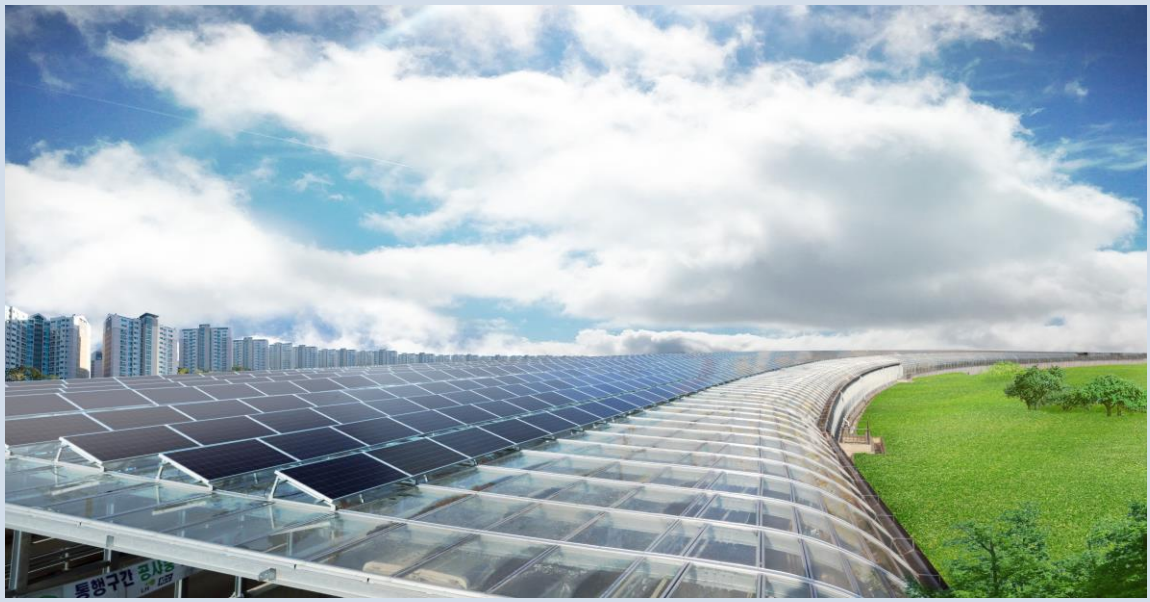
IEA INTERNATIONAL ENERGY AGENCY

New & Renewable Energy

IEA-PVPS

National Survey Report of Photovoltaic Applications in Korea - 2017



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 2017. 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 systems 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 2017 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2017, 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, 909 MW in 2016, and 1 362 MW in 2017, respectively. At the end of 2017, the total installed capacity was about 5,8 GW, among those the grid-connected centralized system accounted for around 91,6% of the total cumulative installed power. The grid-connected distributed system amounted to around 8,4% 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 5 834,5 MW corresponds to 5,0% of total electricity generation capacity of about 116 908 MW, and the installed PV power of 1 362 MW in 2017 accounts for 12,3% of total power generation capacity newly installed (11 042 MW) in 2017, as can be seen in Table 3.
PV in buildings is getting more interest in urban environment, and recent zero-energy complex project in Nowon-gu, Seoul (picture below) demonstrated successful results, receiving many visitors. Floating PV on the lakes is also getting popular in Korea (with potential of ~10 GW). In July 2017, Korea Rural Community Corporation conducted a study about South Korea's potential of on-water PV and estimated 3,26 GW from water reservoir (10% of the total reservoir), 2,633 GW from fresh-water lakes (20% of the total) and 73 MW from irrigation and drain channels (2% of the total). In addition K-Water can utilized 8% of the dams, which sums up to 3,7 GW. Therefore the total on-water PV potential in Korea is estimated to be about 9,7 GW. Agricultural PV (in short agri-PV) is getting higher attention since the new government announced 'RE3020 plan,' and many demonstration projects are being undertaken by power producing companies collaborating with local authorities. BIPV and VIPV are mostly developed and tested through government-led R&D projects which focus on the compatibility of PV modules to design, esthetic appearance, and functional flexibility.

<Nowon-gu Zero-energy House>

<Jipyeong Reservoir On-water PV, 6 MW>

1.2 Total photovoltaic power installed

Table 1 shows the PV power installed in four sub-markets during 2017.

The annual installation data was obtained from the total capacity of the PV systems approved to install in the year of 2017 by the NREC (New & Renewable Energy Centre) at KEA (Korea Energy Agency). In Korea, PV installation statistics is categorized into two sectors, PV for 'business' or PV for 'self-use.' Thus in the tables, grid-connected 'BAPV' is assumed as 'self-use' which includes PV installations in households, public facilities, education facilities, welfare facilities, industrial facilities, commercial facilities and others (off-grids), and grid-connected 'Utility-scale' is assumed as 'business' which include all the PV installations under RPS scheme. 2017 data were taken from the '2017 NRE Deployment Statistics' published by KEA in November 2018.

