IEA INTERNATIONAL ENERGY AGENCY

New & Renewable Energy

National Survey Report of PV Power Applications in Korea

2016

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

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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 Technology Collaboration 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 2015. 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 2016 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2016, 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 the next three years. This was mainly due to the limited Feed-in Tariff (FIT) scheme which played initially an important role in the PV market expansion. Since 2012, Renewable Portfolio Standard (RPS) was introduced as a flagship renewable energy program, replacing FIT. Thanks to new RPS scheme (with PV set-aside requirement), significant PV deployment has been achieved, 295 MW in 2012, 531 MW in 2013, 926 MW in 2014, 1,134 MW in 2015 and 909 MW in 2016 respectively. 22 MW of capacity was reduced in 2016, which made the net capacity increase to 887 MW. At the end of 2016, the total installed capacity was about 4.5 GW, among those the grid-connected centralized system accounted for around 88% of the total cumulative installed power. The grid-connected distributed system amounted to around 12% 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 4,501.6 MW corresponds to 4.1% of total electricity generation capacity of about 109,789 MW, and the installed PV power of 909 MW in 2016 accounts for 18.6% of total power generation capacity newly installed (4,888 MW) in 2016, as can be seen in Table 3.

1.2 Total photovoltaic power installed

Table 1 shows the PV power installed in four sub-markets during 2016.

The annual installation data was obtained from the total capacity of the PV systems approved to install in the year of 2016 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 PV for '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.' 2016 data were taken from the '2016 NRE Deployment Statistics' published by KEA in November 2017 and '2016 Yearbook of Energy Statistics' published by KEEI in December 2017.

Table 1: PV power installed during calendar year 2016

AC			MW installed in 2016 (mandatory)	MW installed in 2016 (optional but HIGHLY NEEDED)	AC or DC
Grid-connected	BAPV	Residential	110.4 MW		DC
		Commercial			
		Industrial			
	BIPV (if a specific legislation exists)	Residential			
		Commercial			
		Industrial			
	Ground-mounted	cSi and TF	798.8 MW		DC
		CPV			
Off-grid		Residential			
		Other			
		Hybrid systems			
		Total	909.2 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.kesis.net www.kopia.asia www.kepco.co.kr www.ketep.re.kr
	Installation data are mainly collected from KEA; electricity data are mainly collected from KEEI and KEPCO; 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	2016 numbers	2015 numbers
Total power generation capacities (all technologies)	110,562 MW	97,649 MW
Total power generation capacities (renewables including hydropower)	13,281 MW	12,120 MW
Total electricity demand (= consumption)	507,746 GWh	483,655 GWh
New power generation capacities installed during the year (all technologies)	4,888 MW	4,433 MW
New power generation capacities installed during the year (renewables including hydropower)	1,445 MW	1,179 MW
Total PV electricity production in GWh-TWh	5,122 GWh	3,598 GWh
Total PV electricity production as a % of total electricity consumption	1.0	0.74

Table 4: Other informations

	2016 Numbers
Number of PV systems in operation in your country (a split per market segment is interesting)	Business (RPS) : 3,950.5 MW Self-use : 551.1 MW
Capacity of decommissioned PV systems during the year in MW	22 MW (decommissioned or downsized)
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	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Stand-alone domestic												
Stand-alone non-domestic												
Grid-connected distributed	12.1	13.2	16.5	16.6	24.2	34.3	35.8	62.2	63.3	68.9	93.8	110.4
Grid-connected centralized	1.4	9.1	28.8	259.1	142.6	92.3	43.0	233.0	467.4	857.4	1,040.1	798.8
TOTAL (MW)	13.5	22.3	45.3	275.7	166.8	126.6	78.8	295.2	530.7	926.3	1,133.9	909.2

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 and Table 8 are the calculated average values.

