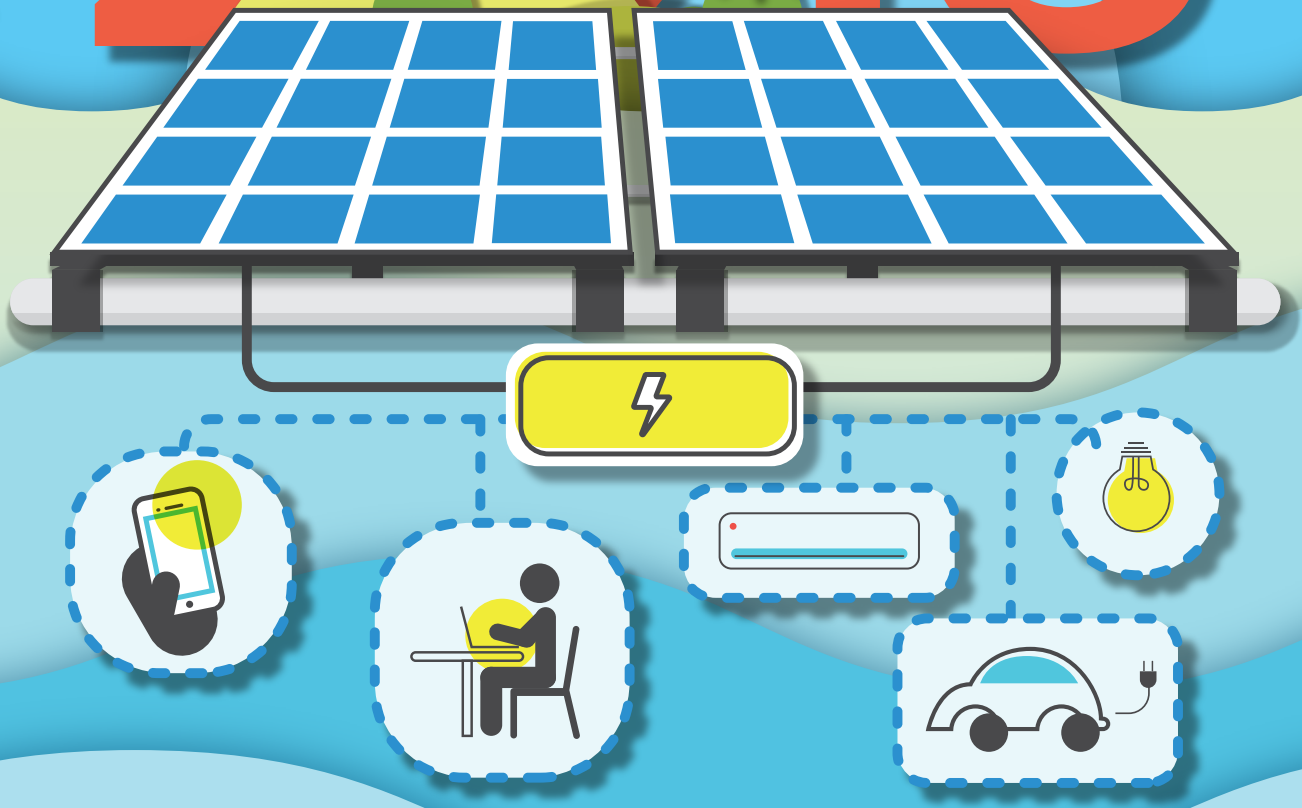
Department of Alternative
Energy Development and Efficiency
MINISTRY OF ENERGY

2018



Thailand
PV STATUS
REPORT B.E. 2561

Department of Alternative
Energy Development and Efficiency
MINISTRY OF ENERGY

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Floating PV system at Sirindhorn Dam, Ubonratchathani Province

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1 Executive Summary

Q Solar1 PV power plant at Kabinburi District, Prachinburi Province

1.1 Installation of PV systems

In 2016, the cumulative installation capacity reached 2,962.44 MW which resulted from AEDP. This capacity is separated into two groups which are (1) grid connected PV systems which includes 588.47 MWp of SPP for 7 projects, 2,340 MWp of VSPP for 533 projects and also VSPP for rooftop PV systems (2) Off-grid PV systems which are mostly located in remote areas.

However, electrical generation from PV systems for self-consumption has significantly increased due to the competitive electricity cost between PV systems and the grid. Moreover, there is increased use of rooftop PV and floating PV systems.

1.2 PV Industry

There has been continuous development of the PV business in Thailand. In 2018, the cumulative installed capacity of PV cell and module production in Thailand stood at 4,381 MW from 15 manufacturers, which includes 8 Thai and 7 international manufacturers.

The cost of PV modules has also continuously decreased. In 2018, PV module of MW-scale production was around 14-16 THB per watt and the PV system cost was around 30-40 THB per watt. However, in kW-scale, PV module and the system cost were around 16-20 THB and 35-55 THB per watt respectively.

Research, development and demonstration (RDD) activities have also increased, especially in research and education institutes. This is also due to the increasing use of energy supplied by PV power plant and PV systems such as rooftop and floating systems. This increase influences the energy structure in Thailand due to VSPP becoming the main PV energy production in Thailand.

1.3 Supporting Measures

In 2018, Thailand launched the AEDP 2015 targeting for 20 years commencing in 2015. The main purpose is to target the use of renewable energy within 2036 with a target for PV systems set at 6,000 MW.

Due to government supporting programs, there has been a rise in the use of PV systems encompassing various technologies such as ground mounted, rooftop and floating PV systems. The initial PV system generation had mainly aimed for trading as adder program for 10 years and 25 years FiT. However, in 2018, the main purpose of PV system generation has changed to be self-consumption due to the competitive electricity cost between PV system and the grid.

According to government policy, there has been a main target to support self-consumption, especially residential usage, by promoting the " Solar for Thai People project ". There is a target of 100 MW installation each year for 10 years, which anticipates that people can produce the electricity for self-consumption on a daily basis, as well as selling any excess to the grid.

Thap Sakae PV power plant at ThapSakae District, Prachuap Khiri Khan Province

PV testing unit at KMUTT Bang KhunThiandistrict, Bangkok

1.4 Energy Reform

According to the Power Development Plan for 2018, there is a target for floating PV systems production at 2,725 MWac and supporting PV systems 10,000 MWp. The initial launched pilot project is 58.5 MWp or 45 MWac of floating PV systems at Sirindhorn Dam, Ubon Ratchthani, expecting COD in 2020.

Non-Firm and Firm electrical generation by renewable energy in 2017 saw the introduction of projects in order to improve the use of renewable energy which are currently under the Blue Solar Co. Ltd. operation who achieved the bid competition, expecting COD in 2021.

The liberalization of PV rooftop systems installation, one of the energy development program in Thailand, in 2018 witnessed preparation for the Solar for Thai People project through development of regulations of practice for rooftop PV systems which will be operated on 2019.

In 2018, electrical generation from PV systems had been limited by the contracts from government and the target. However, the self-consumption PV systems have increased, including the commercial aspects, produced for trading. This change has affected the overall electrical generation structure in Thailand through consumers becoming producers. Consequently, the development of transmission, distribution, energy storage and related regulations are mainly the focus for government.

2 Implementation of PV Systems

Evolution of PV applications

Off-grid PV systems

1980
- PV Mobile Field units
- Rural Doctors units
- Rural Schools

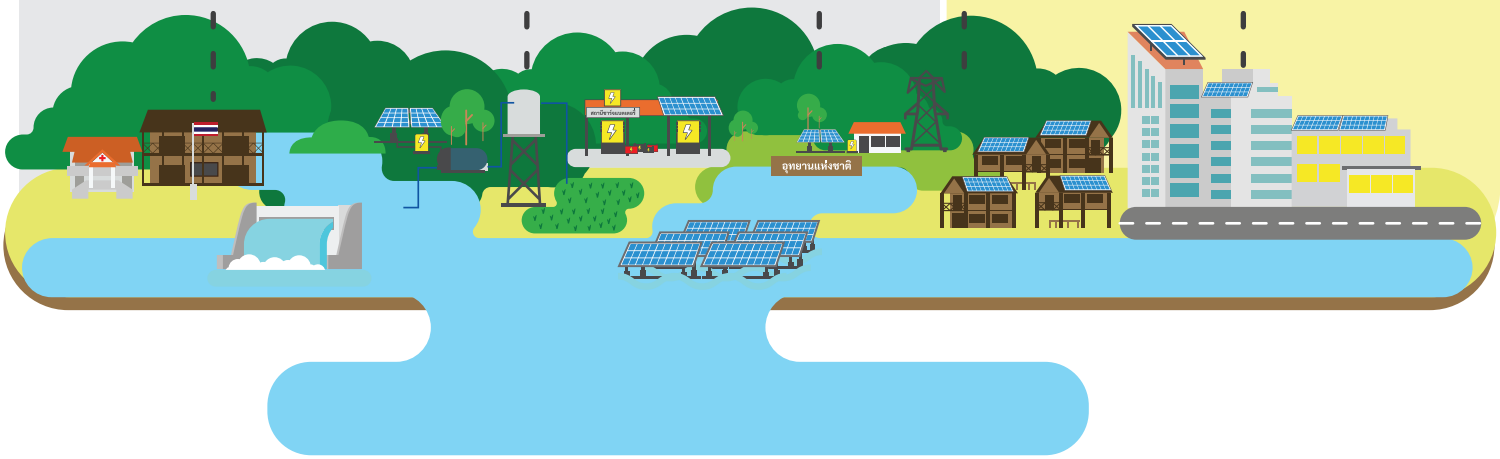
1990
- PV Water Pumping Project
- PV Battery Charging Stations

2000
- PV Hybrid Systems
- Telecom. Repeaters
- Rural Telephones
- Solar Home PV Systems

Grid-connected PV systems

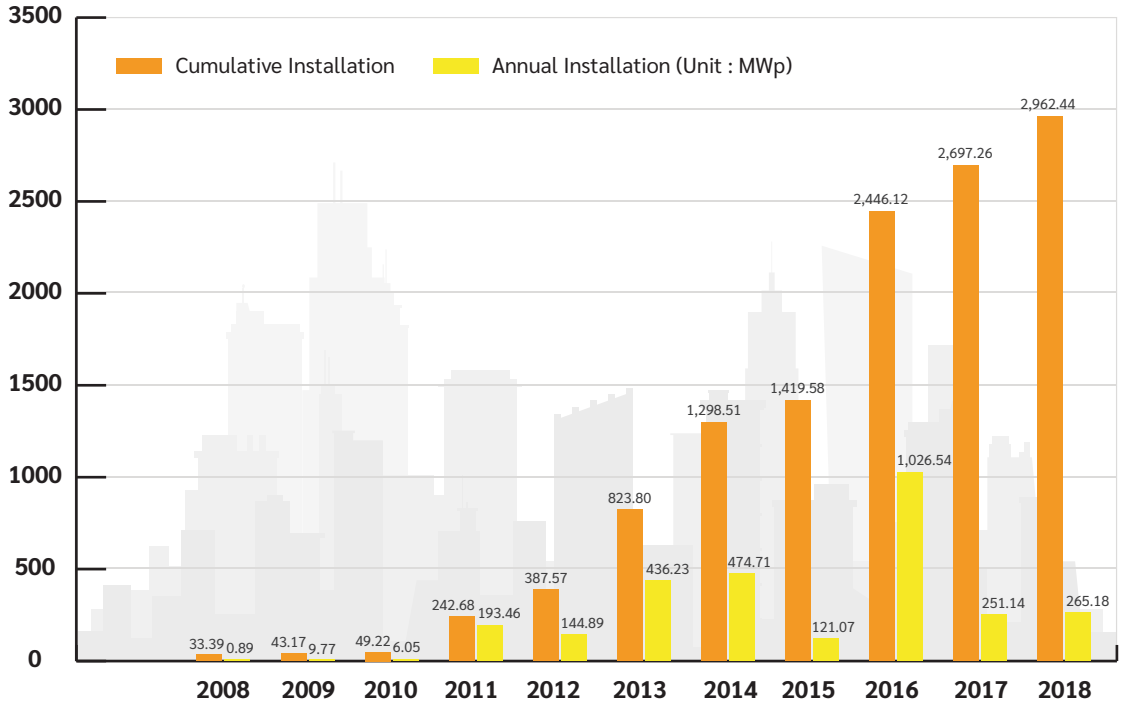
2010
- PV Power Plants with Incentive Scheme
- PV Rooftops Systems with Incentive Scheme
- Self-consumption PV Rooftops Systems

2018
- Self-consumption PV Rooftops Systems
- Initiative Independent Power Supply PV Rooftop Systems



2.1 Installation Capacity of PV Systems

At the end of 2018, the cumulative installation of PV systems in Thailand reached 2,962.44 MW which included 265.18 MW of installation for the year 2018. The main installation in 2018 comes from the ground mounted PV systems for government agencies and agricultural cooperatives program phase II of 2017.