Table 1: PV power installed during calendar year 2017

AC			**MW installed in 2017p**	**MW installed in 2017**	**AC or DC**
Grid-connected	APV	Residential	114,1		DC
		Commercial			
		Industrial			
	BIPV (if a specific legislation exists)	Residential			
		Commercial			
		Industrial			
	Utility-scale	Ground-mounted	1 248,4		DC
		Floatting			
		Agricultural			
Off-grid		Residential (SHS)			
		Other			
		Hybrid systems			
		Total	1 362,5		

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)
Link to official statistics (if this exists)	www.energy.or.kr www.kesis.net www.kopia.asia www.kepco.co.kr
	Installation data are mainly collected from KEA; electricity data are mainly collected from KEPCO and KEEI; industry data are mainly collected by KOPIA.

Table 3: PV power and the broader national energy market

MW-GW for capacities and GWh-TWh for energy	2017 numbers	2016 numbers
Total power generation capacities (all technologies)	116 908 MW	105 866 MW
Total power generation capacities (renewables including hydropower)	15 767 MW	13 962 MW
Total electricity demand (= consumption)	507 746 GWh	497 039 GWh
Total energy demand (= final consumption)	232 501 ktoe	225 681 ktoe
New power generation capacities installed during the year (all technologies)	11 042 MW	4 888 MW
New power generation capacities installed during the year (renewables including hydropower)	1 805 MW	1 445 MW
Total PV electricity production in GWh-TWh	7 056 GWh	5 122 GWh
Total PV electricity production as a % of total electricity consumption	1,4%	1,0%

Table 4: Other informations

	2017 Numbers
Number of PV systems in operation in your country (a split per market segment is interesting)	26,861 (No. of PPA contracts)
Capacity of decommissioned PV systems during the year in MW	
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 (MWp)

Year	**Off-grid (including large hybrids)**	**Grid-connected distributed (BAPV, BIPV)**	**Grid-connected centralized (Ground, floating, agricultural…)**	**Other uses (VIPV, wearables…)**	**Total**
~2005		12,1	1,4		13,5
2006		25,3	10,5		35,8
2007		41,8	39,4		81,2
2008		58,4	298,5		356,9
2009		82,6	441,1		523,7
2010		116,8	533,5		650,3
2011		152,7	576,5		729,2
2012		214,9	809,4		1 024,3
2013		278,1	1 276,9		1 555,0
2014		347,1	2 134,2		2 481,3
2015		440,9	3 174,3		3 615,2
2016		551,1	3 950,6		4 501,7
2017		665,0	5 169,5		5 834,5

1.3 Key enablers of PV development

Table 6: information on key enablers

	Description	2017 Volume (Units)	Total Volume (Units)	Source
Decentralized storage systems (ESS)	Demonstration project started in 2009, and support measures caused remarkable growth of ESS in 2016-2017	410 MWh	900 MWh	Woori Finance Research Institute
Residential Heat Pumps				
Electric cars (and light weight)	Passenger cars registered	13,826	25,593	Ministry of Environment
Electric buses/trucks	Mostly electric buses	81	133	Ministry of Land, Infrastructure and Transport
Other				

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 7 and Table 9 are the calculated average values.

Table 7: Typical module prices for a number of years

Year	1992	2011	2012	2013	2014	2015	2016	2017
Standard module crystalline silicon price(s): Typical		1,400	1,000	974	974	974	646	500
Lowest prices		1,200	800	634	634	634	456	450
Highest prices								800

2.2 System prices

The price of grid-connected systems varied from 1 170 KRW/W to 1 900 KRW/W depending on the type and size of installations.

Table 8: **Turnkey Prices of Typical Applications – local currency**

Category/Size	Typical applications and brief details	Current prices per W
OFF-GRID Up to 1 kW (SHS)		
OFF-GRID > MW scale		
Grid-connected Rooftop up to 5-10 kW (residential BAPV)	Residential housing	KRW 1 290~1 750
Grid-connected Rooftop from 10 to 250 kW (commercial BAPV)	Apartment complex and commercial building	KRW 1 250~1 700
Grid-connected Rooftop above 250kW (industrial BAPV)	Factory	KRW 1 200~1 650
Grid-connected Ground-mounted above 10 MW	Utility	KRW 1 170~1 630
Other category (hybrid diesel-PV, hybrid with battery…)		
Floating PV	On-water PV on the lake and reservoir	KRW 1 700~1 900
Agricultural PV	Farming ground	KRW 1 700~1 900
Residential BIPV (tiles, or complete roof).		
Industrial BIPV		

Table 9: National trends in system prices (current) for different applications – local currency

Price/Wp	2011	2012	2013	2014	2015	2016	2017
Residential PV systems <5-10 KW	4 000	3 000	3 000	3 000	1 750	1 600	1 520
Commercial and industrial BAPV				2 900	2 250	1 500	1 450
Ground-mounted > 10 MW			2 400	2 120	1 700	1 400	1 400

2.3 Cost breakdown of PV installations

The cost information below was collected from the interviews with a few major PV system installation companies in Korea, and the level of reliability is within ±15%.

