014, the budget allocated for PV in this program was 21 420 million KRW (total budget: 54 920 million KRW).

Building Subsidy Programme

The Government supports up to 50% of installation cost for PV systems (below 50 kW) in buildings excluding homes. 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. In 2014, the budget allocated for PV in this program was 4 500 million KRW (total budget: 18 000 million KRW). Various grid-connected PV systems were installed in schools, public facilities, welfare facilities as well as universities.

Regional Deployment Subsidy Programme

The government supports 50% of installation cost for NRE (including PV) systems owned or operated by local authorities. In 2014, the budget allocated for PV in this program was 17 512 million KRW (total budget: 21 000 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 12% (in 2014) of their total expected energy from newly installed renewable energy resource systems. Public institutions include state administrative bodies, local autonomous entities, and state-run companies. The building energy mandate percentage will increase up to 30% by 2020.

PV Rental Programme

Household owners of using more than 350 kWh electricity can apply for this program. Owners pay PV system rental fee (maximum monthly 70 000 KRW which is on the average less than 80% of the electricity bill) for minimum 7 years and can use the PV system with no initial investment and no maintenance cost for the rental period. PV rental companies recover the investment by earning PV rental fee and selling REP (Renewable Energy Point) having no multiplier. In 2014, 6 MW (2006 households) was installed under this programme.

<Subsidy Programs in Common>

Capital Subsidy (NRE Loan) Programme

This program is aimed at tackling the up-front cost barrier, either for specific equipment for NRE use or facilities for NRE products. KEA (Korea Energy Agency, formerly KEMCO) through KNREC (Korea New & Renewable Energy Center) evaluate the proposal from the companies and provide the financing fund to participating financial institutions such as banks, and the participating banks lend money to the companies with low interest rate (typically 1.75% variable), grace period option (1 to 5 years) and amortization option. This subsidy loan can be used for financing facilities (installation, renovation, etc), production funds as well as working capital. In 2014, total budget of 103 400 million KRW was allocated for NRE, and about 20 000 million KRW loan was provided for PV.

3.2.1.2 Prosumers' development measures

3.2.1.3 BIPV development measures

3.2.1.4 Rural electrification measures

Rural electrification measures are adopted and implemented mainly by the local authorities in Korea. For example, Incheon city is installing PV power of 250 kW, small size (10 kW) wind power of 40 kW, energy storage of 1 125 kW in Backa island until the end of 2014 to make the island carbon-free. Similarly, PV power of 120 kW and wind power of 30 kW will be installed in Jungma island, which will provide 388 000 kWh electricity annually. 1 200 kWh size ESS (Energy Storage System) is also installed, and the diesel power will now serve as the supplementary power for the island. These types of measures and programs are being gradually expanded by the most local governments in Korea. Energy-independent Islands project is jointly planned by central government and Gyeongbuk provincial government in 2014 and will be launched in 2015 for Ulleungdo island, and will be expanded to more islands in Korea. Wind power, PV, geothermal and ESS will be combined to increase the NRE portion in Ulleungdo island from 3.6% in 2014 to 68% in 2017. 30 MWh ESS will be installed by 2017.

3.2.1.5 Other measures including decentralized storage and demand response measures

Korean government (MOTIE) launched the smart grid test-bed project in September, 2012 in Jeju island and invested 76,6 billion KRW (total 249,5 billion KRW including the 172,9 billion KRW investment from the private sector). The project ended in May, 2013, and it aimed at verifying the energy systems integration technology using smart metering devices. The project also aimed at developing business models for commercialization. The 2nd phase smart grid diffusion project is designed in 2014 and expected to be launched in 2016.

3.2.2 Support measures phased out in 2014

3.2.3 New support measures implemented in 2014

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 help 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 resources (PV, wind, electricity and heat) and the complex between areas (home, business and public) are primarily considered to benefit from this program.