Source: DEDE, EGAT, PEA and MEA

Figure 2.1 : Cumulative PV systems installation in Thailand from 2008 to 2018

Table 2.1 : PV systems installation from 2008 to 2018 (Unit: MWp)

Year	Cumulative Installation (MWp)				Annual Installation (MWp)
	On-grid	Off-grid		Total	
		DEDE	Other[1]		
2008	4.06	3.20	26.13	33.39	0.89
2009	13.67	3.36	26.13	43.17	9.77
2010	19.57	3.52	26.13	49.22	6.05
2011	212.80	3.91	25.97	242.68	193.46
2012	357.38	4.06	26.13	387.57	144.89
2013	794.07	4.27	25.46	823.80	436.23
2014	1,269.36	4.59	24.56	1,298.51	474.71
2015	1,389.55	4.87	25.16	1,419.58	121.07
2016	2,441.41[2]	4.98	28.82	2,446.12	1,026.54
2017	2,692.21[2]	5.05	29.09	2,697.26	251.14
2018	2,957.55[2]	4.08	26.06	2,962.44	265.18

Remark : This data was provided by DEDE, EGAT, PEA and MEA

[1] Cumulative installation fluctuates due to the unused systems demolition
[2] These data from the calculation that is the total PV installation systems exclude the off-grid PV systems by DEDE.

Floating PV system at Sirindhorn Dam, Ubonratchathani Province

Under the 15 years of the Alternative Energy Development Plan, AEDP (2008 – 2022), the number of ground mounted PV systems installation had continuously increased due to the adder supported program from the government, offering 10 years purchase of electricity. The majority of installation was on-grid ground mounted PV systems and the cumulative installation in 2011 and 2018 were 212.80 MW and 2,957.55 MW respectively. However, in April 2016, OERC announced the termination for the granting of licensing industry operation for ground mounted PV systems and wind power due to the lack of clear supported policies and regulations and to avoid possible disadvantages.

In 2016 the installation reached a peak of 1,026.54 MW because the government had launched the FiT program since 2015. The previous participating manufacturers, who had applied the adder program and whose installation capacity was less than 10 MWp, could then change to FiT program by connecting to the grid within June 2016. In 2017 and 2018, the main supporting organizations for the ground mounted PV system program was the government agencies and agricultural cooperatives program phase II.

2.2 Grid-connected PV Systems

Electricity generation in Thailand is divided into five main sources as follows;

(1) Electricity generation of EGAT

(2) Independent Power Producer (IPP)

(3) Small Power Producer (SPP)

(4) Imported power purchasing

(5) Very Small Power Producer (VSPP)

In 2018, the cumulative electricity generation reached 43,372.50 MW, excluding VSPP of 4,008 MW. So, the total volume of generation, including VSPP, was 47,380.50 MW. Figure 2.2 shows the electrical installation capacity of Thailand in 2018. It shows SPP and VSPP ground mounted PV systems as 588.47 and 2,340 MW, respectively, which together provide a total of 2,928.47 MW.

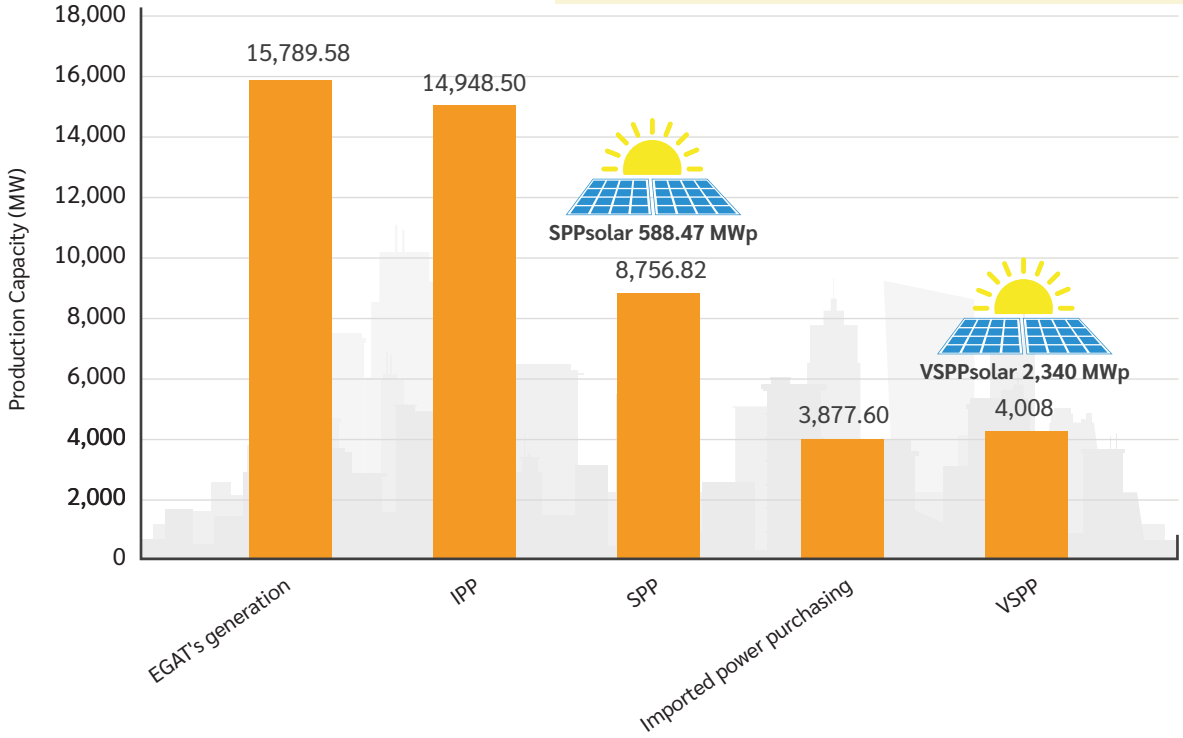


Figure 2.2 : Electrical installation capacity of Thailand in 2018.

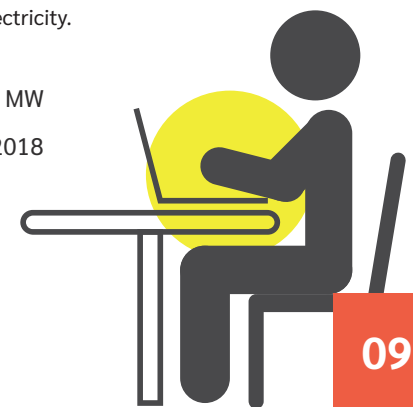
Source: EGAT and EPPO

Table 2.2 : Ground mounted PV systems installation for SPP and VSPP in 2018

PV system power plants	Number of projects	Installation capacity (MW)
SPP_{solar}	7	588.47
$VSPP_{solar}$	553	2,340
Total	**560**	**2,928.47**

Remark: This data was provided by ERC from the licensing industry operation for electricity.

"Ground mounted PV systems installation in 2018 from SPP and VSPP accounted for 588.47 and 2,340 MW which were 7 and 533 projects, respectively. The total ground mounted PV systems installation in 2018 was 2,928.74 MW including 560 projects."



2.2.1 Small Power Producers (SPPs)

There are seven Small Power Producers using PV with a total installation capacity of 588.47 MWp. These projects are mainly located in the central areas of Thailand. The first and last location had COD on December 2011 and April 2016 respectively. Normally, the operation duration of PV modules is expected to be around 20 to 25 years.

Table 2.3 : SPP power plants of PV systems in Thailand

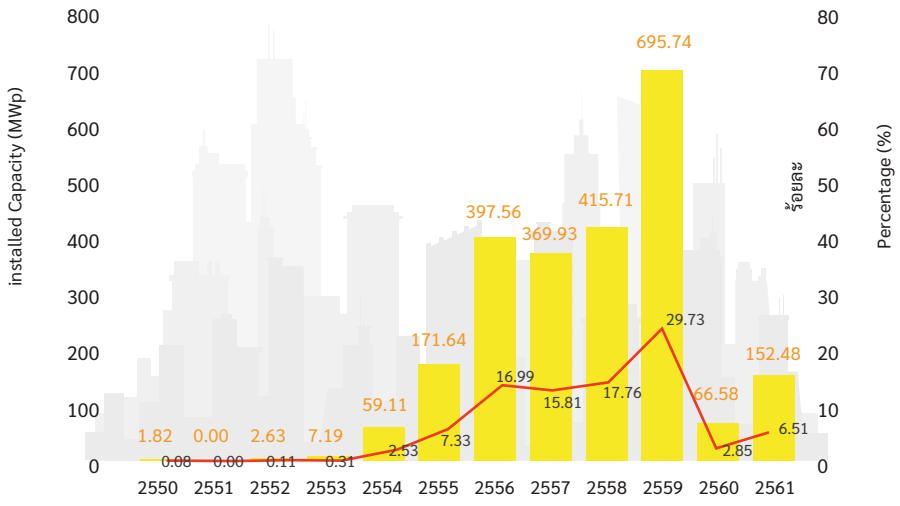
PV Plant Owner	Location	Installed Capacity (MWp)	COD
1. NED	Lopburi	72.59	Dec-11
2. BSE	Ayutthaya	34.44	July-12
3. EA Solar Nakornsawan	Nakornsawan	126.13	Dec-13
4. Serm Sang Palang Ngan	Lopburi	52	Feb-15
5. EA Solar Lampang	Lampang	128.39	Feb-15
6. SPP Six	Lopburi	41	Dec-15
7. EA Solar Phisanulok	Phitsanuloke	133.92	Apr-16
Total		**588.47**	

Source: OERC and PV Power Plant owner

2.2.2 Very Small Power Producers (VSPPs) using Ground Mounted PV Systems

MEA has responsibility for VSPPs which located in Bangkok, Nonthaburi and Samutprakarn, while PEA focuses on other locations. Most ground mounted VSPP PV systems have been monitored by PEA under the incentive programs of the Adder and the FiT.

Fig. 2.3 illustrates the Installation capacity of VSPP ground mounted PV systems during 2017 and 2018. In 2018, the cumulative installation reached 2,340 MWp which accounted for 553 locations. The increase of installation started in 2011 and then remained stable during 2013 and 2015 under the Adder incentive program. There was the highest installation in 2016 due to the FiT incentive program including the remaining manufacturers from Adder program.