Table 6: Typical module prices for a number of years

Year	1992	2011	2012	2013	2014	2015	2016
Standard module crystalline silicon price(s): Typical		1,400	1,000	974	974	974	646
Lowest prices		1,200	800	634	634	634	456
Highest prices							

2.2 System prices

The price of grid-connected systems varied from 1,400 KRW/W to 2,300 KRW/W depending on the type and size of installations

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)		KRW 1,500~2,000
Grid-connected Rooftop from 10 to 250 kW (commercial)		KRW 2,200~2,300
Grid-connected Rooftop above 250kW (industrial)		
Grid-connected Ground-mounted above 1 MW		KRW 1,400~2,000
Other category (hybrid diesel-PV, hybrid with battery…)		

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

Price/Wp	1992	2011	2012	2013	2014	2015	2016
Residential PV systems < 10 KW		4,000	3,000	3,000	3,000	1,750	1,600
Commercial and industrial					2,900	2,250	1,500
Ground-mounted				2,400	2,120	1,700	1,400

2.3 Cost breakdown of PV installations

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	1,070		
Inverter			
Other (racking, wiring…)	140		
Soft costs			
Installation	340		
Customer Acquisition	50		
Profit			
Other (permitting, contracting, financing…)			
Subtotal Hardware	1,210		
Subtotal Soft costs	390		
Total	1,600		

2.3.2 Utility-scale PV systems > 5 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	765		
Inverter			
Other (racking, wiring, etc.)	87		
Soft cost			
Installation Labor	478		
Customer acquisition	70		
Profit			
Other (contracting, permitting, financing etc.)			
Subtotal Hardware	852		
Subtotal - Soft cost	548		
Total Installed Cost	1,400		

2.4 Financial Parameters and specific financing programs

Table 11: PV financing scheme

Average rate of loans – residential installations	3.7 ～ 4.0 %
Average rate of loans – commercial installations	3.7 ～ 4.0 %
Average cost of capital – industrial and ground-mounted installations	3.7 ～ 4.0 %

2.5 Specific investments programs: N/A

Third Party Ownership (no investment)	
Renting	
Leasing	
Financing through utilities	
Investment in PV plants against free electricity	
Crowdfunding (investment in PV plants)	
Other (please specify)	

2.6 Additional Country information

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Table 12: Country information

Retail Electricity Prices for an household (range)	KRW 93.3~280.6
Retail Electricity Prices for a commercial company (range)	KRW 53.7~196.6
Retail Electricity Prices for an industrial company (range)	KRW 53.7~196.6
Population at the end of 2014 (or latest known)	51.246 million as of 2016
Country size (km^2)	100,295.4 as of 2015
Average PV yield (according to the current PV development in the country) in kWh/kWp	1 314 kWh/kWp
Name and market share of major electric utilities.	KEPCO

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 for PV installations

3.1.1 New, existing or phased out measures in 2016

3.1.1.1 Description of support measures excluding BIPV, and rural electrification

Various incentives have been used to support PV development. The "Fourth Basic Plan for the Promotion of Technological Development, Use, and Diffusion of New and Renewable Energy (NRE)" based on the "Second Basic National Energy Plan" was still effective in 2016. 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 NRE 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. In terms of NRE electricity mix, PV is expected to occupy 22% by 2035. To achieve these ambitious goals, the plan includes many 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 power generation 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, 18 obligators (electricity utility companies with electricity generation capacity of 500 MW or above) are required to supply 10% of their electricity from NRE sources by 2024, starting from 2% in 2012. The PV set-aside requirement was set to be 1,5 GW by 2015, and the goal was surpassed. In 2016 alone, about 804 MW (cumulative 3, 289 MW) was installed under this programme. In a cumulative amount, about 68% of the total PV installations in Korea was made under RPS scheme, while total 497 MW (about 14%) was installed under FIT programme which was 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 2016, total 27 MW PV systems were installed for 25,090 households with the budget of 21,065 million KRW under this programme.

Building Subsidy Programme

The Government supports up to 50% of the installation cost for PV systems (below 50 kW) in buildings excluding private 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 2016, the budget spent for PV in this program was 8,086 million KRW, and total 349 buildings (6 MW) benefited from this programme. Various grid-connected PV systems were installed in schools, public facilities, welfare facilities as well as universities.

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 18% (in 2016) 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. Total 42 MW PV systems were installed by this programme in 2016.