PV Rental Programme

In 2013, MOTIE (through NREC) introduced this new scheme to promote PV deployment and launched a few demo projects for 60 detached houses. The PV Rental program fully began since

2014. It is designed in such a way that the private companies take care of installations and after-services without government support, while consumers pay the PV rental fee. Total 2007 detached houses have benefited from this program in 2014, and more than 5 000 households including detached houses using 350 kWh or more electricity per month and apartments are expected to benefit from this program. Rental fee, rental period, REP (Renewable Energy Point) price are properly set to motivate the participation of PV rental companies and consumers.

<Comparison between PV subsidy program and PV rental program>

	PV Subsidy Program	**PV Rental Program**
Government Subsidy	Certain portion of the Installation cost	No support
Consumer Expense	Certain portion of the installation cost	Rental fee
Leasing Company	Installation cost	Rental fee+REP sales income
Ownership	Household	Leasing company (Transfer of ownership to consumers after the contract period)

<Annual target of PV rental program>

Year	**2013**	**2014**	**2015**	**2016**	**2017**
Homes	60 (Result)	2 007 (Result)	5 000 (Target)	7 500 (Target)	10 000 (Target)
	Detached houses only 		Detached houses and apartments 		

Eco-friendly Energy Town Programme

A new demo program has been launched by the Korean government (MOTIE, MOE and MSIP) in 2014 for three regions (Gwangju (MOTIE), Hongcheon (MOE) and Jincheon (MSIP)) of deploying the eco-friendly energy generation facilities to the avoiding facilities or sites such as waste incinerators and waste landfill sites. The Korean government has a plan to strengthen and expand this program into whole nation since 2015 by improving the program details from the lessons learned from the demo program.

<Eco-friendly energy town program contents>

Site	Program Contents
Hongcheon, Gangwon Province (MOE)	Recycling of animal and food wastes into biogas or fertilizer and reuse & sale; installation of 340 kW PV and 25 kW small-size hydro power in waste water treatment sites
Woonjeong, Gwangju City (MOTIE)	Installation of 20 MW PV in waste landfill sites; green villages (PV and solar thermal); new & renewable energy experience centre
Jincheon, Choongbuk Province (MSIP)	Installation of 950 kW PV and 10 kW fuel cell in waste water treatment sites; storage and reuse of solar thermal, geothermal and waste water thermal energy as heating source for winter season by using seasonal thermal energy storage system

Opening of Negawatt Electricity Market

MOTIE announced the opening of DRR (Demand Respond Resource) electricity trading market as of November 25, 2014 by approving the revision of 'Electricity Trading Market Operating Rules' on Oct. 3, 2014. This so-called 'Negawatt Electricity Market' was launched as one of 'the Six New Energy Industry Projects for Climate Change Response.' Now new businesses for trading saved electricity are expected to grow more since 2015.

3.2.4 Measures currently discussed but not implemented yet

Bonus-Malus System

Introduction of the Bonus-Malus system was proposed by Korean Ministry of Environment to launch this new measure in Korea since 2015, but after the strong debate, it was temporarily postponed, considering the global competitiveness of Korean automobile industry.

3.2.5 Financing and cost of support measures

The cost of PV incentives in Korea is mainly covered by the central government (tax payers' money) and regional governments. Some costs are covered by the RPS obligators indirectly affecting the electricity prices.

3.3 Indirect policy issues

3.3.1 International policies affecting the use of PV Power Systems

Worldwide effort to reduce the greenhouse gas emissions led by the COP is indirectly affecting the use of PV power systems in Korea. The INDC (Intended Nationally Determined Contributions) of Korea is targeted at 37% reduction (on BAU basis) in greenhouse gases by 2030, which was announced in COP21 in Paris, 2015.