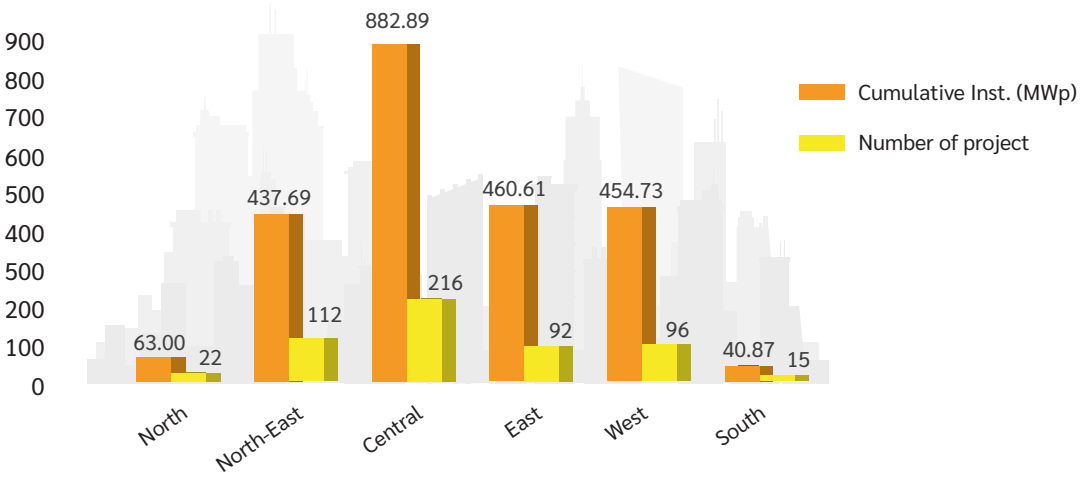


Source: OERC

Figure 2.3 : Installation capacity of VSPP ground mounted PV systems in 2018

The increase in ground mounted PV systems installation has initially come from the Adder incentive program for 10 years which was firstly applied in 2005. After that the incentive program was changed to be FiT for 25 years, beginning in 2016. Consequently, these systems are separated into two categories which are firstly from the Adder program, 995 MW for 292 projects, and FiT program, 1,345 MW for 261 projects. Unfortunately, in April 2016, OERC announced the termination for the granting of Licensing Industry Operation for ground mounted PV systems. It is expected that in around 1-2 years, the number of ground mounted PV systems installation will be stable.

Fig. 2.4 illustrates the share of installed capacity of VSPP ground mounted PV systems by regions in Thailand in 2018. From this figure, most of the PV systems come from central region, 882.89 MWp for 216 projects, followed by east, west, north-east, north and southern regions respectively.



Source: OERC

Figure 2.4 : VSPP installation capacity of ground mounted PV systems by regions of Thailand in 2018

2.2.3 Very Small Power Producers (VSPPs) of Rooftop PV Systems

In 2013, the PV promotion program with the feed-in-tariff (FiT) incentive was launched to purchase electricity from rooftop solar PV projects for generation capacity of PV system from 1-1,000 kWp, in total target capacity 200 MWp. The FiT incentive program has 25 years duration which is divided into 3 groups namely (1) residential, the installed capacity less than 10 kWp (2) small-scale commercial building, the installed capacity between 10-250 kWp (3) large-scale commercial building or factory, the installed capacity between > 250-1,000 kWp. The program was separated into two phases which were completed in 2016.

The first phase of the program targeted COD within June 2015 which has extended from previous target due to the technical and regulation issues. The second phase has mainly focused on the residential, because in the first phase there was less participation than expected, the second phase had the COD in June 2016.

Consequently, the cumulative installation of rooftop PV projects for two phases regarding FiT incentive program in 2015 was 129.68 MWp and 6,135 projects which are the responsibility of MEA 40 percent (50.98 MWp and 2,163 projects) and PEA 60 percent (78.70 MWp and 3,972 projects).

Following this, there was pilot projects of public rooftop PV systems in 2016 for demonstrating the public rooftop PV systems performance. When the projects were completed, the cumulative installation under this program was 5.63 MWp and 180 projects.

Additionally, there has been continuous growth in the number of participants who are interested in private rooftop PV systems. As per the grid registered application in 2018, the cumulative installation was 463.55 MW and 1,223 projects. The cumulative installation for three groups accounted for 598.86 MW and 7,538 projects.

Table 2.4 : Installed capacity of rooftop PV systems between 2013 and 2018

Project Name	Number of Projects	Installed capacity (MWp)
Rooftop PV systems in 2013 with FiT incentive program	6,135	129.68
Pilot project of public rooftop PV systems in 2016 of self-consumption scheme	180	5.63
Private rooftop PV systems in 2018	1,223	463.55
Total	**7,538**	**598.86**

Source: PEA, MEA, OERC and DEDE

2.2.4 Self-consumption PV Systems

Self-consumption rooftop PV on-grid systems were introduced in 2016 and have continuously increased due to the competitiveness of electricity tariff between PV systems and regular grid. Additionally, there is a lower price of electricity for time of use rate (TOU). In 2018, cumulative installation reached 463.55 MW for 1,223 projects which were the responsibility of MEA as 18.57 MWp for 220 projects, accounting for 4 percent, and PEA as 444.98 MWp for 1,003 projects, accounting for 96 percent.

Figure 2.5 illustrates the distribution of self-consumption rooftop PV systems under MEA responsibility in 2018. Most is the installed capacity between 500 and 1,000 kWp or large-scale commercial building/factory, total 7.22 MWp for 10 projects and followed by small-scale commercial building (10–250 kWp) total 4.91 MWp, medium-scale commercial building (250 – 500 kWp) total 4.41 MWp, as well as the factory with more than 1,000 MWp 1.46 MWp and finally the residential that has a capacity less than 10 kWp total 0.58 MWp, respectively.

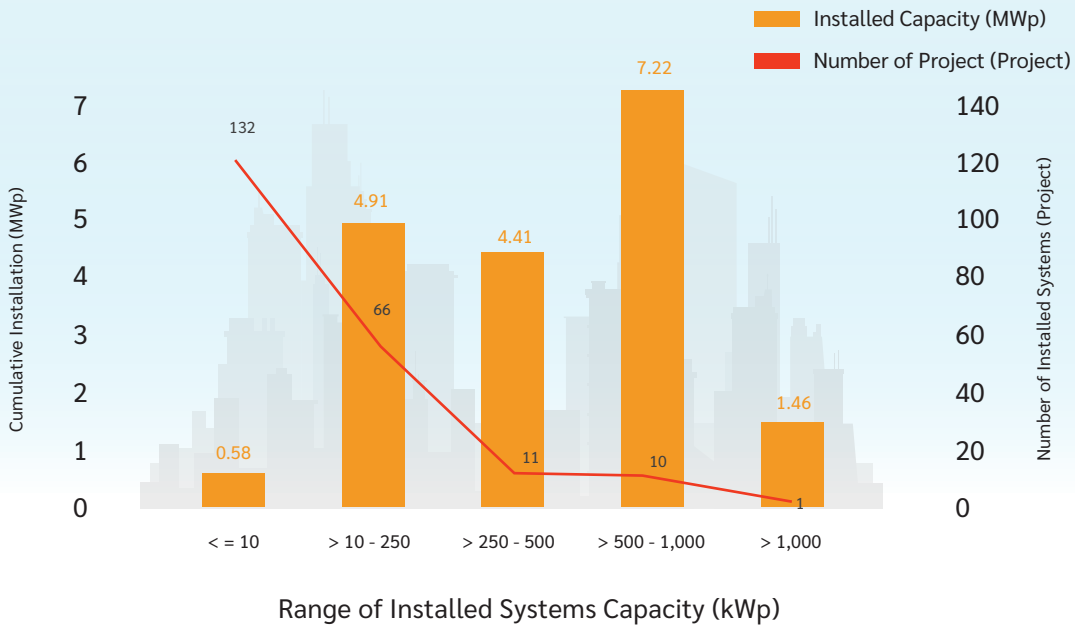


Figure 2.5 : MEA self-consumption using PV systems by range of installed systems capacity in 2018

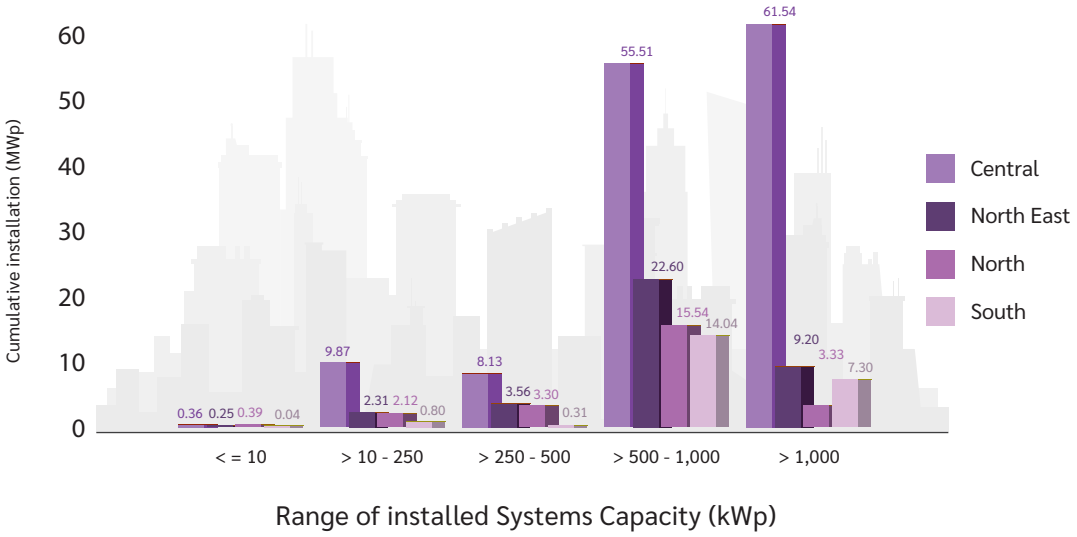


Figure 2.6 : PEA self-consumption installation capacity by range of installed systems capacity in regions in 2018

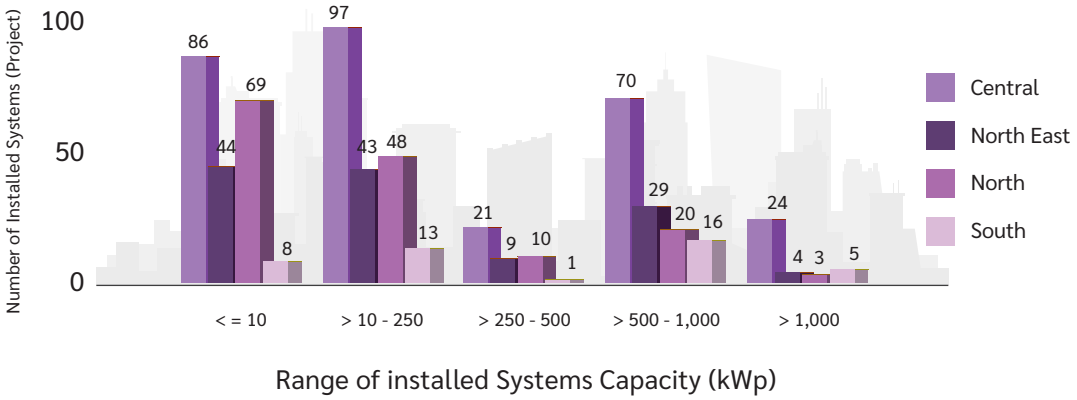


Figure 2.7 : PEA self-consumption number of installed systems by range of installed systems capacity in regions in 2018