2.3.1 Residential PV System <5-10 kW

Table 10: 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	650	500	800
Inverter	250	230	270
Other (racking, wiring…)	270	230	310
Soft costs			
Installation	200	180	220
Customer Acquisition	50	50	50
Profit	50	50	50
Other (permitting, contracting, financing…)	50	50	50
Subtotal Hardware	1 170	960	1 380
Subtotal Soft costs	350	330	370
Total	1 520	1 290	1 750

2.3.2 Utility-scale PV systems >10 MW

Table 11: Cost breakdown for a utility-scale PV system – local currency

Cost Category	Average (local currency/W)	Low (local currency/W)	High (local currency/W)
Hardware			
Module	495	450	540
Inverter	75	70	80
Other (racking, wiring, etc.)	370	300	440
Soft cost			
Installation Labor	390	300	480
Customer acquisition	70	50	90
Profit			
Other (contracting, permitting, financing etc.)			
Subtotal Hardware	940	820	1 060
Subtotal - Soft cost	460	350	570
Total Installed Cost	1 400	1 170	1 630

2.4 Financial Parameters and specific financing programs

Table 12: PV financing scheme

Average rate of loans– residential installations	5,5% (3,0% from agricultural cooperatives)
Average rate of loans – commercial installations	4,0 ~ 5.5%
Average cost of capital – industrial and ground-mounted installations	4,0% (project financing)

2.5 Specific investments programs

Table 13: Specific investment programs

Third Party Ownership (no investment)	
Renting	
Leasing	Korea Energy Agency (KEA) offers solar lease program for households using electricity more than 200 kWh/month on the average in the recent one year period. The household pays less than 80% of the typical electricity bill for (PV leasing fee + electricity fare), and the leasing company provides O&M services and makes profit from collecting leasing fee from the household and selling REP[1] to the RPS obligators.

Financing through utilities	
Investment in PV plants against free electricity	
Crowdfunding (investment in PV plants)	Private companies attract investors for PV power plants by crowdfunding scheme, and typical earning rate is about 7%.
Community solar	Maximum 20% increase in REC multiplier when community residents are involved in the projects
Other (please specify)	

[1]REP: Renewable Energy Point

2.6 Additional Country information

Table 14: Country information

Retail Electricity Prices for an household (range)	93,3~280,6 KRW/kWh for low voltage[2] (93,3 for 0-200 kWh; 187,9 for 200-400 kWh; 280,6 for >400 kWh)
Retail Electricity Prices for a commercial company (range)[3]	53,7~196,6 KRW/kWh
Retail Electricity Prices for an industrial company (range)	52,8~196,6 KRW/kWh
Population at the end of 2017 (or latest known)	51,778 million as of 2017
Country size (km^2)	100 363,7 km^2 as of 2017
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

[2]Low voltage: 110-380 V; High voltage A: 3 300-66 000 V; High voltage B: 154 000 V; High voltage C: 345 000 V or higher.

[3]Retail electricity prices for a commercial company varies depending on the contract power (lower or higher than 300 kW), existence or absence of divided meters, time or season of use (summer, spring & fall, winter, day or night), and supply voltage. Electricity prices for educational facilities and farming use follow different fare structure.

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 2017

3.1.1.1 Climate change commitments

The INDC (Intended Nationally Determined Contribution) target of Korea is 37% reduction of GHG (Greenhouse Gas) for the period of 2018~2030 on the BAU (Business As Usual) basis. Since the BAU-based GHG emission in Korea is estimated to be 850,8 Mton in 2030, the expected emission amount in 2030 after subtracting the reduction target will be 536,0 Mton which is 22.3% reduced from the 2015 emission amount of 690 Mton. Korean government announced the modified version of GHG reduction roadmap on July 24th, 2018, which confirmed the commitment to achieve Korea's NDC target again and increased the domestic reduction percentage from original 25,7% to 32,5%. In more detail, industry sector, building sector, transportation sector, and other sectors (agricultural & stock raising, waste reduction, public sector, etc) will reduce 98,6 Mton, 64,5 Mton, 30,8 Mton, 14,6 Mton, respectively, whereas power sector will reduce 57,8 Mton (23,7 Mton confirmed and 34,1 Mton will be confirmed by 2020 before NDC submission). The rest of the reduction will come from the new industries in energy sector and CCUS (10,3 Mton), absorption by forest (22,1 Mton) and reduction in foreign sites (16,2 Mton). PV will be fully utilized in various sectors including buildings and power generation plants. Cap & trade scheme will also be used to drive the industry (for 591 companies) to move towards reducing the GHG emissions.