Regional Deployment Subsidy Programme

The government supports up to 50% of installation cost for NRE (including PV) systems owned or operated by local authorities. In 2016, the budget spent for PV in this program was 21,303 million KRW, and total 329 projects (12 MW) were supported from this programme.

PV Rental Programme

In 2013, MOTIE (through KNREC) 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. Household owners of using more than 300 kWh (monthly average) electricity can apply for this program. Owners pay PV system rental fee (monthly maximum: 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 O&M cost for the rental period. PV rental companies recover the investment by earning PV rental fee from the households and selling REP (Renewable Energy Point) having no multiplier. Rental fee, rental period, REP price are properly set to motivate the participation of PV rental companies and consumers. In 2016, 10,362 households got supported for their PV installation by 8 participating companies under this programme.

<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
Households	60 (Result)	2 007 (Result)	8 796 (Target)	7 500 (Target)	10 000 (Target)
	Detached houses only 		Detached houses and apartments 		

Convergence and Integration Subsidy Program for NRE

This is a new NRE subsidy program started in 2013. A consortium led either by local authority or public institution with NRE manufacturing companies and individuals 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. Total 7 MW of PV systems were installed in 2016 with the 9,971 million KRW budget spent for 1,030 projects.

<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) evaluates 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 (purchase, installation, upgrade, etc), production funds as well as working capital. In 2016, total budget of 100,000 million KRW was allocated for NRE, and 35.7% (35,690 million KRW) of the loan was provided for PV.

Investment Tax Credit

This program is aimed at promoting the energy savings for individuals and companies, and provides exemption of tax for the investment of energy-saving facilities (including NRE facilities). This programme will last until the end of 2016. Small-size enterprises get 6% tax exemption, medium-size enterprises get 3% tax exemption, and Korean national individuals get 1% tax exemption.

3.1.1.2 BIPV development measures

REC multiplier for BIPV installations

A government level discussion is on the way to provide the REC multiplier (greater than 1.0) for BIPV installations, and a new subsidy measure is expected to be introduced from 2017.

Zero Energy Building (ZEB) demonstration projects

The Ministry of Land, Infrastructure and Transport (MOLIT) launched the five nearly (greater than 90% self-support) ZEB demonstration projects in December, 2014 and is actively continuing total seven projects (5 residential and 2 commercial) in 2015 using both passive and active ingredients. Maximum 30 to 50% of the NRE installation cost is supported by the Government, and the building owners get 15% tax (acquisition and property taxes) exemption for 5 years. The MOLIT has a plan to make the nearly ZEB as a mandatary requirement for all new buildings constructed since 2020 starting from the public buildings.

3.1.1.3 Rural electrification measures

Rural electrification measures are adopted and implemented mainly by the local authorities in Korea. For example, Incheon city implemented a project, installing PV power of 250 kW, small size (10 kW) wind power of 40 kW, energy storage of 1 125 kW in Backa island, and finished the project at the end of 2014 to make the island carbon-free. Similarly, PV power of 120 kW and wind power of 30 kW were installed in Jungma island, which will provide 388 000 kWh electricity annually. 1 200 kWh size ESS (Energy Storage System) was also installed, and the diesel power is now serving 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 was jointly planned by central government and Gyeongbuk provincial government in 2014 and was 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.

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

3.1.1.4 Support for electricity 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.

Table 13: PV support measures (summary table)

	On-going measures residential	Measures that commenced during 2016 - residential	On-going measures Commercial + industrial	Measures that commenced during 2016 – commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2016 – ground mounted
Feed-in tariffs	Ended as of 2011F					
Feed-in premium (above market price)						
Capital subsidies	√		√		√	
Green certificates						
Renewable portfolio standards (RPS) with/without PV requirements	√		√		√	
Income tax credits	√		√		√	
Self-consumption						
Net-metering						
Net-billing						
Collective self-consumption and virtual net-metering						
Commercial bank activities e.g. green mortgages promoting PV	√		√		√	
Activities of electricity utility businesses	√		√		√	