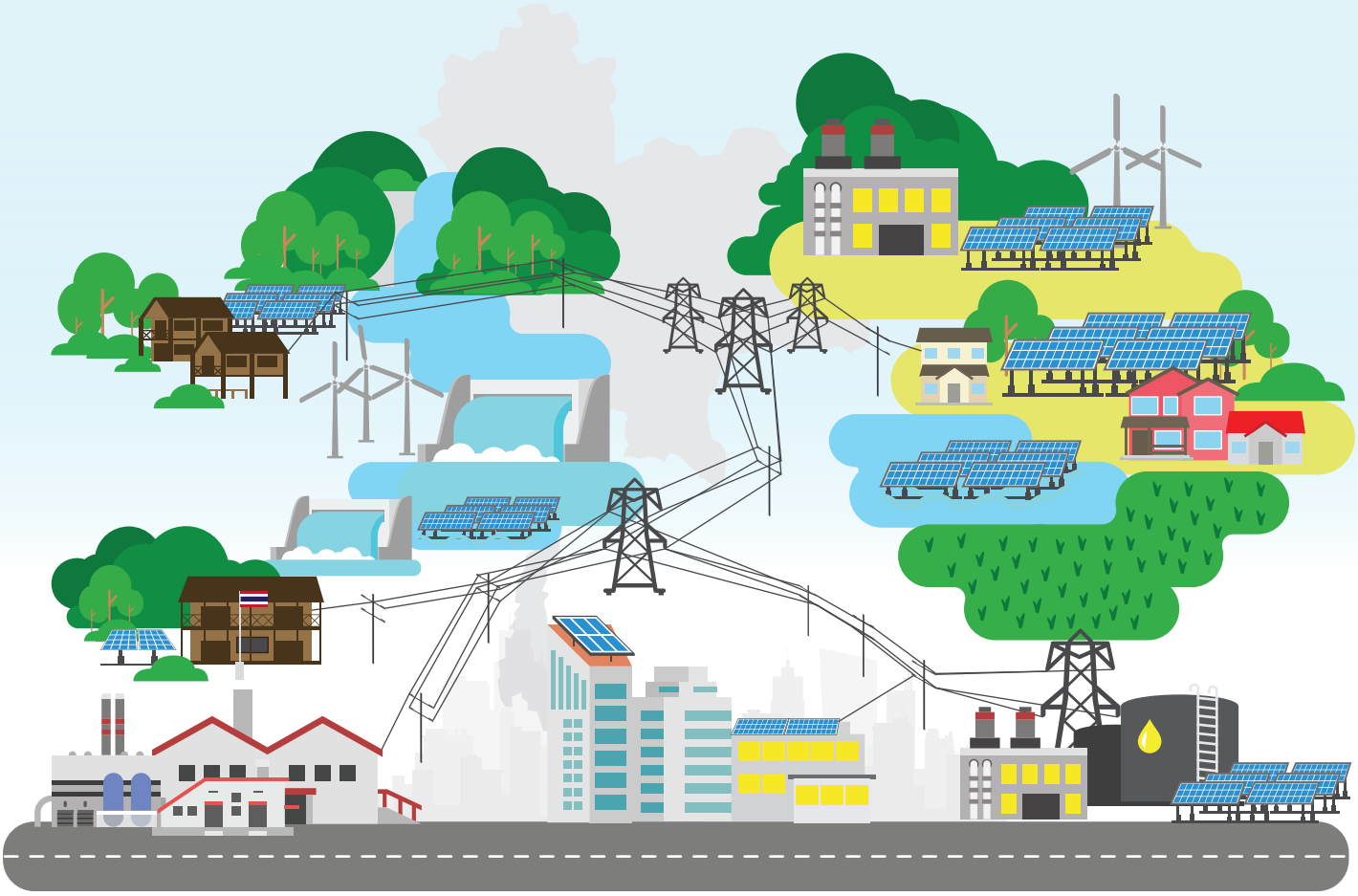
Figure 2.6 illustrates the distribution of self-consumption rooftop PV systems under PEA by region in 2018. The cumulative installation reached 220.5 MWp, for which the central region has the highest installation, 135.41 MWp for 298 projects, accounting for 61.41 percent, followed by north-east, 37.93 MWp, north, 24.68 MWp and south, 22.49 MWp, respectively. Figure 2.7 shows the number of installed systems by range of installed systems capacity in region in 2018.

Furthermore, the cumulative installation and the numbers of installed systems with the range of installed systems capacity are (1) about 48.84 percent for the installed capacity of the systems between 500 to 1,000 kWp or large-scale commercial building/factory as 107.69 MWp for 135 projects. Followed by, (2) 36.90 percent (81.36 MWp) for the system capacity larger than 1,000 kWp for 36 projects, (3) 6.94 percent (15.3 MWp) of the system capacity between 250 to 500 kWp for 41 projects, (4) 6.85 percent (15.1 MWp) of the system capacity from 10 to 250 kWp for 201 projects and (5) 0.47 percent (1.04 MWp) of the system capacity less than 10 kWp for 207 projects.

2.2.5 Floating PV Systems

The application of floating PV systems (FPV) in Thailand was initiated by EGAT. The first FPV system of EGAT was the 249.6 kWp system at the Sirindhom Dam, Ubon Ratchathani Province in 2017. After that, FPV was expanded to a total of 58.8 MWp or 45 MW (ac) expecting to connect with the grid at the end of 2020. In addition, the FPVs are in the EGAT energy production plan according to Thailand Power Development Plan 2018 (PDP2018) which will be the pilot projects of integrated FPV with electrical hydro-power dams within 2037, targeting 2,725 MW (ac).

In 2018 the growth of FPV in the private sector show the potential of FPV through the self-consumption scheme and the direct electricity supply to groups of business units as private power distributors.



2.3 Off-Grid PV Systems

The off-grid PV systems in Thailand have been promoted and monitored by government. In 2018, the cumulative installation reached 30,138.76 kWp, including the introduction of solar home projects in 2005. Currently it is not possible to indicate the exact total of installation capacity. Additionally, some reports show a decrease of cumulative installation due to the decommissioning of unused and non functioning systems.

Off-grid PV systems by DEDE

Off-Grid PV Systems

OFF-Grid PV Systems in 2018

Installation Capacity : 30.138 MWp including 24.388 MWp of Solar Home projects in 2005

Table 2.5 Shows the off-grid PV systems supported by DEDE in 2018

Total installed capacity 4.08 MWp and 2,633 projects as cumulative installation in ascending order. List of historical off-grid PV systems projects under DEDE from 1993–2017 are in Chronological order as follows:

(1) Battery charging stations for the villages in remote areas were operated in 1993–2004.

(2) The royal development projects have been operating from 1999–2017.

(3) Military operations bases and border protection bases were operated in 2002–2014.

(4) Rural schools in remote areas have been operating since 2002–2017.

(5) Solar pumping systems for the villages in remote areas were operated in 2003–2015.

(6) Sub-district health promotion hospitals were operated in 2003–2016.

(7) Mae Fah Luang the Tribal Community learning center has been operating since 2004–2017.

(8) National parks and forests were operated in 2006–2016.

As of 2018, the off-grid PV systems under DEDE have no new installation systems but in fact 67.10 kWp of unused systems, or 31 projects, were decommissioned, as well as 387 kWp systems, or 108 projects, are in the process of decommissioning.

Table 2.5 : Off-grid PV systems application by DEDE in 2018 , Sorted by size

No.	Applications	Year	Cumulative installed systems (kWp) (project)	Decommissioned systems (kWp) (project)	Systems transfer from DEDE (kWp) (project)	DEDE remaining systems (kWp) (project)
1	Solar pumping systems	2003 - 2015	200.00 (100)	0.00 (0)	200.00 (100)	126.00 (63)
2	Sub-district health promoting hospitals	2003 - 2016	238.00 (111)	0.00 (0)	238.00 (111)	180.00 (81)
3	National parks and forests	2006 - 2016	298.00 (92)	0.00 (0)	298.00 (92)	289.00 (89)
4	Mae Fah Luang the Tribal Community learning center	2004 - 2017	384.00 (256)	0.00 (0)	384.00 (256)	132.00 (88)
5	Military operations base and border protection base	2002 - 2014	388.38 (802)	0.00 (0)	388.38 (802)	132.00 (88)
6	The royal development projects	1999 - 2017	506.19 (1,066)	10.10 (19)	506.19 (1,066)	488.29 (1,038)
7	Battery charging stations	1993 - 2004	1,306.20 (386)	20.00 (1)	1,306.20 (386)	1,185.70 (354)
8	Battery charging stations	2002 - 2017	1,633.00 (423)	37.00 (11)	1,633.00 (423)	1,398.75 (366)
Total			**4,953.76 (3,236)**	**67.10 (31)**	**801.68 (572)**	**4,084.99 (2,633)**

Source : DEDE

2.4 Micro-grid with PV Systems

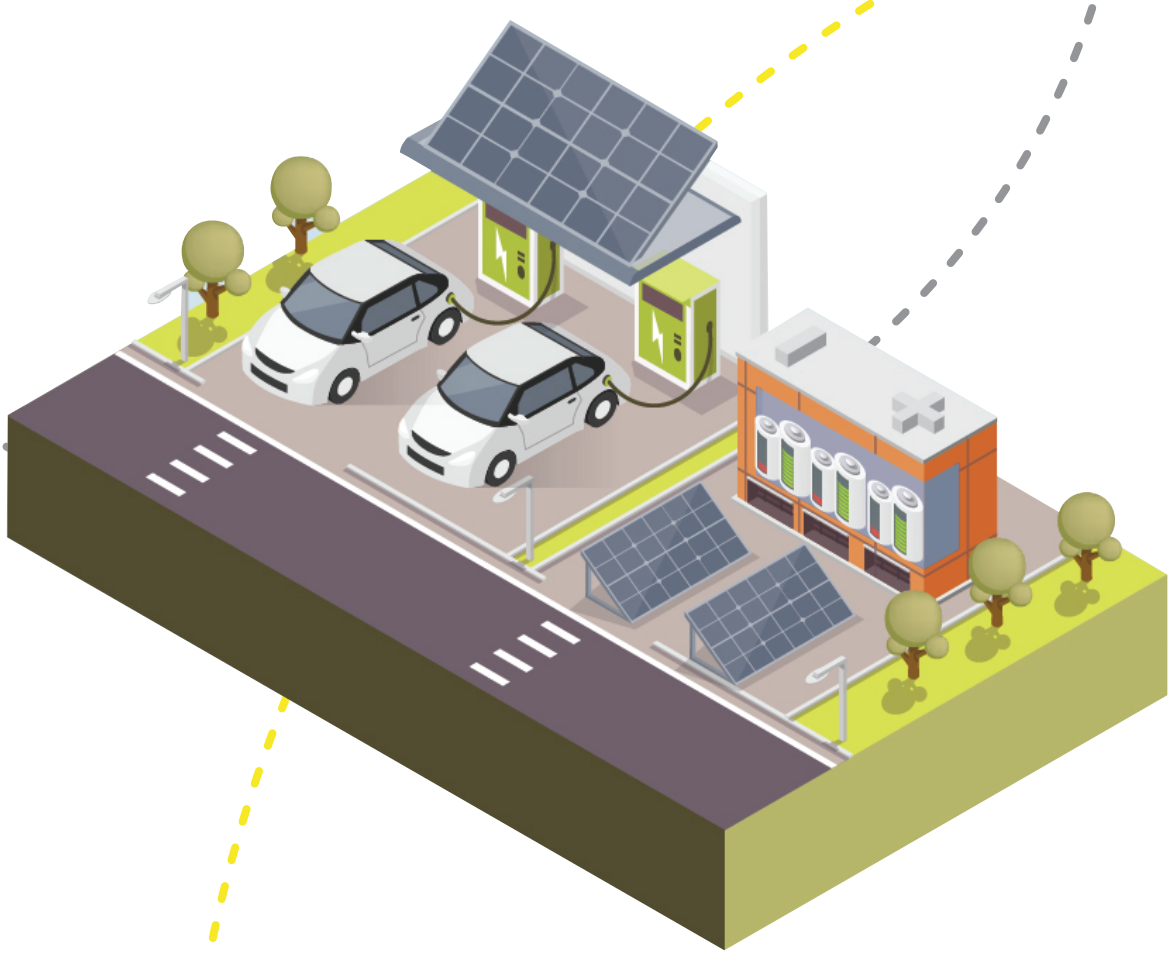
Micro-grid PV systems are localized solar PV systems including more than one source of electricity, such as diesel engine generator, small hydro power plant, biomass power plant, wind power plant. It connects to the localized grid system and can produce for self-consumption in case of no operation of the grid. The system usually has a combination of PV system and battery. Another form of mini-grid PV system is a solar system with a range of electricity sources and not connected to the distribution line of the utility. The advantages of micro-grid are to improve reliability and security of the power system and to reduce the electricity cost from various sources. Table 2.6 illustrates the typical micro-grid installations in different locations.