3.1.1.2 Description of support measures (excluding BIPV, VIPV and rural electrification)

Since the start of the current government in 2017, Korea has been trying to change the energy infrastructure from using a centralized system with more than 75 percent coal and nuclear into a more distributed system based on renewable energy resources. That is supported by many citizens suffering from coal plants -- the fine dust issue -- and also the nuclear safety issue -- emphasized by the recent earthquakes near the nuke-populated areas. Government announced the "Renewable Energy 3020 Plan" in 2018, which aims at supplying 20% of the electricity from renewable sources. Due to this plan, the cumulative installed capacity of renewable electricity will be 63,8 GW by 2030 (currently 15,1 GW in 2017), among which PV (57%) and wind (28%) will occupy 85%. Newly installed capacities of PV and wind during the planned period will be 30,8 GW and 16,5 GW, respectively. In this context, many support measures will be used and newly introduced. Korea's current policy structure to promote PV deployment can be categorized into four areas: 1) subsidies for installation, 2) incentives, 3) obligatory measures, and 4) infrastructure building. The "Third National Energy Master Plan" will be prepared in 2018 to provide the legal ground for future energy transition in Korea. The policy structure remained the same in 2017, however, and was based on the "Second National Energy Master Plan," which is summarized below.

<Subsidy Programs for PV Installation>

Subsidy for Residential Installation

This program was launched in 2004 that merged the existing 100 000 rooftop PV system installation program, and it aims at constructing one million green homes utilizing PV as well as solar thermal, geothermal, small-size wind, fuel cell and bio-energy until 2020. In general, single-family houses and multi-family houses including apartments can benefit from this program. The KEA provides maximum 60% of the initial PV system cost for single-family and private multi-family houses, and maximum 100% for public multi-family rent houses. The maximum PV capacity allowed for a household is 3 kW. In 2017, total 28,708 MW PV systems were installed under this program.

Subsidy for Building Installation

The KEA supports up to 50% of the installation cost for PV systems (below 50 kW) in buildings excluding private homes. In addition, the KEA supports maximum 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 2017, total 50,515 MW PV systems were installed under this program. Various grid-connected PV systems were installed in schools, public facilities, welfare facilities as well as universities.

Subsidy for Local Government

The KEA supports up to 50% of installation cost for NRE (including PV) systems owned or operated by local authorities. In 2017, 10,267 MW PV systems were supported from this program.

Subsidy for Hybrid Installation

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 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 for this program, thus the optimal integration of 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 4,941 MW PV systems were installed in 2017 under this program.

Solar Lease Program

In 2013, MOTIE (through KNREC) introduced this new scheme to promote PV deployment and launched a few demo projects for 60 detached houses. The Solar Lease program fully began from 2014, and it is designed in such a way that the private companies take care of installations and maintenance without support from the Government, while consumers pay the leasing fee. Household owners of using more than 200 kWh/month (monthly average in the recent one year period) can apply for this program. Owners pay PV system leasing fee (monthly maximum: 70 000 KRW) which is on the average less than 80% of the typical electricity bill) for minimum 7 years and can use the PV system with no initial investment and O&M cost for the leasing period. PV leasing companies recover the investment by earning PV leasing fee from the households and selling REP (Renewable Energy Point) to RPS obligators with no multiplier. Leasing fee, lease period and REP price are properly set to motivate the participation of PV leasing companies and consumers. The maximum PV capacity allowed for a household is 3 kW for houses of consuming 200~599 kWh electricity monthly average and maximum 9 kW for houses of consuming 600 kWh or higher electricity monthly average. In 2017, 19,630 MW PV systems were installed under this program.

<Comparison between PV subsidy program and Solar lease program>

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

Korean-type Feed in Tariff (FiT)

To improve the bankability of small-scale distributed PV system installations, a new temporary (for the period of 2018-2022) subsidy measure will be introduced in 2018. A fixed contract price of 189 175 KRW (for 20 years) will be provided for systems less than 30 kW with no restriction, and for systems less than 100 kW if they are run by farmers, fishermen or Co-ops.

<Incentive Programs>

Capital Subsidy (NRE Loan) Program

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) 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 (up to 90% of the necessary fund) to the companies with low interest rate (typically 1,75% variable), grace period option (1 to 5 years) and amortization option (2 to 10 years). This subsidy loan can be used for financing facilities (purchase, installation, upgrade, etc.), production funds as well as a working capital. In 2017, total budget of 66 million KRW was allocated for NRE.

Investment Tax Credit Incentive Program

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 production facilities) and manufacturing facilities for NRE production (e.g. polysilicon production equipment, silicon wafer production equipment, solar cell & module manufacturing equipment, etc.). This program will last until the end of 2018. Small-size enterprises get 6% tax exemption, medium-size enterprises get 3% tax exemption, and Korean national individuals get 1% tax exemption from investment cost.