3.3.2 The introduction of any favourable environmental regulations

Cap & Trade System

The Cap & Trade system will be introduced in Korea since January 1st, 2015. The greenhouse gas (GHG) emissions allowance for the first phase (2015-2017) is set at 1,687 billion CO_2 ton, defined as KAU (Korean Allowance Unit: 1 CO_2 ton). 1,598 billion KAU will be allowed by companies before launching the Cap & Trade system, and 0,89 billion KAU will be allowed during the first phase as

spare amount. 573 460 million KAU for 2015, 562 180 million KAU for 2016, and 550 900 million KAU for 2017 will be allowed as the total emissions in Korea. In industry sectors, 730 850 million KAU for power plants and energy industry, 357 600 million KAU for steel industry, 143 700 million KAU for petrochemical industry, and 128 000 million KAU for cement industry will be allowed. The Korean Ministry of Environment announced the total 526 companies including POSCO steel company which will be subjected to the Cap & Trade system for the first phase in September, 2014.

3.3.3 Policies relating to externalities of conventional energy

3.3.4 Taxes on pollution (e.g. carbon tax)

3.3.5 National policies and programmes to promote the use of PV in foreign non-IEA countries

KOICA (Korea International Cooperation Agency)'s ODA (Official Development Assistance) Projects
KOICA has several programs to assist and aid in installing new & renewable energy (NRE) facilities to non-IEA countries. These programs are launched to participate in the worldwide effort (e.g. UNFCCC) to mitigate and control the world's climate changes. The objective of the programs includes international collaborative actions to promote low-carbon green growth of East-Asian countries and technical support in NRE application sectors for developing countries. The countries benefited from these programs include Mongolia, Ghana, Morocco, Egypt, Tunisia, Bolivia, Ecuador, Uzbekistan and Iraq.

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

The national PV R&D budget in 2013 amounted to 213,1 billion KRW, slightly decreased from the peak budget of 224,9 billion KRW in 2011. Although official statistics for national PV R&D budget was not released for 2014, total PV R&D budget is estimated to be more than 200 billion KRW. Since 2008, Korean government has promoted the NRE development extensively under the slogan of "Green and Strong Nation," and government-led R&D programs have been consistently launched. Annual averaged growth of PV R&D budget for the period of 2009-2013 was 8.7%, which was similar to that in other sectors of national R&D. However, after peaking in 2011, PV R&D budget started to decrease slightly each year (annual average decrease of 2.7%) due partly to the recession of worldwide PV market. As of 2013F, the percentage of PV R&D budget with respect to the total national R&D budget was about 1.3%. The average PV R&D budget for a single project was decreased to 350 million KRW in 2013 from 380 million KRW in 2009, which became closer to the average R&D budget for a single project in other sectors of national R&D.

<The national PV R&D budget of Korea (2009-2013)>

(Billion KRW, %)

Year		2009	2010	2011	2012	2013	Average Annual Growth Rate ('09~'13)
PV R&D (A)	Budget	158	208,6	224,9	219,9	213,1	8.7
	No. of Projects	412	564	614	656	604	11.7
	Budget/No. of Projects	0,38	0,37	0,37	0,34	0,35	
National R&D (B)	Budget	12 414,5	13 682,7	14 852,8	15 906,4	16 913,9	9.1
	No. of Projects	39 471	39 179	41 619	49 948	50 865	7.2
	Budget/No. of Projects	0,31	0,35	0,36	0,32	0,33	
Ratio (A/B)	Budget	1.3	1.5	1.5	1.4	1.3	
	No. of Projects	1.0	1.4	1.5	1.3	1.2	

The R&D budget for relatively matured crystalline silicon solar cell technology has decreased significantly from 59,8 billion KRW in 2011 to 40,8 billion KRW in 2013. Instead, investments on the next-generation solar cells such as OPVs, quantum-dot solar cells and perovskite solar cells has consistently increased in the last few years. The investment on fundamental research was revived and reached to 25.3% in 2013 from 18.7% in 2011.