G-Power Source PV power plant at Bung Sam Phan, Phetchabun Province

Table 2.6 : Typical PV based micro-grid systems in Thailand

Project	Location	Organization
KhunPhae Power Plant	Chom Thong, Chiang Mai *Details* ▸ PV system ▸ Hydro power ▸ Diesel generation	PEA 7.3 kWp 96 kWp 56 kWp
The Electrification Improvement by the Micro-grid System	Mae Sa Riang, Mae Hong Son *Details* ▸ PV system ▸ Battery storage system	PEA VSPP 3 MW / 1.5 MWh type: Li-Ion
Smart Grid at the School of Renewable Energy of Naresuan University	Phitsanuloke *Details* ▸ PV system ▸ Battery storage system	Naresuan University 400 kWp 100 kWh (type: SLA)
PTT Gas Station	Sam Kok, PhathumThani *Details* ▸ PV system ▸ Battery storage system	PTT Public Co., Ltd. 550 kWp 2,000 kWh (type: SLA)
BCP Gas Station	Sri Nakarin Road, Bangkok *Details* ▸ PV system ▸ Battery storage system	BCPG Public Co., Ltd or BCPG- 270 kWp 1,023 kWh (type: Li-Ion)

Source: PEA and manufacturers



Source : Office of Energy Regulatory Commission

Electricity generation from PV systems in Thailand has been continuously growing, especially in 2018, with the rooftop PV systems and ground mounted systems for government agencies and agricultural cooperatives phase II program in 2017. In terms of module manufacturers, there are a total of 15 manufacturers, including domestic and international which make up a total of 4,381 MW installed capacity.

3 PV Industry and Growth

PV testing unit at KMUTT Bang Khun Thian district, Bangkok

3.1 Development of PV Cell and Module Production

PV manufacturers in Thailand were established since 2004, Which primarily employ crystalline silicon technology and the amorphous silicon of thin film technology in order to support the use of PV systems in rural areas, particularly solar home projects. The capacity of PV module production from Thai manufacturers was 300 MW from six manufacturers. However, in 2015, international PV cell and module manufacturers have invested in Thailand, primarily to produce for export. As a result, there has been significant growth in the export of PV modules and PV cell and module manufacturing totaling 3,850 MW of production capacity in 2018.

Table 3.1 : PV cell and module manufacturers in Thailand in 2018

No.	Manufacturers	Location, province	Production Capacity (MW) : Cell (MW)	Production Capacity (MW) : Module (MW)	Production : PV module (MW/year)
1	Canadian Solar	Si Racha, Chon Buri	1,000	800	n/a
2	Gintech	Nava Nakorn, Pathum Thani	n/a	1,000	650
3	Jetion Solar	Si Racha, Chon Buri	140	250	250
4	Solartron	Pak Chong, Nakhon Ratchasima	850	800	800
5	TaleSun[1]	Pluak Daeng, Rayong	n/a	200	180
6	Trina Solar	Pluak Daeng, Rayong	700	500	n/a
7	Yingli Solar	Pluak Daeng, Rayong	n/a	300	n/a
Total			**n/a**	**3,850**	**n/a**

Source: Manufacturers and investors

Remark : [1] Zhongli Talesun Solar (Thailand) Co.,Ltd. changed to Talesun Technology (Thailand) Co.,Ltd.

Table 3.2 : PV module manufacturer and production capacity in 2018

No.	Manufacturer	Location	Production Capacity (MW)	Module production (MW/year)
1	G.K.	Bang Kruai, Nonthaburi	90	81
2	Schutten Solar	Si Racha, Chon Buri	30	12
3	Solar Power Technology	Sam Khok, Pathum Thani	25	3
4	Fullsolar	Si Racha, Chon Buri	50	8
5	Irradiance Solar	Muang, Samut Sakhon	6	6
6	Ekarat Solar	Bang pakong, Chachoengsao	50	4
7	Pornjaroen Tempered Safety Glass	Muang, Lumphun	30	30
8	Solar PPM	Si Racha, Chon Buri	250	7.5
Total			**531**	**151.5**

Source: Manufacturers and investors

Thap Sakae PV power plant at Thap Sakae district, Prachuap Khiri Khan Province

Table 3.1 illustrates the PV cell and module manufacturers and production in 2018 which mainly were international manufacturers excluding Solartron. The total production capacity was 3,850 MW from 7 major manufacturers. Table 3.2 shows only PV module manufacturers and production in 2018 which mainly were Thai manufacturers excluding Schutten Solar. Total production capacity was 531 MW, from 8 manufacturers.

3.2 PV Module and System Pricing

The installation of PV systems depends on the context of prices, with the rule of thumb that the cost of the PV module amounts to half of the total cost. Currently, PV module production and PV system installation have generally increased which has resulted in a massive reduction of PV module cost. Moreover, the similarity between electricity cost from PV systems and from utility is the key. Of increasing PV installation trend.

The timeline of the prices of PV modules and systems from 1997 to 2018 are demonstrated in Table 3.3 and 3.4 respectively.

Bangkhenchai PV power plant at Pak Thong Chai district, Nakhon Ratchasima Province

Table 3.3 : Typical module prices for a number of years (Unit: THB/Wp)

Year	1997 - 1998	1999 - 2000	2002 - 2003	2011	2012	2013	2014	2015	2016	2017	2018
Typical module price, kW-scale (THB/Wp)	180 - 200			110	70 - 80	50 - 60	35 - 50	25 - 40	16 - 22	16 - 20	16 - 20
Best module price, MW-scale (THB/Wp)	-				50 - 60	35 - 45	20 - 25	20 - 25	15 - 20	15 - 17	14 - 16

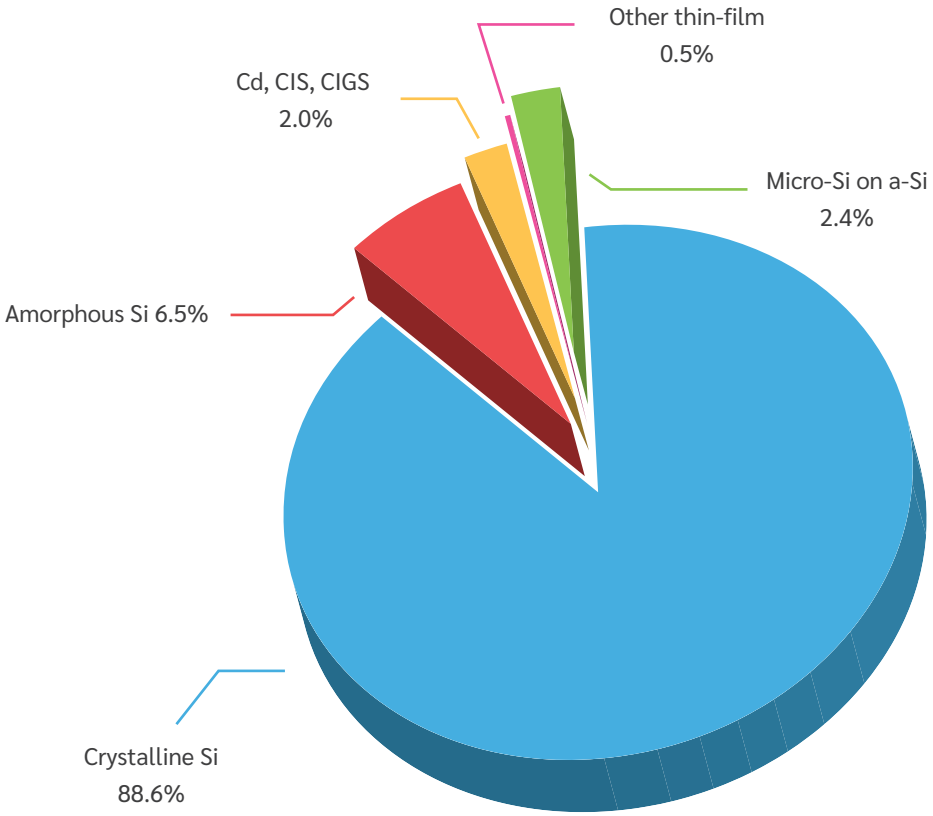
Source: Manufacturers and investors

Table 3.4 : Trend of system prices for different application from 1997 to 2018 (Unit: THB/Wp)

Year	1997 - 1998	1999 - 2000	2002 - 2003	2011	2012	2013	2014	2015	2016	2017	2018
Residential PV systems (<10 kWp, THB/Wp)	210 - 250		200 - 220	n/a		90 - 150	65 - 100	60 - 100	52 - 73	51 - 64	50 - 55
Commercial / Factories (>10 – 1,000 kWp, THB/Wp)	-		n/a			90 - 150	60 - 65	50 - 55	43 - 57	45 -54	35 - 45
Ground mounted PV systems (> 1,000kWp, THB/Wp)	-			110		60 - 100	40 - 60	30 - 50	42 - 57	41 - 48	30 - 40

Source: Manufacturers and investors

“Fig. 3.1 illustrates the share of cell technologies for ground mounted PV systems in 2018, which dominated the market by 88.6% from crystalline silicon in both mono and poly type, followed by 6.5% of amorphous, 2.4% of micro crystalline on amorphous, 2% of Cadmium telluride and copper indium gallium selenide with 2% share and other 5% of non-defined thin film, CIS and CIGS and 0.5% of non-defined thin film.”



Source: OERC

Figure 3.1 : Share of PV module technologies for ground mounted PV systems in 2018

3.3 Research, Development and Demonstration Activities

The research, development and demonstration (RD&D) of PV technology in Thailand can be classified into 6 categories. There are (i) Fabrication of solar cells and materials, (ii) Invention and application of system components, (iii) PV applications, (iv) Policy support research, (v) Integrated research, and (vi) Energy storage systems. Table 3.5 shows the RD&D activities and organization between 2016 in 2018, according to (i) to (vi) categories.

Table 3.5 : RD&D activities and organization in 2016 - 2018

No.	Organization	Academic		i	ii	iii	iv	v	vi
		Yes	No	Fabrication of solar cells and materials	Invention and application of system components	PV applications	Policy support research	Energy storage systems	Integrated research
1	DEDE		■			■	■		
2	BRU	■							■
3	CMRU	■				■			
4	CMU	■		■					
5	CU	■		■	■		■		
6	EGAT		■			■			
7	KKU	■		■				■	
8	KMITL	■		■		■			
9	KMUTT	■		■		■	■		■
10	KU	■		■				■	
11	MU	■		■					
12	NIDA	■					■		
13	NPU	■		■					
14	NRRU	■				■			
15	NSTDA		■	■	■	■	■	■	■
16	NU	■			■	■			
17	PCRU	■		■	■	■			
18	PEA		■			■			
19	RMUTK	■			■	■			
20	RMUTL	■			■	■		■	■
21	RMUTSB	■							■
22	RMUTT	■				■			
23	SNRU	■		■					■
24	SU	■		■					■
25	SUT	■		■	■				■
26	SWU	■		■	■	■			
27	UBRU	■				■			
28	UBU	■		■					
29	UP	■				■			
Total		**25**	**4**	**15**	**8**	**16**	**5**	**4**	**8**