Sustainable building requirements						
BIPV incentives						
Other						

3.2 Self-consumption measures

. Mandatory

PV self-consumption	1	Right to self-consume	
	2	Revenues from self-consumed PV	
	3	Charges to finance Transmission & Distribution grids	
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	
	5	Maximum timeframe for compensation of fluxes	
	6	Geographical compensation	
Other characteristics	7	Regulatory scheme duration	
	8	Third party ownership accepted	
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	
	10	Regulations on enablers of self-consumption (storage, DSM…)	
	11	PV system size limitations	
	12	Electricity system limitations	
	13	Additional features	

3.3 Collective self-consumption, community solar and similar measures

3.4 Tenders, auctions & similar schemes

Opening of Negawatt Electricity Market

MOTIE announced the opening of DRR (Demand Response 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 Energy-related New Industry Development Plan for Climate Change Response.' Now new businesses for trading saved electricity are expected to grow more since 2016.

3.5 Financing and cost of support measures

The cost of PV incentives in Korea is mainly covered by the central and regional governments (tax payers' money). Some costs are covered by the 18 RPS obligators indirectly affecting the electricity prices.

3.6 Indirect policy issues

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% (25.7% domestic; 11.3% from abroad) reduction (on BAU basis) in greenhouse gases by 2030, which was announced in COP21 in Paris, 2015.

Introduction of Favourable Environmental Regulation (Cap & Trade System)

The Cap & Trade system was 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 is allowed by companies before launching the Cap & Trade system, and 0,89 billion KAU is 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 the 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 are allowed. The Korean Ministry of Environment (MOE) 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.

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.

2030 Energy-related New Industry Development Plan

Korean government announced '2030 Energy-related New Industry Development Plan for Climate Change Response' on November 23, 2015. It is the five-year plan with detailed action items targeting specific goals for 2030 to achieve the Korea's INDC of 37% GHG reduction (on BAU basis). By 2030, Korean government plans to generate 100 trillion KRW new market, 500 000 new employments and 55 million tons of GHG reduction from the energy-related new industries. Key contents of the plan are listed below.

<Contents of 2030 Energy-related New Industry Development Plan>

Category	Contents
Energy Prosumer (12.8% of Power Generation)	Micro-Grid, Demand Resource Market (Nega-Watt Market), ZEB, Eco-friendly Town, Energy-independent Islands, Solar PV Home, etc.
Low Carbon Power Generation (40% of Coal Power Plants)	NRE Power Generation, Supercritical CO_2 Power Generation, Large-scale Gas Turbine, CCS, HVDC Transmission, Superconducting Cables, ESS, etc.
Electric Vehicle (1 million)	Battery Lease, Charging Service, Electric Car/Motocycle/Bicycle, Utilization of Waste Battery, Electric Vehicle Insurance, etc.
Eco-friendly Processes	Smart Factory (40 000), Hydrogen-reduced Steel Manufacturing, Eco-friendly Refrigerant, Waste Hot Water Utilization from Power Plant, LNG Cold Heat, etc.

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

Total eight Korean ministries were involved in planning and managing the national PV R&D projects. The majority of PV R&D budget was managed by MOTIE and MSIP, and the rest was managed by other six government entities including Small and Medium Business Administration (SMBA) and Ministry of Education (MOE).

KETEP (Korea Institute of Energy Technology Evaluation and Planning) controls the biggest portion of the MOTIE-led national PV R&D budget and managed about 416 billion KRW for the period of 2008~2015 for total 427 short-term and mid/long term projects.

The national PV R&D budget managed by KETEP initially concentrated on developing crystalline Si solar cells. The scope of R&D expanded from initially the solar cell to a wider spectrum including 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. 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.

About 43.7 billion KRW was set aside for R&D of Energy Storage System (ESS) in 2017.

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

Table 14: Public budgets for R&D, demonstration/field test programmes and market incentives.