Total eight Korean ministries were involved in planning and managing the national PV R&D projects. In 2013, 86.9% of total PV R&D budget was managed by MOTIE and MSIP (112,0 billion KRW by MOTIE and 73,3 billion KRW by MSIP), and the rest was managed by other six government entities including Small and Medium Business Administration (SMBA) (16,4 billion KRW) and Ministry of Education (MOE) (7,5 billion KRW). The KETEP (Korea Institute of Energy Technology Evaluation and Planning) controls the biggest portion of the MOTIE-led national PV R&D budget and managed total

489 Billion KRW for the period of 2008~2014. About 60 Billion KRW was invested in PV R&D through KETEP in 2014. Below are the summaries of PV R&D budget allocated to KETEP from 2008 to 2014 and the scope of national PV R&D projects. Major achievements from the national PV R&D projects are also highlighted below.

<The annual PV R&D budget of KETEP>

Year		2008	2009	2010	2011	2012	2013	2014	Total
Number of Projects (ea)	Short-term	26	46	63	67	49	39	33	323
	Mid/Large Scale	13	11	12	13	21	21	21	112
	Total	39	57	75	80	70	60	54	435
Government Budget (Billion KRW)	Short-term	11,814	30,833	35,534	29,014	20,707	15,350	16,165	159,417
	Mid/Large Scale	44,863	39,806	48,886	47,759	56,577	48,246	43,490	329,627
	Total	56,677	70,639	84,420	76,773	77,284	63,596	59,655	489,044

The national PV R&D budget managed by KETEP increased dramatically in 2008 to more than 55 billion KRW compared to that of less than 10 Billion KRW in 2007. This increased PV R&D budget concentrated on developing the crystalline Si solar cells (70~80%). The scope of PV R&D then expanded to a broader spectrum, reducing the Si solar cell related R&D, while increasing the thin film related R&D. The objectives of PV R&D also shifted from initially the solar cell focused R&D to a wider spectrum including R&Ds for PV systems, PV electricity generation and various PV applications in order to facilitate the diffusion of PV dissemination.

The government-led PV R&D initiatives generated several noticeable outcomes. Breakthrough and core technologies essential to various types of solar cells were developed, and Korean-made polysilicon manufacturing technology was acquired. Especially, the Korean-made polysilicon manufacturing technology was transferred to the mass production of polysilicon in Korea. Currently the market share of Korean-made polysilicon is among the top 4 in the world, and the export of Korean-made polysilicon is continuously increasing due to its high quality and cost-competitiveness. PV inverters for grid connection was also developed from the national PV R&D, and these inverters are designed and fabricated in Korea and now are being used in the PV system installations in Korea. The rapidly changing global PV market situation due to oversupply of PV-related products (mostly originated from aggressive market entry by Chinese products) caused the change in Korean PV R&D support. In particular, the projects aiming to secure the economic competitiveness of PV system as a whole have been recently launched to reduce the LCOE (Levelized Cost of Energy). These projects are targeted to search for various types of business models to expand the PV arena. International joint R&D and demonstration projects are also being planned, and a joint project for demonstrating the stand-alone grid PV systems will be launched in August, 2015 with the State of Hawaii (having MOU signed between Hawaii and Korea), which utilizes the technologies developed in Korean islands.

Below is the summary of major achievements from KETEP's PV R&D.

<Major achievements from KETEP's PV R&D>

Subject	Major Achievements
Polysilicon manufacturing and mass production technology	Acquisition of Korean-made, turn-key polysilicon mass production technology *OCI: World's top 4 in the production capacity - 42,000 ton/yr
Development of 150 ㎛ thick crystalline silicon solar cells	Acquisition of Korean-made fabrication equipment and materials technology *Cell sorter, Laminator, Tabbing & Stringer, EVA film
Development of PV inverters for grid connection	Acquisition of Korean-made design and fabrication technology *Commercialization and entry into both domestic and global market
Development of PV modules for desert applications	100 kW system in demonstration in the middle-eastern countries such as Oman and Saudi Arabia
Commercialization of DSC (Dye-Sensitized Solar Cell) modules	Acquisition of world's best DSC module reliability and core technologies for BIPV applications *Korean-made fabrication equipment and core materials; acquisition of mass production technologies
Development of stand-alone grid PV systems and demonstration of 100 kW PV power plants	Two 100 kW demo R&Ds are on the way at one domestic site and at one foreign site targeting the emerging PV markets in USA (Hawaii, California, etc.) and south-east Asian countries. The project will be accomplished in 2017.