Source: NRCT, TSRI, EGAT, PEA, DEDE, NSTDA, CU and KMUTT

Table 3.6 : Typical RD&D projects in 2018 - 2019 , listed by categories

Category	Project	Research Topics	Organization
i	Development of Transparent Conductive Oxide Films on Flexible Substrate for Perovskite Solar Cells	(A) Fabrication of solar cells and materials	1. SU 2. NECTEC, NSTDA 3. KMUTT
ii	A Prototype of Portable Solar PV system for Using in Rural Area, “SolarMove”	(B) Invention and application of system components	NECTEC, NSTDA
	Study on Potential of Electricity Production and development of CPV in Thailand		1. NECTEC, NSTDA 2. DECC, NSTDA
	Study, Design and Installation monitoring system of electrical generate and usage of CMWC		NECTEC, NSTDA
iii	Development of PV output forecasting model for Tropical climate region	(C) PV applications	1. NECTEC, NSTDA 2. DECC, NSTDA
	Design of renewable energy hybrid system for remote mobile base station		NECTEC, NSTDA
	Study, design and evaluate the performance of Vertical PV system on mobile base		
	Evaluation and comparison of anti-soiling coating (ASC) in solar cell panels		1. KMUTT 2. NECTEC, NSTDA
	A study on the impact of dust on the performance of a solar power systems in Thailand		1. KMUTT 2. NU
	Central data for PV power plant in Thailand		
v	Study on Battery Energy Storage System for SPP hybrid firm (Phase I)	(E) Energy storage systems	1. MTEC, NSTDA 2. NECTEC, NSTDA
	High Efficiency Power Pack		1. DECC, NSTDA 2. NECTEC, NSTDA
	20C Discharge C-Rate & Pole Solid State Battery		
	Management of Electricity Demand using the Battery Energy Storage System of households		RMUTL
	Development of Wireless Battery Charging Station		

Source: NSTDA, RMUTL and KMUTT

3.4 Solar Electricity Business and Services

Electricity generation from PV systems under private company operation are regulated and controlled by the government according to the Alternative Energy Development Plan (AEDP). This results in the development of PV technology industry in Thailand as shown in Fig. 3.2

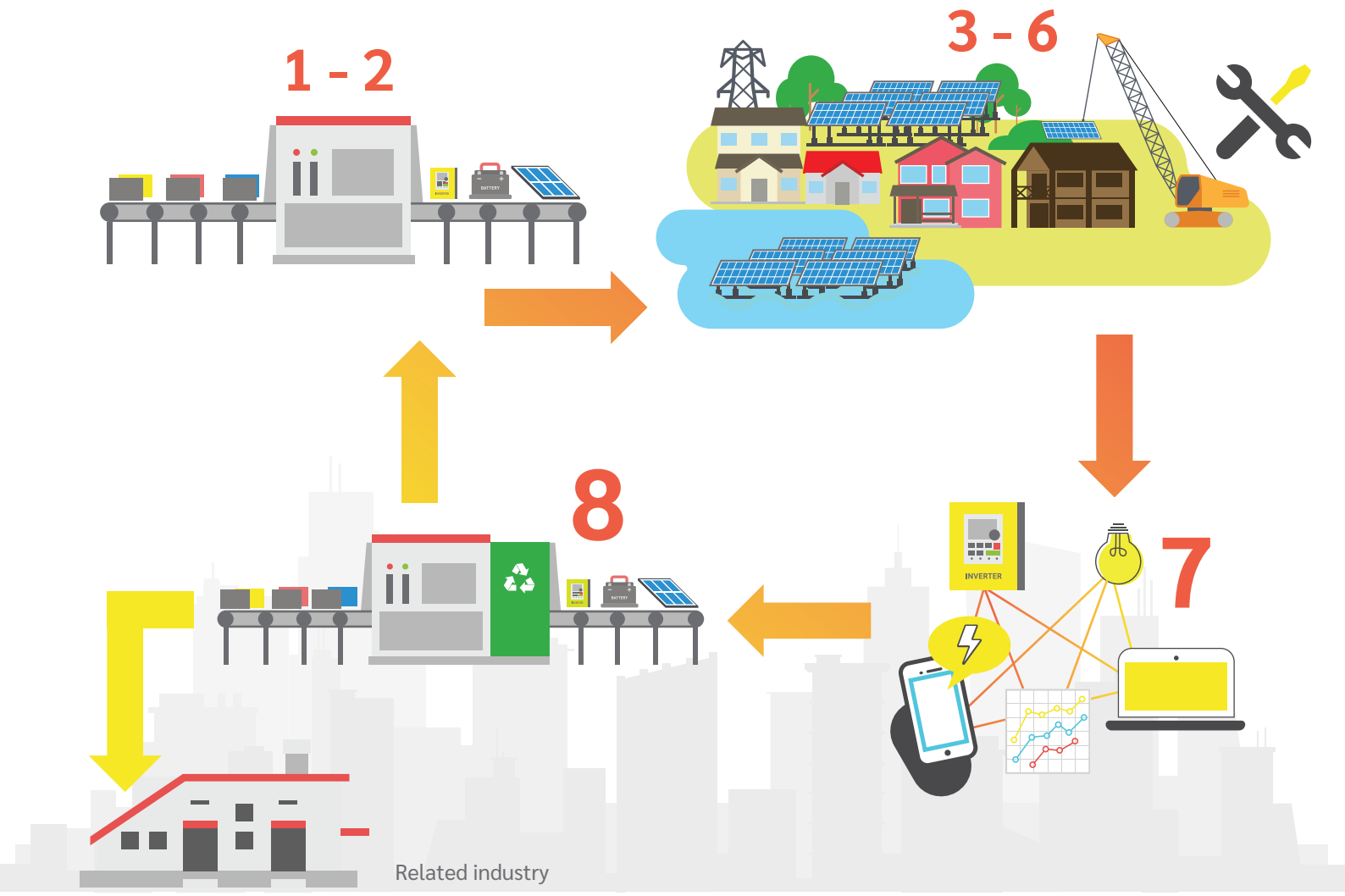


Figure 3.2 : Value Chain of PV Systems with 8 involving sectors

Including :

(1) Cell and PV module fabrication

(2) Inverter and battery business both manufacturers and distributors

(3) Ground mounted PV power plants

(4) Rooftop PV systems

(5) Floating PV systems

(6) Services of the operations and maintenance business

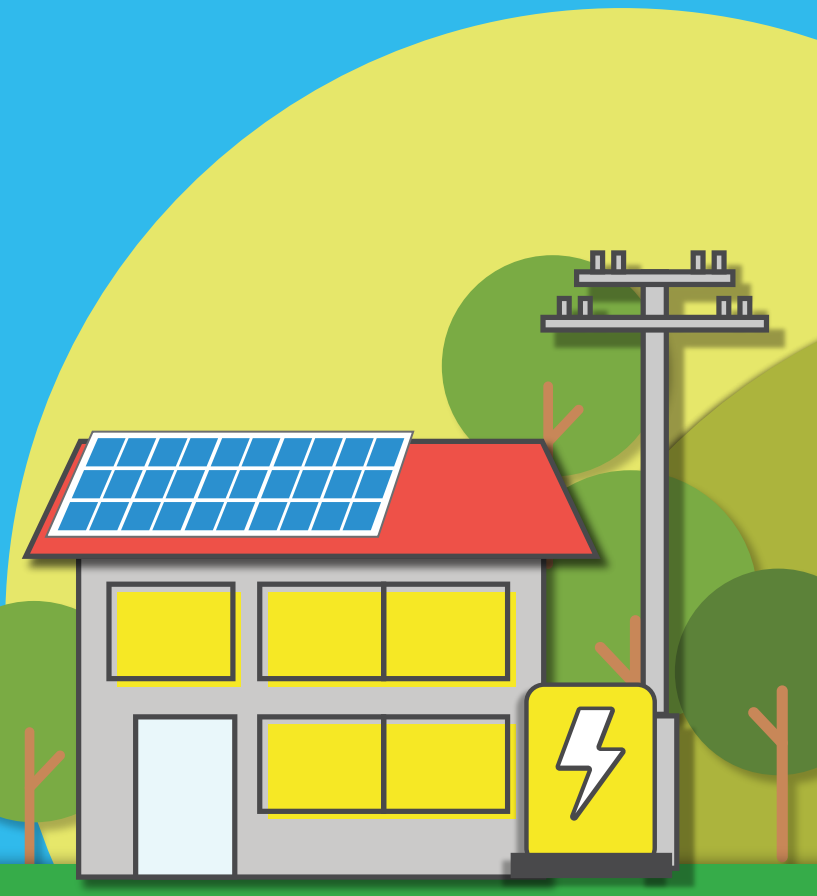
(7) Data information & communication services

and (8) PV recycle business

4 Framework for Deployment

Thai government has continuously promoted electricity generation from PV systems. In the past, the government supported the investment in PV installation. Following that, there were development of energy plans to support the growth of RE. As a result, there has been a dramatic increase of PV systems. This can be seen from Table 4.1.

Due to continuous growth in the business, there is a variety of business entities involved in electricity generation. Furthermore, the private sector is currently responsible for both consumer and producer at the same time. This raises the government's responsibility for managing the resources since electricity is one of the main factor for society in modern times. Government has the core responsibility to arrange the energy resources and distribute to the areas. Moreover, the regulation and technical aspects have to be also considered for safety reasons.



4.1 Alternative Energy Development Plan and Results: PV systems

As a result of intensive promotion of RE through AEDP, Thailand became the top of ASEAN countries for generation from PV systems. In addition, the development of renewable energy fossil fuel management with is currently the primary concern.

Table 4.1 : Renewable Energy Development Plan and PV Support Projects during 2007-2018

Item	Plan or Project	Details	Results
1	Renewable Energy Development Plan (REDP) Year 2007 – 2022	- Started in 2007 - Targeting 500 MWp of PV systems	In 2007 the cumulative installation of PV systems was 3.6 MWp. Next in 2012 PV systems installation were increased to 357.4 MWp.
2	Alternative Energy Development Plan (AEDP) Year 2012 – 2021	- Improved the Renewable Energy Plan in 2011. - Increaseing the target to 2,000 MWp of PV systems	
3	1st Revision of AEDP Year 2012 – 2021	- Started in 2013 - Increaseing the target to 3,000 MWp of PV systems	• In 2013 the cumulative installation of PV systems was 794.1 MWp. In September the initiative PV rooftop system with Feed in Tariff was announcement. • There were two phases of PV rooftop project that both had finished and selling to the grid in June 2016, totaling 130 MWp and 6,166 projects.
4	2nd Revision of AEDP Year 2012 – 2021	- Started in 2014 - Increase the target to 3,800 MWp of PV systems	In 2014 the cumulative installation of PV systems was 1,269.36 MWps including 969 MWp of Feed in Tariff scheme (FiT). These FiT change from Adder scheme.
5	Alternative Energy Development Plan (AEDP 2015) Year 2015 – 2036	- Started in 2015 - Increase the target to 6,000 MWp of PV systems	• In 2015 the second phase of rooftop PV systems was announced on February with selling to the grid on April 2016. Both phase of rooftop PV systems with FiT had totaling 130 MWp. • The other rooftop PV system on self-consumption scheme namely Pilot Project of liberalization of solar rooftop systems. This very short time project in 6-month (August 2016 – January 2017) had totaling 5.63 MWp. • In 2017 the second phase of ground-mounted PV projects for government agencies and agricultural cooperatives was announced and finished on December 2018. Totaling 417.18 MWp of installation capacity. Meanwhile the first phase of this projects has totaling 217.87 MWp. Then both phase has totaling 635.05 Mwp. • Moreover the SPP Hybrid Firm project which introduces the energy storage system to renewable energy. The COD schedule has around January 2020 to December 2021.
6	Residentail solar rooftop project with 100 MWp of annually target during 10 years under Thailand Energy Reform	- Started in 2018 to prepare the related regulation. - Invited to participate the project in 2019.	Energy Regulatory Commission has been announced the regulation of residential solar rooftop project in Government Gazette on 21 May 2019.