<Obligatory Programs>

RPS Program for Power Businesses

The RPS is a mandated requirement that the electricity utility business sources a portion of their electricity supplies from renewable energies. In Korea, 21 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 2023, 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 2017 alone, 1 248,4 MW (cumulative 4 537 MW) was installed under this program. In a cumulative amount, about 78% of the total PV installations in Korea was made under RPS scheme, while total 497 MW (about 9%) was installed under FIT program 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 small-scale

installations (less than 100 kW size) by adjusting the REC and multipliers (1,2), and unifying the PV and non-PV markets. To further enhance the predictability of profit (to attract project financing entities), MOTIE launched a new long-term (20 years) fixed price (SMP+REC) RPS scheme in 2017. This scheme has an advantage of guaranteeing the long-term power purchase with a fixed price which is determined by the market-following system including competitive bidding. In 2017, the fixed price was 188~189 KRW/kWh. To facilitate the involvement of local communities, MOTIE also launched a new REC multiplier scheme, in which maximum 20% increase in REC multiplier when community residents are involved in the projects. Grid connection of PV systems is guaranteed up to 1 MW by the Government since 2017. Newly adjusted REC multiplier scheme based on five evaluation criteria (economic feasibility, environmental effect, potential, industry promotion effect, and policy priority) is summarized below.

<REC Multipliers in RPS>

Multiplier	Eligible Energy Sources	
	Installation Type	Details
1,2	On land	Less than 100 kW
1,0		100 kW ~ 3 000 kW
0,7		More than 3 000 kW
0,7	On forestland	Regardless of capacities
1,5	On building or existing facilities	Less than or equal to 3 000 kW
1,0		More than 3 000 kW
1,5	Floating on the water surface	

NRE Mandatory Use for Public Buildings

The new buildings of public institutions, the floor area of which exceeds 1,000 m^2, are obliged by law to use more than 21% (in 2017) of their total expected energy from newly installed renewable energy resources. Public institutions include state administrative bodies, local autonomous entities, and state-run companies and institutions. The building energy mandate percentage will increase up to 30% by 2020.

3.1.1.3 BIPV development measures

Support Measures for BIPV Installation

A government level discussion is on the way to provide support measures for BIPV installations such as adjusting the REC multiplier (greater than 1.0), amending the regulations of local governments, and financial support. New subsidy measures are expected to be introduced from 2019.

Zero Energy Building (ZEB) Demonstration Projects

The Ministry of Land, Infrastructure and Transport (MOLIT) launched 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 from 2020, first making the nearly ZEB to be obligatory for the public buildings.

3.1.1.4 Utility-scale measures including floating and agricultural PV

Floating PV Installation

Floating PV on the lakes is getting popular in Korea (with potential of ~10 GW). In July 2017, Korea Rural Community Corporation conducted a study about South Korea's potential of on-water PV and estimated 3,26 GW from water reservoir (10% of the total reservoir), 2,633 GW from fresh-water lakes (20% of the total) and 73 MW from irrigation and drain channels (2% of the total). In addition K-Water can utilized 8% of the dams, which sums up to 3,7 GW. Therefore the total on-water PV potential in Korea is estimated to be about 9,7 GW. Floating PV gets 1,5 REC multiplier under current RPS scheme and thus is very attractive to the developers. Also Korean government recently announced 4 GW Saemangeum project in the region southwest of the capital city and that includes about 2,8 GW of PV and 1 GW of off-shore wind. The Saemangeum area was originally sea area and now it is reclaimed but still many parts are salty water. So the technology developed for floating PV will have more opportunities to be used in that area but in a salty water situation.

Agricultural PV Installation

Agricultural PV (in short Agri-PV) is getting higher attention since the new government announced 'RE3020 plan,' and many demonstration projects are being undertaken by power producing companies collaborating with local authorities. The 3,3 GW by 2022 and 10 GW by 2030 Agri-PV installation is planned by the Government, and governmental level discussions are on the way to facilitate Agri-PV installations.

3.1.1.5 Rural electrification measures

Rural electrification measures are adopted and implemented mainly by the local authorities. 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. 'Carbon-free Island Jeju by 2030 Project' was jointly planned by Jeju provincial government and central government in 2012 and will be expanded to more islands in Korea. Wind power, PV, geothermal, ESS, and EV will be utilized within the smart grid infrastructure to increase the NRE portion in the energy mix for the islands. Jeju island plans to make the island completely fossil free by 2030.

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)), which is designed to deploy 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 the 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

	center
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

3.1.1.6 Support for electricity storage and demand response measures

ESS demo project was first launched in 2009, and the early ESS was typically used for frequency regulation purposes. Due to the recent support from the Government since 2016, mainly giving incentives in electricity fare for consumers equipped with ESS system for peak-load reduction, the cumulative ESS installation was remarkably increased in the recent few years (89 MWh in 2014, 490 MWh in 2016 and 900 MWh in 2017). Consumers can get maximum 50% savings in their electricity use under the current scheme.

Support Measures for PV+ESS Installation

Government provides very attractive REC weighting factor for PV power with ESS system. It is a temporary subsidy, though, giving 5,0 REC weighting factor for 2018 and 2019, and it will be decreased to 4,0 in 2020. Also self-use PV electricity transactions get 1,0 REC weighting factor.