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

Table 12: Public budgets for R&D, demonstration/field test programmes and market incentives.

	R & D	Demo/Field test
National/federal		
State/regional		
Total		

5 INDUSTRY

5.1 Production of feedstocks, ingots and wafers (crystalline silicon industry)

Table 13: Production information for the year for silicon feedstock, ingot and wafer producers

Manufacturers	Process & Technology	Total Production (Capacity)	Product Destination (if known)	Price (if known)
OCI	polysilicon feedstock	42,000 ton/yr	mainly to China and Taiwan	
Hankook Silicon	polysilicon feedstock	15,000 ton/yr	-	-
Hanwha Chemical	polysilicon feedstock	10,000 ton/yr	mainly to China	-
KCC (in abeyance)	polysilicon feedstock	3,000 ton/yr		
Samsung MEMC Polysilicon (SMP)	polysilicon feedstock	13,000 ton/yr		-
Total	**polysilicon feedstock**	**83,000 ton/yr**		USD 18~19/kg in a spot price
SKC Solmics	Ingot	150 MW/yr	-	-
Osung LST	Ingot	350 MW/yr	-	-
Woongjin Energy	Ingot	1 000 MW/yr	mainly to USA	-
Nexolon	Ingot	1 750 MW/yr	mainly to China	-
Total	**Ingot**	**3 250 MW/yr**		
SKC Solmics	Wafer	130 MW/yr	-	-
Osung LST	Wafer	350 MW/yr	-	-
Woongjin Energy	Wafer	500 MW/yr	mainly to USA	-
Nexolon	Wafer	1, 750 MW/yr	mainly to China	
Total	**Wafer**	**2,730 MW/yr**		USD 0.84~0.87/ wafer sheet

Osung LST, in April 2015, officially announced that it would withdraw from solar PV business.

PTC, the joint venture of KCC and MEC, completed the construction of polysilicon plant in Saudi Arabia with the production capacity of 3 000 ton/yr in October, 2014. PTC has been running the tests to prepare its mass production. On the contrary the polysilicon plant of KCC located in Korea has been in abeyance since 2012.

Hanwha SolarOne is operating an 800 MW ingot and wafer capacity plant in China.

5.2 Production of photovoltaic cells and modules (including TF and CPV)

Module manufacturing is defined as the industry where the process of the production of PV modules (the encapsulation) is done. A company may also be involved in the production of ingots, wafers or the processing of cells, in addition to fabricating the modules with frames, junction boxes etc. The manufacturing of modules may only be counted to a country if the encapsulation takes place in that country.

Total PV cell and module manufacture together with production capacity information is summarised in Table 14 below.

Table 14: Production and production capacity information for 2014

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					
Solar Tech	Crystalline Silicon type				30
Solariver					20
SDN					100
S-Energy			350		350
BJ Power					20
Hyundai Heavy Industries		540	540	600	600
Shinsung Solar Energy		400	120	350	150
Hansol Technics			280		350
Dayou SE			100		120
LSIS			120		150
Woori S-tech					50
JSPV					100
Solarpark Korea					650
Topsun					150
LG Electronics		520	520	500	500
E&R Solar		80	50	180	50
T & Solar					50
Luxco			150		150
Kyung Won (K Solar)					30
Total				**1 630**	**3 620**
Thin film manufacturers					
None				0	*0*
Cells for concentration					
None				0	*0*
TOTALS				**1 630**	**3 620**

In 2014, it is estimated that Korean PV manufacturers got revenues worth around USD 5 billion. The total amount of export accounts for around 50% in their revenues, with the record of about USD 2.7 billion. The main exported items are polysilicon feedstock and module.