Source: Meeting report of the National Energy Policy Committee and OERC

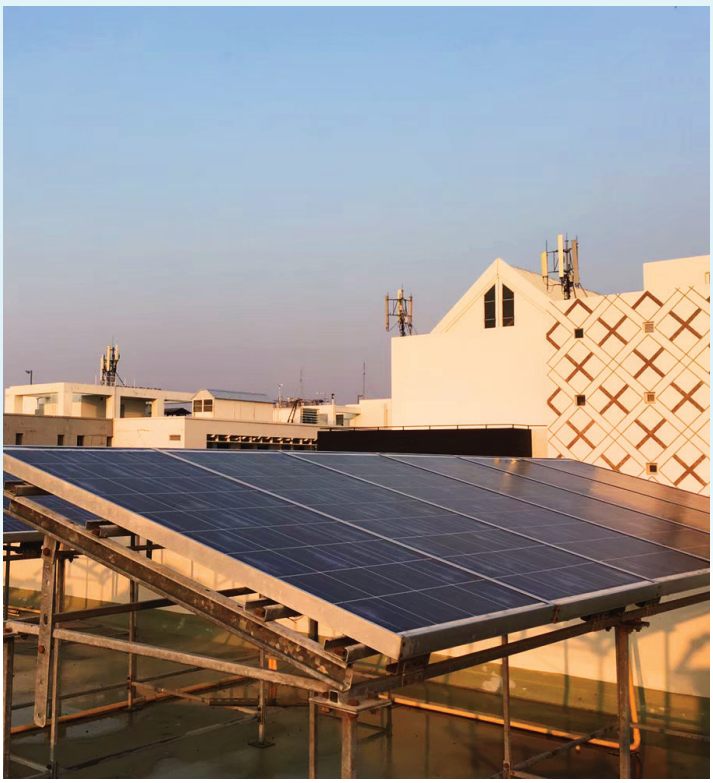
4.2 Investment Promotion for PV Industry (BOI)

According to the announcement of BOI No.2/2557, there is investment and promotion support which can be divided into three categories, (1) PV activities including solar cells and related equipment, (2) the manufacture of solar cells and electronic parts involving the PV modules such as battery and inverter (3) solar power plant.

There are 17 projects receiving BOI support for PV activities such as fabrication of modules in 2018, which the cumulative installed capacity reached 4,345 MW, as shown in Figure 4.1. In 2017, the installed capacity was around 3,100 MW for 2 projects.

Table 4.2 shows BOI support for PV systems with different applications such as ground-mounted systems, rooftop systems and floating systems. It shows, in 2018, that the cumulative installation reached 2,786.4 MW which had the maximum installation in 2015 as 1,065.5 MW due to the change of policy from Adder to FiT.

For PV rooftop systems, in 2018, the cumulative installation was around 220.6 MWp which in this year has the peak installation as 94.1 MW, followed by 70.8 MW in 2014. In addition, the number of cumulative installations for floating PV systems stands at 7.3 MW during 2016 to 2018.



Building Applied PV system at KMUTT Bang Khun Thian district, Bangkok

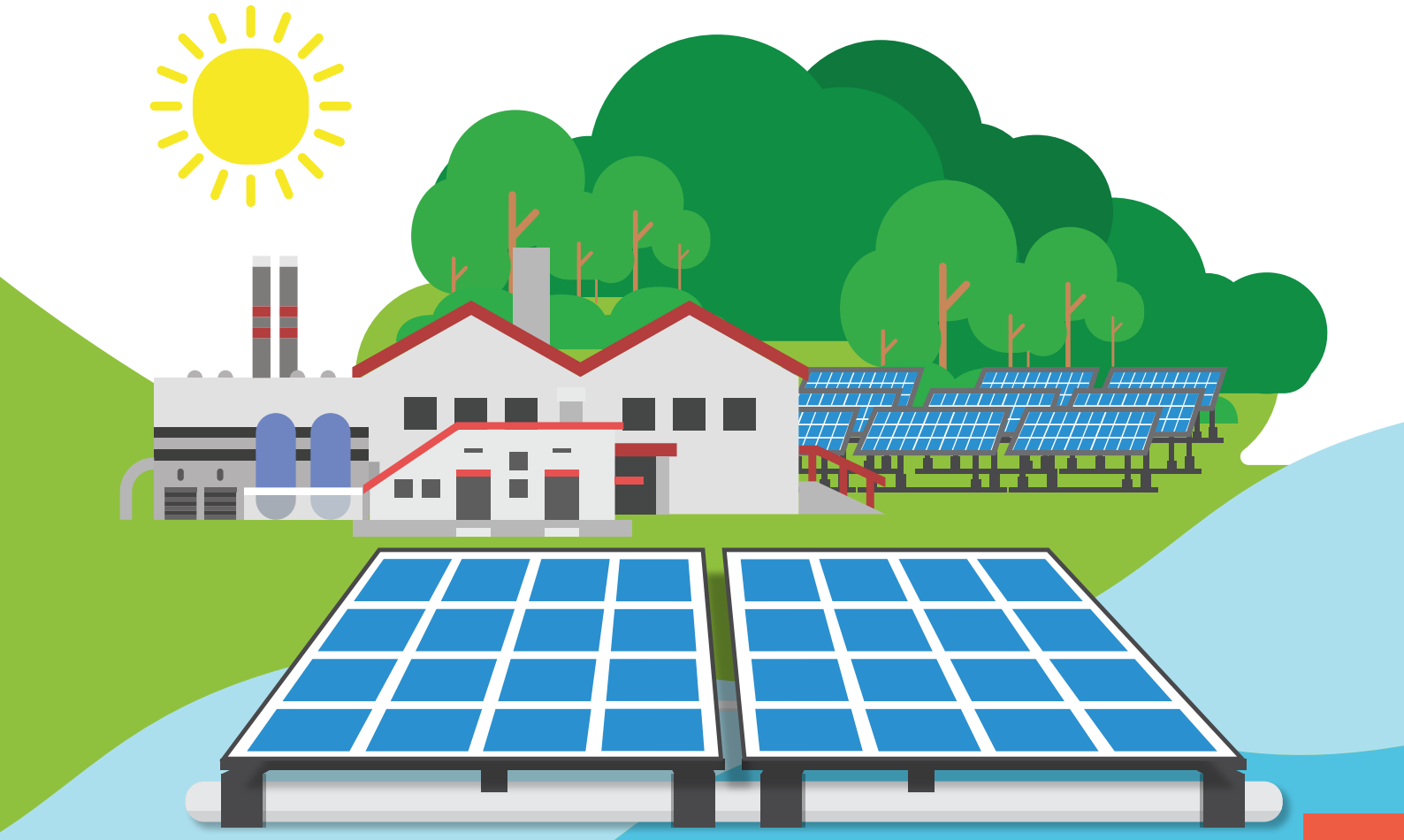
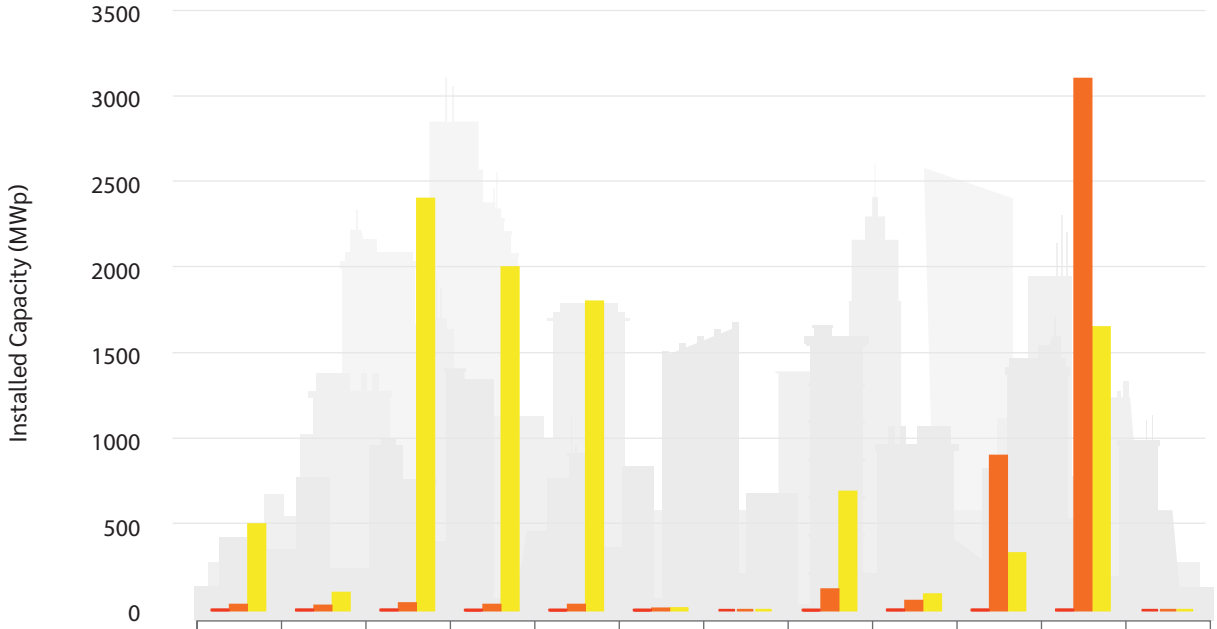


Figure 4.1 : BOI support for PV module fabrication between 2004 and 2018



	2004	2005	2006	2007	2008	2012	2013	2014	2015	2016	2017	2018
Number of systems (Project)	2	2	2	2	1	1	0	1	2	2	2	0
Installed capacity (MWp)	30	25	40	39	30	8	0	120	53	900	3,100	0

Remark : During 2004 – 2018 totally 17 projects, the cumulative installation 4,345 MW, accounting for 9,572 MTHB.

Source : BOI

Table 4.2 : BOI support for PV systems between 2011 and 2018

Year	Ground Mounted PV systems	Rooftop PV systems	Floating PV systems
	Capacity (MW)	Capacity (MW)	Capacity (MW)
Cumulative until 2011	541.4	n/a	n/a
2012	621.5		
2013	139.0	6.2	
2014	1.0	70.8	
2015	1,065.5	7.9	
2016	241.6	6.2	0.5
2017	16.5	35.4	2.0
2018	159.9	94.1	4.8
Total	**2,786.4**	**220.6**	**7.3**

Source: BOI

4.3 Supporting programs for Renewable Energy

Investment policy of the Ministry of Energy, EE Revolving Fund, was implemented to improve the energy efficiency of Thailand which mainly focuses on the manufacturer and the company who are working in energy conservation. The interest rate does not exceed 4% per year, with an installment period not exceeding 7 years, and a credit line not exceeding 50 M THB. There are 10 banks participating which are (1) Siam Commercial Bank, (2) UOB, (3) Kasikorn Bank, (4) Bank of Ayudhya, (5) Krung Thai Bank, (6) TMB Bank, (7) SME Bank, (8) Siam City Bank, (9) EXIM Bank and (10) CIMB Bank.

Similar to the EE Revolving Fund, there is also Soft loan Programs where the interest rate does not exceed 3.5% per year with a credit line not exceeding 50 M THB baht and not exceeding 5 years installment period. This program aims to support energy conservation projects.

There is a Block Grant program to support energy efficiency and renewable energy uses for government in Thailand. It expands the lifetime of equipment in order to conserve budget for new equipment.

In addition, there are services from electrical authorities such as (1) MEA services the design and installation of electrical systems. (2) PEA services PV system installation by PEA Solar Hero Application.

PEA Solar Hero Application

4.3.1 Supporting Residential Solar rooftop project

Energy development by promoting public rooftop PV system installation aims to support public electricity generation which can trade the electricity in order to generate income, as well as developing a trading platform that is convenient for tracking electricity generation.

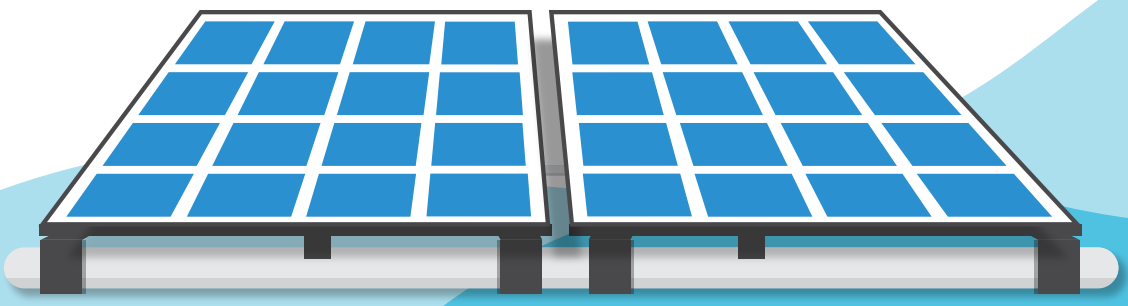
In 2018, the Administrative Energy Policy Committee agreed The Solar Project for Thai People Phase I on December 24th, which has the following details;

(1) Residential targeted group with installed capacity less than 10 kWp, mainly produce for self-consumption and sell for the rest.