3.1.1.7 Support for electric vehicles (and VIPV)

The Government recently announced a very aggressive plan to expand the domestic production of eco-friendly vehicles, in which the cumulative EVs will be 430 0000 vehicles by 2022 (56 000 vehicles as of 2018), and the cumulative hydrogen fuel cell vehicles will be 65 000 vehicles by 2022 (923 vehicles as of 2018). To achieve the goals, the obligatory purchase percentage of eco-friendly vehicles by public entities will rise to 100% by 2020 (currently 70% in 2018), and 2 000 hydrogen buses (cumulative) will be deployed by 2022. Ten hydrogen taxis will be operating in Seoul as a demonstration and test since 2019. Charging infrastructures for EVs and hydrogen fuel cell cars will be prepared by local governments with support from the central government. Currently this movement in Korea is not directly related with the VIPV development, but automobile companies (Hyundai/Kia) are developing VIPV as an option for eco-friendly vehicles. The first VIPV electric vehicle will show up in 2019 made by Hyundai/Kia.

Table 15: PV support measures (summary table)

	On-going measures residential	**Measures that commenced during 2017 - residential**	**On-going measures Commercial + industrial**	**Measures that commenced during 2017 – commercial + industrial**	**On-going measures Ground-mounted, including floating**	**Measures that commenced during 2017 – ground mounted, including floating**
Feed-in tariffs	Ended in 2011					
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

Table 16: Self-Consumption Schemes

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

In Korea, community solar is increasing due to the recent announcement by the Government. Then new scheme provides maximum 20% increase in REC multiplier when community residents are involved in the projects.

3.4 Tenders, auctions & similar schemes

Tenders and Auctions

Currently Korea's RPS scheme relies on the auction system with upper and lower bound managed by the Government.

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 October 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 slowly growing 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 21 RPS obligators indirectly affecting the electricity prices (Government controls the electricity price).

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% reduction (on BAU basis) in greenhouse gases by 2030, which was announced in COP21 in Paris, 2015.

Introduction of Favorable Environmental Regulation (Cap & Trade System)

The Cap & Trade system was first 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. The Cap & Trade system and emission allowance for each sector will be revised due to the revision of GHG reduction roadmap in 2018.

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 INDUSTRY

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

Table 17: Production information for the year for silicon feedstock, ingot and wafer producers

Manufacturers (or Total National Production)	Process & Technology	Total Production Capacity	Product Destination (if known)	Price (if known)
OCI	Siemens Process	52 000 tonnes	China, Taiwan, etc.	
HK Silicon	Siemens Process	15 000 tonnes	China, Korea, etc.	
Hanwha Chemical	Siemens Process	15 000 tonnes	China, Korea, etc.	
Total	Silicon Feedstock	82 000 tonnes		
Woongjin Energy	Si Ingot (mono)	1 500 MW	Germany, USA, etc.	
Nexolon	Si Ingot (mono, multi)	1 750 MW		
Total	Si Ingot	3 250 MW		
Woongjin Energy	Si Wafer(mono)	2 000 MW	USA, Germany, Korea, etc.	
Total		2 000 MW		

OCI obtained 100% of shares from Tokuyama Malaysia and upgraded the Malaysia plant (Line 1) to a production capacity of 13 800 tonnes in 2017. OCI's Malaysia plant (Line 1 and 2) is expected to have a total capacity of more than 24 000 tonnes in 2019. With Korea and Malaysia plants of more than 76 000 tonnes OCI is expected to be No. 1 polysilicon supplier in the world. HK Silicon, however, went bankrupt and was not operational in 2017.

In the area of ingot and wafer, Woongjin Energy ramped up its facilities from 2016 to March of 2017 and increased productivity and cost competitiveness through process improvement. Nexolon, however, went bankrupt and was not operational in 2017.

Due to the second wave of the reconstruction of photovoltaic industry in a global context with heavy competitiveness and oversupply, Korean companies are also going through a turmoil of 'Innovation and Survival."

4.2 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 below.

Table 18: Production and production capacity information for 2017

Cell/Module Manufacturer (or Total National Production)	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum Production Capacity (MW/yr)	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
1 SolarTech	c-Si				30
2 Solariver	c-Si				20
3 SDN	c-Si			45	100
4 DTC	c-Si			60	
5 S-Energy	c-Si				500
6 BJ Power	c-Si				20
7 HHI Green	c-Si			600	600
8 Hanwha Q-Cells	c-Si			3,700	3,700
9 Shinsung E&G	c-Si			500	200
10 Hansol Technics	c-Si				400
11 Dayou SE	c-Si				120
12 LS IS	c-Si				150
13 JSPV	c-Si				400
14 SolarParkKorea	c-Si				600
15 TopSun	c-Si				150
16 LG Electronics	c-Si			1,500	1,500
18 Luxco	c-Si				200
19 KPE	c-Si			100	
Total	**c-Si**			***6,505***	***8,690***
Thin film manufacturers					
1		x	*x*	y	*y*
2					
Cells for concentration					
1		g		h	
2.					
TOTALS		**a+c+x+g**	**d+x**	**6,505**	**8,690**

Hanwha Q-Cells Korea aggressively expanded its production capacities in 2017. Owing to its active investment in solar PV manufacturing, it became the most leading-player in terms of production capacities in Korea as well as in the world. It has been also increasing the efficiency of products with its own Q.ANTUM technology.