When it comes to cell efficiency, LG Electronics is offering the series “MonoX NeOn”, whose front side efficiency of commercially available bifacial cells is more than 21%. Other cell manufacturers (e.g. Shinsung Solar Energy) are focusing on PERC (Passivated Emitter Rear Contact) technology to produce high efficiency cells in mass production.

On top of that, some specially designed products are promoted to win a foothold. For instance, some players have been developing and marketing the on-water PV systems and the PV modules appropriate for desert environment such as in middle-east areas.

Hanwha Q-cells started to invest in Korea to establish cell and module manufacturing plants. In addition to its existing manufacturing plants in China and Malaysia, Hanwha Q-cells has the plan to build up the cell and module factories with the annual production capacities of 1 500 MW and 500 MW, respectively by the end of 2015.

Most module companies in Korea have been purchasing cells from China and Taiwan manufacturers. LG Electronics is providing total in-house cells to produce its modules, and Hyundai Heavy Industries is utilizing most in-house cells to produce modules, though some cells are sold. Shinsung Solar Energy is using in-house cells, but the ratios of using in-house cells are low. E&R Solar is using in-house cells, but sales of cells is also running parallel.

Around 80% of produced modules in Korea were exported to other countries, and the main export region was Japan.

Hanwha Group is operating cell and module production overseas. Hanwha Chemicals merged with Chinese company (Hanwha Solarone) and German company (Hanwha Q-cells). In 2014, these two companies merged again to form a single company (Hanwha Q-Cells). With this merger and acquisition, Hanwha Q-cells became world’s No. 1 in cell production capacity and No. 4 in module production capacity. Hanwha Q-Cells’ cells and modules are produced in China and Malaysia with the total nameplate capacities of 3 240 MW and 2 420 MW, respectively.

5.3 Manufacturers and suppliers of other components

PV inverters (for grid-connection and stand-alone systems) and their typical prices

It is estimated that the market volume of PV inverters is about USD 50 million in Korea in 2014. Korean inverter players dominate local market because after sales service is important in PV inverter business. As the volume of Korean market is under expansion, however, some foreign players like Chinese companies have shown interest in Korean PV inverter market. Korean manufactures of PV inverters have increased their capacities, and the price for home system is currently below USD 800/3 kW.

Storage batteries

In Korea, LG Chemical, Samsung SDI and SK Innovation are the major developers and suppliers of ESS (Energy Storage System). While their storages are mainly based on lithium ion system, new entrants such as OCI, Lotte Chemical are developing energy storages based on vanadium-Redox flow battery.

Korean government is promoting the ESS business in Korea by designating the ESS as a new energy industry item. In line with that, Korean players are making attempts to combine ESS and energy management business with renewable energy supply. Accordingly, it is expected that new business models like ESS lease service will be introduced in 2015.

Battery charge controllers

DC switchgear

Supporting structures

6 PV IN THE ECONOMY

6.1 Labour places

Table 17: Estimated PV-related labour places in 2013 (2014 statistics is not available yet)

Research and development (not including companies)	Not available
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	7 525 (manufacturing company basis)
Distributors of PV products	
System and installation companies	
Electricity utility businesses and government	Not available
Other	Not available
Total	

6.2 Business value

Table 18: Value of PV business

Sub-market	**Capacity installed *in 2014* (MW)**	**Price per W** *(from table 7)*	**Value**	**Totals**
Off-grid domestic				
Off-grid non-domestic				
Grid-connected distributed	**68,9**	**3 000**	*206,7 billion KRW*	
Grid-connected centralized	**857,4**	**2 400**	*2 057,8 billion KRW*	
				2 264,5 billion KRW
Export of PV products				*2 968,1 billion KRW*
Change in stocks held				*1 000 billion KRW*
Import of PV products				*3 000 billion KRW*
Value of PV business				***9 232,6 billion KRW***

In Korea, the industry value chain for crystalline silicon PV is completely established from raw materials (polysilicon feedstock, EVA sheet, etc.), ingot and wafers, cells, modules, BOS components, systems and power plants. Among these, polysilicon production capacity is currently No. 4 in the world. Korean-made products are mostly exported to foreign countries including China, EU, Japan and USA.