	R & D	Demo/Field test
National/federal	55,804 mil. KRW	
State/regional		
Total		

5 INDUSTRY

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

Table 15: Production information for the year for silicon feedstock, ingot and wafer producers

Manufacturers (or total national production)	Process & technology	Total Production Capacities	Product destination (if known)	Price (if known)
OCI	Silicon feedstock	52,000 tonnes	China, Taiwan, etc	
Hanwha Chemical	Silicon feedstock	15,000 tonnes	China, Korea, etc	
Hankook Silicon	Silicon feedstock	15,000 tonnes	China, Taiwan, etc	
Total	*Silicon Feedstock*	*82,000 tonnes*		
Woongjin Energy	sc-Si ingots.	1,150MW	Germany, USA, etc	
Nexolon	mc-Si ingots	1,750MW		
Total	*Si ingots*	*2,900MW*		
Woongjin Energy	sc-Si wafers	630MW	USA, Germany, Korea	
Nexolon	mc-Si wafers	1,750MW		
Total	*Si wafers*	*2,380MW*		

OCI made a contract to purchase the polysilicon plant of Tokuyama located in Malaysia in 2016. After OCI entered into taking over the shares of Tokuyama Malaysia, it had proceeded the process to purchase all stocks of Tokuayama Malaysia from October 2016 to April 2017. Finally, OCI obtained 100% of shares of Tokuyama Malaysia in April 2017. As described Table 15, OCI was already equipped with the production capacity of 52,000 tonnes in Korea. Combining that local production ability and the production capacity in Malaysia, OCI could produce 72,000 tonnes of polysilicon a year. In the field of ingot and wafer, Hanwha Q-cells has been operating ingot and wafer production sites 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 9 below.

Table 16: Production and production capacity information for 2016

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					
Solartech	mc-Si			0	30
Solarriver	mc-Si			0	20
SDN	mc-Si			0	100
DCT	mc-Si			45	0
S-Energy	mc-Si			0	350
BJ Power	mc-Si			0	20
Hyundai Green Energy	mc-Si			600	600
Hanwha Q-Cells	mc-Si			1500	1500
Shinsung E&G	mc-Si			420	150
Hansol Technics	mc-Si			0	350
Daeyoo SE	mc-Si			0	120
LS IS	mc-Si			0	150
JSPV	mc-Si			0	400
Solarpark Korea	mc-Si			0	600
Topsun	mc-Si			0	120
LG Electronics	Sc-Si			1100	1100
T&Solar	mc-Si			0	50
Luxco	mc-Si			0	150
KPE	mc-Si			40	0
Total				*3,705*	*5,810*
Thin film manufacturers					
Solarplus	CIGS			0	0
Cells for concentration					
None				0	0
TOTALS				**3,705**	**5,810**

Hanwha Q-Cells Korea has been expanding production capacities of cell and module in Korean sites. Hanwha also noted that its cell conversion efficiencies were approaching 20% in multi-PERC cell and 22% for mono-PERC through its Q.ANTUM cell technology.

LG Electronics has been focusing on N-type mono solar cell and module production while many other PV players are setting central axis on p-type products. In addition to NeON®2 model, the n-type bifacial product, it also developed back-contact modules that eliminate metal electrode on the front side. This back-contact model came into production since 2017. LG Electronics also has been increasing its production capacities with the aim to equip its production line with the ability to produce 1,800MW/year of cell and module by 2018, respectively.

Hyundai Green Energy, a spinoff from Hyundai Heavy Industries, and Shinsung E&G whose company name was changed from Shingsung Solar Energy increased the capacity to produce PERC cells.

5.3 Manufacturers and suppliers of other components

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

In domestic PV inverter market, local inverter players take initiative because local inverter companies are stronger than foreign inverter players in follow-up service which is important in PV inverter area. The price of inverter for residential system (3 kW) is around 715,000 KRW.

- Storage batteries

Korean government has been awarding the multiplier of 5.0 in REC(Renewable Energy Certificate) trading of PV systems combined with ESS. The benefit was offered from 2016 and it would last by 2018. The ESS should use lithium ion battery to get the benefits of REC for PV+ESS. In addition to the benefit for PV systems combined ESS, Korean government has been placing diverse policies to promote ESS installation. For instance, electricity tariff is half of normal price when ESS is used to reduce the electricity consumption. On top of that, the price of discharging electricity from ESS is 3 times higher than normal electricity price. Those policies enhance the business value of ESS. Accordingly, the storage batteries are in high demand. LG Chemical and Samsung SDI are two major local manufacturers to produce lithium ion batteries for ESS.