LG Electronics has been pursuing the technological edge of premium solar cell and module through its n-type mono bifacial technology, while gradually ramping up its production capacities. Hyundai Green Energy and Shinsung E&G have been increasing the amount of PERC (Passivated Emitter and Rear Contact) cell products.

4.3 Manufacturers and suppliers of other components

PV Inverters

As the volume of Korean PV market increases, many foreign inverter players have been knocking on the Korean PV market by establishing sales points and service networks in Korea. Responding to the increase of such competition, Korean PV inverter makers have been expanding their business territory, too. For instance, Korean companies are increasing the production of PCS (Power Conditioning System) used in ESS (Energy Storage System). On top of that, they have been building up competence in the O&M field, incorporating the technology of big data, predictive control, IoT and energy management.

Storage Batteries

The demand of storage batteries has been outstripping the supply in Korean market. This is due to the subsidy measure to award the multiplier of 5,0 in REC (Renewable Energy Certificate) for solar PV systems combined with ESS and other policies promoting ESS in electricity charge and discharge. The manufacturers of storage battery such as LG Chemicals, Samsung SDI and SK Innovation have increased the production capacities in order to respond to the increasing demand. However, it seems the shortage of storage batteries continue longer, because Korean government decided to extend the term to award the multiplier of REC (5,0 in 2018 and 2019, and 4,0 in 2020) and the battery manufactures can put more value on the market of electric vehicles.

5 PV IN THE ECONOMY

5.1 Labour places

Table 19: Estimated PV-related labour places in 2017

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	**7 522**

5.2 Business value

Table 20: Value of PV business

Sub-market	**Capacity installed *in 2017* (MW)**	**Price per W (KRW)** *(from Table 9)*	**Value (KRW)**	**Totals (KRW)**
Off-grid domestic	*X*	*Y*	*a = X xY x 1 000 000*	
Off-grid non-domestic			*b*	
Grid-connected distributed	114,1	1 520	*173 432 000 000*	
Grid-connected centralized	1 248,4	1 400	*1 747 760 000 000*	
				1 921 192 000 000[1]
Export of PV products				*3 674 000 000 000*
Change in stocks held				*f*
Import of PV products				*g*
Value of PV business				***6 435 800 000 000***

[1]Domestic PV market revenue was KRW 1 933 100 000 000 according to 2017 New and Renewable Energy Industry Statistics by KEA.

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. 2 in the world, and silicon solar cell capacity is currently No. 1 in the world. The Korean-made products are mostly exported to foreign countries including China, EU, Japan and USA.

6 INTEREST FROM ELECTRICITY STAKEHOLDERS

6.1 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

6.2 Interest from electricity utility businesses

Since 2012, the RPS scheme started and replaced the FiT which lasted until 2011. Total 21 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 preferred 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 into one. After the merger, the annual average REC price increased from 92 638 KRW/kW in 2015 to 144 136 KRW/kW in 2016. In 2017, 92.9% of the duties was attained, supplying 17 626 GWh (duties: 18 975 GWh). The REC price was also stabilized down to average 131 000 KRW/kW.

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 five criteria: 1. Influence on environment, 2. Technology development and industry vitalization, 3. Cost in electricity generation, 4. Potential amount, and 5. Policy priority. In practice, however, there exist some mismatches and conflicts to hinder the RPS participants from fulfilling their duties. Some regions with large PV potential have either low REC weighting factor or under strict regulation. The first year's RPS practice revealed many of these problems. Thus Korean government simplified the REC weighting factor scheme in 2014, and minor adjustments were made from time to time to reflect the issues arising from implementation.

Electricity utility businesses in general were originally hesitant to participate aggressively in the PV deployment and were asking for more support from the Government. However, since the start of new government in 2016 and due to the recent RE3020 plan, electricity utility businesses are now actively engaged in PV deployment. Large-scale PV deployment projects are being announced competitively by the electricity utility businesses. Especially, recently announced 4 GW Saemangeum project in the region southwest of the capital city and that includes about 2,8 GW of PV and 1 GW of off-shore wind is expected to drive the electricity utility businesses more into participating in the PV installations.

Solar lease program (third party ownership) is introduced in 2014, and grew fast in the following years. A so-called "Negawatt" market was also introduced in 2014 and has been fully operational. 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 "RE3020 Plan," KEPCO started to more actively engage in various PV development and dissemination projects.