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

Short description of the electricity industry landscape	- Vertically integrated - Monopoly - Public ownership - Regulated by central government

7.2 Interest from electricity utility businesses

Since 2012, the RPS scheme started and replaced the FIT scheme which lasted until 2011. Total 14 companies including 6 electricity generation companies, electricity generation business companies and two other corporates have participated mandatorily. 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 to drop significantly together with the fast falling PV product prices. The electricity utility businesses would like to have more PV to replace the non-PV RPS to lower the cost and fulfil their duties. This trend continued in 2013 and 2014, and the REC cost dropped even further, now the REC cost is below 100 KRW/W.

In the 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. Thus Korean government decided to simplify the REC weighting factor scheme in 2014, and from 2015, the new simplified REC weighting factor scheme has been in effect.

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 have been prepared in 2014 to resolve some of the issues surfaced in 2012 and 2013.

PV rental program (third party ownership) is introduced in 2014, and is expected to grow in near future. A so-called "Negawatt" market was also introduced in 2014 and will be fully operational since 2015. This is an electricity trade scheme not on a production or supply basis but on a saving and peak time trading basis.

KEPCO, the largest and only electricity business company in Korea, participated in many PV related activities including "Energy-independent Islands Project." and "Korea Smart-grid Project."

7.3 Interest from municipalities and local governments

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 consumption and to increase the NRE dissemination. This plan is to reduce the energy consumption in Seoul as much as 2 million toe (equivalent to the energy supplied by on nuclear power plant). As a result, Seoul's energy consumption was reduced to total 2.04 million toe as of June, 2014. Seoul revived a modified type of FIT scheme to

facilitate the PV deployment in the energy production area. The second phase of "One Less Nuclear Power Plant for Seoul" will begin in 2015 targeting total 4 million toe reduction, and the goals involve the 20% electricity independence rate (currently 13%) of Seoul by 2020: In particular, total 40 000 mini-PV (typically 250 W) power plants in households will be installed, and citizen crowd-funded PV power plants will be launched in 2015.

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 met a goal of installing 170 MW of PV power by 2013 and has a plan to construct 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. The "22nd World Energy Congress" in 2013, "7th World Water Forum" and "ISES Solar World Congress" in 2015 were held in Daegu. Solar Cell/Module RIC (Regional Innovation Centre) is located in Yeungnam University in the neighbouring Gyeongbuk 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 Gyeongbuk Province. Gyeongbuk province chose "Energy Parts Industry" as its strategic industry for the future. Gyeongbuk province prepared a plan for "Sunlight Energy Farming" in 2014 to secure a small but regular income for rural households (relatively disadvantaged from recent FTA with foreign countries) using low interest rate fund from provincial government and REC purchasing agreement with KHNP (Korea Hydro & Nuclear Power). The project will be launched in 2015.

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.

8 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. KTC is designated as CBTL for high power inverters and PCS in 2013, and KCL is designated as CBTL for BIPV in 2014. TUV Rheinland Yeungnam University Testing Center is designated as CBTL for crystalline PV modules and thin film PV modules. The use of certified products is obligatory for the government-subsidized PV systems.

KNREC governs the "NRE Standardization Programs" and provides services on "Certification of NRE Systems" (including the issuing of certificates for domestic installations) and "Certification of Buildings Using NRE."

KATS became an official member of IECRE as of July 28, 2014, and participating member in PV and Wind Power sectors as of October 31, 2014.