- Battery charge controllers
- DC switchgear
- Supporting structures

6 PV IN THE ECONOMY

6.1 Labour places

Table 17: Estimated PV-related labour places in 2016: N/A

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

6.2 Business value

Table 18: Value of PV business

Sub-market	**Capacity installed *in 2016* (MW)**	**Price per W(KRW)** *(from table 7)*	**Value(KRW)**	**Totals(KRW)**
Off-grid domestic				
Off-grid non-domestic				
Grid-connected distributed	**110.4**	**1,600**	*176,640,000,000*	
Grid-connected centralized	**798.8**	**1,400**	*1,118,320,000,000*	
				1,294,960,000,000[1]
Export of PV products				*2,865,000,000,000*
Change in stocks held				
Import of PV products				
Value of PV business				***4,159,960,000,000***

In Korea, the PV industry value chain for crystalline silicon solar cells is completely established from raw materials (polysilicon), ingot and wafers, cells, modules, systems and power plants. Among these, polysilicon production capacity is currently No. 3 in the world. The Korean-made products are mostly exported to foreign countries including China, EU, Japan and USA.

[1] Domestic PV market revenue was KRW 2,077,700,000,000 according to 2016 New and Renewable Energy Industry Statistics by KEA.

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

Short description of the electricity industry landscape	- Vertically integrated structure - Retailers and network businesses 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 18 companies including electricity generation companies, electricity generation business companies and 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. In March 2016, PV REC market and non-PV REC were merged. After the merger, the annual average REC price increased from 92, 638 KRW/kW in 2015 to 144,136 KRW/kW in 2016.

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 grew fast in 2015. A so-called "Negawatt" market was also introduced in 2014 and was fully operational in 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." Especially after the announcement of "2030 Energy-related New Industry Development Plan," KEPCO started to actively engage in the various NRE development and dissemination projects.

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 conducted 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 electricity consumption was reduced from 46,903 GWh in 2011 to 45,019 GWh in 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" began 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 were 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. Chungbuk Technopark is located in the neighbouring Cheongju city and actively engaged in PV module testing and certification. KIER (Korea Institute of Energy Research) is also 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 was successfully 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 insolation 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. GEI (Green Energy Institute) is also located in the neighbouring city, Mokpo.

8 HIGHLIGHTS AND PROSPECTS

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 the next three years. This was mainly due to the limited Feed-in Tariff (FIT) scheme which played initially an important role in the PV market expansion. Since 2012, Renewable Portfolio Standard (RPS) was introduced as a flagship renewable energy program, replacing FIT. Thanks to new RPS scheme (with PV set-aside requirement), significant PV deployment has been achieved, 295 MW in 2012, 531 MW in 2013, 926 MW in 2014, 1,133 MW in 2015 and 909 MW in 2016 respectively. 22 MW of capacity was reduced in 2016, which made net increased capacity to 887 MW. At the end of 2016, the total installed capacity was about 4.5 GW, among those the grid-connected centralized system accounted for around 88% of the total cumulative installed power. The grid-connected distributed system amounted to around 12% 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 4,501.6 MW corresponds to 4.1% of total electricity generation capacity of about 109,789 MW, and the installed PV power of 909 MW in 2016 accounts for 18.6% of total power generation capacity newly installed (4,888 MW) in 2016.

Korean government continued its support to strongly promote 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 per year plays a major role in boosting PV deployment and technology development. Korean government announced '2030 Energy-related New Industry Development Plan for Climate Change Response' on November 23, 2015. It is the five-year plan with detailed action items targeting specific goals for 2030 to achieve the Korea's INDC of 37% GHG reduction (on BAU basis). By 2030, Korean government plans to generate 100 trillion KRW new market, 500 000 new employments and 55 million tons of GHG reduction from the energy-related new industries. PV will take a very important role in energy-related new industry development, targeting a cumulative PV installations of 17.5 GW by 2035, which will provide 22% of total NRE generated electricity.

Various incentives have been used to support PV development. Under the Forth Basic NRE 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 implemented in 2015, and these subsidy measures and programs are expected to expand 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.

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