6.3 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 GHG 10 million ton reduction, and the goals involve the 20% electricity independence rate (currently 13%) of Seoul by 2020. In particular, cumulative 42 332 PV systems (37 405 kW) including 31 951 (8 630 kW) mini-PV (typically 250 W) for households was installed in 2017, and citizen crowd-funded PV power plants were also launched in 2015. Seoul metropolitan government announced a new slogan of ‘City of Sun 2022’ which aims at deploying 157 384 kW (605 185 systems) PV power plants by 2022.

Chungbuk Province’s slogan is “A Land of Life and Sun.” In this province, more than 50% of Korean-made PV modules (more than 70% of PV cells) are produced, and about 100 PV related companies are in business. The province is holding ‘Solar Festival’ every year and recently established a plan to construct a PV R&BD hub (called ‘Asia Solar Valley’). Chungbuk Technopark is located in Cheongju city and actively engaged in PV module (including BIPV) testing and certification. The province is trying to host the KITECH (Korea Institute of Industrial Technology) Chungbuk Branch and building a ‘PV Tech Support Center’ for region’s SMEs. KIER (Korea Institute of Energy Research), a national laboratory covering all kinds of energy except nuclear energy, is also located in the neighboring 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) and MOTIE-sponsored MW PV Testbed are located in Yeungnam University in the neighboring 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 also launched a project called “Sunlight Energy Farming” in 2015 to secure regular incomes 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).

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 and thus the largest number of PV power plants in Korea. KEPCO, KPX, Honam PV test-bed at Jeonnam Technopark and KITECH (Korea Institute of Industrial Technology) Jeonnam Branch are both located in Jeonnam province and the neighboring city, Gwangju (meaning ‘Sunshine Village’). GEI (Green Energy Institute) is also located in the neighboring city, Mokpo.

Other provinces including Busan metropolitan city (second largest city in Korea), Gyeonggi province, Ulsan city and Chungnam province also began to be actively engaged in PV deployment and PV related industry development since the start of the new government.

7 HIGHLIGHTS AND PROSPECTS

In Korea, photovoltaic system is mainly applied to the electric power generation.
Since "The Renewable Portfolio Standards" (RPS) replaced the FiT from 2012, the Korean PV market followed an upward trend that stabilized around the GW mark: The country installed 1,36 GW in 2017, after having installed 909 MW in 2016. Utility-scale PV plants accounted for around 1,25 GW of the installed capacity in 2017. Distributed PV systems amounted to around 8,4% of the total cumulative capacity. The share of off-grid PV systems has continued to decrease and represents less than 1% of the total cumulative installed PV capacity. At the end of 2017, the total installed capacity reached 5,8 GW, and PV contributed to 1,4% of the total electricity consumption.

Korean government continued its support to strongly promote the PV deployment, R&BD, infrastructure building and market promotion. Among these, the government-driven RPS scheme and R&BD support play major roles in boosting PV deployment and technology development. The Government announced the “Renewable Energy 3020 Plan” in December 20th, 2017, which aims at supplying 20% of the electricity from renewable sources. Due to this plan, the cumulative installed capacity of renewable electricity will be 63,8 GW by 2030 (currently 15,1 GW in 2017), among which PV (57%) and wind (28%) will occupy 85%. Newly installed capacities of PV and wind during the planned period will be 30,8 GW and 16,5 GW, respectively. To achieve these goals, two-track approach will be taken, which aims at deploying small-scale PV systems for individual households and cooperative unions in one track, and large-scale PV systems for agricultural sites and pre-planned sites (e.g. reclaimed area) on another track.

Korean government also announced the modified version of GHG reduction roadmap on July 24th, 2018, which confirmed the commitment to achieve Korea’s NDC target (37% on a BAU basis) again but increased the domestic reduction percentage from original 25,7% to 32,5%. PV will be fully utilized in various sectors including buildings and power generation plants. Cap & trade scheme will also be used to drive the industry (591 companies in obligation) to move towards reducing the GHG emissions. Total 314.8 Mton of GHG reduction is targeted until 2030.

Korean PV industry, completely established the value chain for crystalline silicon solar cells from raw materials (polysilicon), ingot and wafers, cells, modules, systems and power plants, continued to grow and expand its production capacities. Among these, OCI’s polysilicon production capacity is currently No. 2 in the world, and Hanwha Q-Cells’ silicon solar cell capacity is currently No. 1 in the world. High efficiency silicon technologies of Korean PV manufacturers kept improving including Hanwha Q-Cells’ Q.ANTUM technology, LG Electronics’ n-type mono bifacial technology, and Hyundai Green Energy and Shinsung E&G’s PERC cell technology. The Korean-made products are mostly exported to foreign countries including China, EU, Japan and USA.

In the next generation PV technology area, Korea is leading the research on Perovskite solar cell and its tandem cell technology. VIPV is also being developed by research institutes, and Hyundai/Kia motor company is expected to launch the first production of VIPV cars in 2019.