9 HIGHLIGHTS AND PROSPECTS

Since the record-breaking year of 2008, that saw 276 MW of PV installations, the PV market remained stagnant in Korea during the next three years. This was mainly due to the limited FiT scheme which played initially an important role in the PV market expansion. However, 230 MW in 2012, 531 MW in 2013 and finally 926 MW in 2014, respectively, were installed, reaching the highest level of installations so far. Thanks mainly to the newly introduced RPS scheme (with PV set-aside requirement), the market started to react in 2013 and continued its development in 2014. At the end of 2014, the total installed capacity was about 2,5 GW, among those the grid-connected centralized system accounted for around 86% of the total cumulative installed power. The share of off-grid non-domestic and domestic systems has continued to decrease and represents less than 1% of the total cumulative installed PV power. The total capacity of 2481,3 MW corresponds to 2,66% of total electricity generation capacity of about 93,216 GW, and the installed PV power of 926 MW in 2014 accounts for 14,8% of total power generation capacity newly installed in 2014.

In 2014, it is estimated that Korean PV manufacturers got revenues worth around USD 5 billion. The total amount of export accounts for around 50% in their revenues, with the record of about USD 2.7 billion. The main exported items are polysilicon feedstock and module. The production capacities of Korea in each PV value chain sectors as of 2014 are 83 000 ton/yr of polysilicon feedstock, 3 250 MW/yr for silicon ingots, 2 730 MW/yr for silicon wafers, 1 630 MW/yr for silicon solar cells and 3 620 MW/yr for silicon PV modules, respectively.

When it comes to cell efficiency, LG Electronics is offering the series “MonoX NeOn”, whose front side efficiency of commercially available bifacial cells is more than 21%. Other cell manufacturers (e.g. Shinsung Solar Energy) are focusing on PERC (Passivated Emitter Rear Contact) technology to produce high efficiency cells in mass production.

Hanwha Q-Cells will dig the ground in Korea to construct the silicon solar cell manufacturing plant of 1.5 GW size in 2015 and start the commercial operation in 2016.

Korean government continued to support strongly the PV deployment, R&D, infrastructure building and market promotion. Among these, the government-driven RPS scheme and R&D support of about 200 million KRW played major role in boosting PV deployment and technology development.

Korean government announced “The Second Energy Basic Plan” in early 2013, and the renewable energy proportion is kept at 11% by 2035. Distributed power is planned to increase from the current 5% to 15% by 2035. The government has also prepared and announced “The Fourth Basic Plan for the Promotion of Technological Development, Use, and Diffusion of New & Renewable Energy” in 2014, which included detailed development plans for the renewables. PV and wind will be the two major areas to be focused. Due to the plan, New & Renewables (NRE) will increase to 13.4% in electricity generation by 2035, and PV will occupy 14.1% of total NRE (including hydro) by 2035 (2.7% of total NRE in 2012F).

Worldwide effort to reduce the greenhouse gas emissions led by the COP is indirectly affecting the use of PV power systems in Korea. The INDC (Intended Nationally Determined Contributions) of Korea is targeted at 37% reduction (on BAU basis) in greenhouse gases by 2030, which was announced in COP21 in Paris, 2015.

Various incentives have been used to support PV development. Under the Forth Basic Plan, many new subsidy measures including the development of “Eco-friendly Energy Towns,” “Energy-independent Islands,” and “PV Rental Programs” are launched in 2014 and these subsidy measures and programs will be expanded in the following years. The RPS scheme launched in 2012 will be the main driving force for PV deployment, which will be active until 2024 with the final NRE supply goal of 10% by the obligators.

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 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

Compensation schemes (self-consumption, net-metering, net-billing…)	These schemes allow consumers to reduce their electricity bill thanks to PV production valuation. The schemes must be detailed in order to better understand if we are facing self-consumption schemes (electricity consumed in real-time is not accounted and not invoiced) or net-billing schemes (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). The compensation for both the electricity self-consumed and injected into the grid should be detailed. Net-metering schemes are specific since they 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
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