(2) Trading with 100 MWp per year. The responsible area for electrical authorities are divided into (1) MEA 30 MWp and (2) PEA 70 MWp. The program will begin in 2019.

(3) Electricity selling price is 1.68 THB / kWh which is Short Run Marginal Cost: SRMC by the EGAT provided data.

(4) The operating time is for 10 years



4.3.2 Initial Smart Grid Development Plan

Thailand has invested in smart grid and disruptive technology for development of the industry and living convenience. However, electrical systems in Thailand still need improvement which relates to this technology.

The investment in smart grid in Thailand has followed the initial Smart Grid Development Plan, announced in February 2015, which has duration from 2015 to 2036. The smart grid will support

(1) energy efficiency (2) distribution systems

(3) widespread electricity generation.

There are objective categories for smart grid development, divided into 3 categories which are

(1) Smart System (2) Smart Life and

(3) Green Society.

In addition, the initial smart grid plan is separated into 4 periods as below;

(1) Operation period 1: 2 years for preparation (2015-2016), this is to prepare the responsible organization which needs to monitor the development of the plan and also arrange the collaboration between the utilities. Furthermore, there is the need to support the research and development of resources related to smart grid technology.

(2) Operation period 2: short term for 5 years plan (2017-2021), this will develop the pilot project, in order to evaluate the appropriate technique and investment in the technology, by supporting the research. Moreover, the electrical authorities will be responsible for the investment of smart grid pilot projects.

(3) Operation period 3: middle term for 10 years plan (2022-2031), this is to develop primary structure in order to transfer into a new generation of smart grid. There will be adjustments to the policy and regulations to support the development of advanced smart grid, including supporting electrical authorities to invest in primary structure of smart grid.

(4) Operation period 4: long term for 5 years plan (2031-2036), the smart grid will be continuously examined since period 3. Moreover, the electrical authorities will prepare the investment in the advanced smart grid and also support the residential, commercial building and factory to invest in communication technology related with smart grid.

4.4 Standards, Codes and Regulations

Thai Industrial Standards Institute (TISI) is an organization that controls and pronounces the industrial standards in Thailand. The TISI is also a member of the International Electrotechnical Commission (IEC) as a representative of Thailand. Table 4.3 shows TISI standards for PV modules, inverters and PV systems in 2018.

Furthermore, the electrical installation standards in Thailand, especially rooftop PV systems, has been announced and published, 1st edition on November 2016 and 2nd edition on March 2018, by the Engineering Institute of Thailand (EIT).

During 2018 – 2019, the Ministry of Industry announced industrial standards for PV modules on ground systems which includes the design and acceptance for crystalline silicon PV module testing, TIS 61215 No.1 (1) – 2018 on May 2019. This resulted in the termination of the previous crystalline silicon PV module testing standard, namely TIS 1843:2010.

Table 4.3 : TISI standards for PV modules, inverters and PV systems in 2018

Product	TISI Standard	Harmonization Standard
PV Module	TIS 1843 : 2553[1]	IEC 61215:2005[1]
	TIS 2210 : 2555	IEC 61646:2008
	TIS 2580-1 : 2555	IEC 61730-1:2004-10 and IEC 61730-1 am.1:2011-11
	TIS 2580-2:2555	IEC 61730-2:2004-10 and IEC 61730-2 am.1:2011-11
	TIS 61215 No. 1 (1) : 2561	IEC 61215-1 (1) : 2016
Grid-connected Inverter	TIS 2603 No. 1 : 2556	IEC 62109-1 Ed.1 (2010-04)
	TIS 2603 No. 2 : 2556	IEC 62109-2 Ed.1 (2011-06)
	TIS 2606 : 2557	IEC 61727 Ed.2 (2004-12)
	TIS 2607 : 2557	IEC 62116 Ed.1 (2008-09)
Solar photovoltaic (PV) power systems	TIS 2572 : 2555	IEC 60364-7-712

Source : [1] Terminated and replaced by TIS 61215 No.1 (1), 2018 announced on 3rd May 2019

4.5 Electric Vehicle Promotion

Energy Regulatory Commission (OERC) has announced the regulation of battery charging stations for electric vehicles (EV) in the Government Gazette on 20th October 2017. This is to manage the registration of EV battery charging stations for more than 1,000 kVA. There are 4 business types of EV battery charging station.

(1) Grid connected battery charging station

(2) Grid connected battery charging station integrating with other sources such as PV systems.

(3) Grid connected battery charging station integrating with battery energy storage system.

(4) Grid connected battery charging station intergrating with other sources and battery energy storage system.

Rooftop PV system at KMUTT Bang Khun Thian district, Bangkok

5

Highlights and Prospects

2018 witnessed considerable change for PV systems in Thailand. This was mostly through

(1) The introduction of floating PV systems as part of EGAT plan
(2) Continuous improvement of firm renewable energy generation
(3) The initiative to residential solar rooftop project
(4) The change of electricity generation context: generation, distribution and services
(5) Overall energy development in Thailand.

5.1 Floating PV systems

The development of 58.8 MWp or 45 MWac floating PV systems at the Sirindhorn Dam, Ubonratchathani Province was in accordance with the Power Development Plan of Thailand 2018 (PDP2018) which officially targets installed capacity of floating PV systems with large hydro power in dams as 2,725 MWac as shown in Table 5.1.

Table 5.1 : Power Development Plan by renewable energy in 2018 – 2037. (PDP2018)

Renewable Energy Technology Types / Energy conservation	Contracted Capacity (MW)	Reliable Capacity (MW)
Solar Energy	10,000 MWp	4,250
Biomass	3,376	2,296
Floating PV system with large hydro power	2,725	1,158
Wind energy	1,485	189
Biogas	546	325
Industrial waste	44	26
Electrical energy conservation	-	4,000
Total in 2037	18,176	12,244

Source: DEDE and EGAT

Remark: Unit of MWp is only for Solar Energy source.

The reliable capacity relates to the stability of the electrical system. The electricity production must be assured during the peak demand months, minimizing the risk of large power plants shutting down. The calculation is as below;

Reliable Capacity = Contracted Capacity x Dependable Capacity Factor x Reliable Capacity Factor

Contracted Capacity is the electrical energy production regarding the power purchase agreement with the authority as demonstrated in Table 5.2.

Table 5.2 : Assumption of percentage declaration between % Dependable Capacity and % Reliable Capacity

Power plant type	% Dependable Capacity	% Reliable Capacity
Main power plants		
• EGAT	100%	85%
• IPP	100%	85%
• SPP-Firm	100%	85%
• Purchasing from international country	55-100%	85%
Renewable Energy for Non-firm power plant		
• Biomass	52% , 80%	85%
• Biogas	28% , 70%	85%
• Wind Energy	14%	85%
• Solar Energy	42% , 50%	85%
• Hydro power	Average 77%	85%
• Others	29-70%	85%

5.2 Renewable energy development from Non-Firm to Firm

In 2017, the SPP Hybrid Firm Renewable Energy project was announced by the government wherein the private company, Blue Solar Co., Ltd., was one the approved bidder of the project's Which integrated PV+ESS. They use PV systems with storage. The system was designed by using 42 MWp PV systems with 12 MW / 54 MWh energy storage in order to sell the electricity to the grid for 12 MW of firm structure during 9.00-22.00 and 7.8 MW of non-firm structure during 22.00-9.00.

5.3 Rooftop PV system for Thai people project

In 2018 there was preparation for the project called “solar for Thai people”. Draft regulations were developed for PV rooftop systems and will be implemented promulgated by OERC in May 2019.

Online registration will be opened between May to December 2019 by applying for MEA at https://spv.mea.or.th and PEA at http://ppim.pea.co.th. The qualification for applicants includes

(1) owner of electricity meter
(2) electricity user type is residential
(3) limitation of installation capacity not more than 10 kWp.

Formal documents then have to be submitted to the appropriate electricity authority. All the projects need to be completed and COD within December 2019.

Announcement of consideration will be started in June 2019 by email and website. The rooftop PV system for Thai people has targeted for 10 years, with each year plans for 100 MW installation.

5.4 Context of electrical generation in Thailand changing : Production Distribution and Services

Within the electrical generation structure in Thailand, there are production, distribution, control and trading for which the government is responsible. In the past, electrical generation aimed to develop the country and people for the better life which provide the enough generation for household, public utility and industry.

Following this, the country has developed to a point which clearly separates the activities, including investment and revenue, between government and private enterprise. Thailand has been faced with new technology transformation, as have most countries in the world. With regard to PV systems, they have become a major player for electrical generation by integrating with energy storage which controls the production and distribution from smart grid. The consumer is becoming a producer and this trend will be significantly increased in the future. OERC has been monitoring and will be applying the procedures for the prosumers.

5.5 Thailand Energy Reform

Thailand Energy Reform was announced in the Government Gazette on 6th April 2018 and PV systems are included in the plan. There are 3 related aspects in terms of electrical energy

(1) energy development structure by allocating the share of fuels and management
(2) supporting the competition in energy activities
(3) reform of the electricity administration structure.

In terms of supporting renewable energy, this translates into

(1) reform the administration of biomass using fast growing plants
(2) supporting and solving problems of using the municipal waste in electricity production
(3) supporting the liberation of installation for PV rooftop systems
(4) reform the transportation sector in terms of electrical energy application.

Support for PV rooftop systems involves mainly

(1) raising the awareness regarding renewable energy for the residential Sector
(2) independent electricity purchasing
(3) continuous growth of rooftop PV business and employment such as PV module fabrication, inverter and battery
(4) reducing the greenhouse effects.

Floating PV system at Sirindhorn Dam, Ubonratchathani Province

Definitions

Adder	Adder is an incentive measure in purchasing of renewable energy such as wind, solar, small and micro hydro, biogas, biomass and municipal waste with the adder to existing electricity price for a certain period.
Biomass	Agricultural residues or wastes from production and agricultural products, lumber or wood from reforestation as fuel.
Feed-in Tariff (FiT)	FiT is an incentive measure in purchasing of renewable energy such as wind, solar, small and micro hydro, biogas, biomass and municipal waste with the fixed-rate electricity price for a certain period.
Kilowatt Peak (kWp) and Megawatt Peak (MWp)	The maximum power production of PV modules (or systems) under standard test condition (STC) for PV module testing according to the scale of the power output as kilowatt and megawatt, respectively.
Microgrid	The power production from renewable energy source such as hydro, biomass, wind, that are integrated to the grid with battery energy storage systems. The system shell provides the electricity when the grid line is not operated.
Municipal waste / Solid waste	Garbage such as paper, rag, waste food, scrap products, plastic bags, food containers, carcasses, including anything else that is swept from the streets, market, animal husbandry or elsewhere from the community, and includes residual wastes, and landfill waste that is dredged and reburied into energy. This does not include industrial waste, infected/toxic waste and residual wastes from agricultural processed products or from harvesting.
Performance Ratio (PR)	PR is a ratio of actual energy production divided by installed capacity to the incident solar irradiation divided by the reference solar irradiance at STC (1000 W/m2).
Reliable Capacity	The electrical power involves the security of the power system with more reliability. This value is also concerned with the risk of the main power plant not operating.
Small Power Producer (SPP)	SPP is a private or state enterprise generating electricity using a cogeneration system (heat and power generation) or non-conventional energy sources with generation capacity from 10 to 90 MW. (1) Non-conventional energy sources such as wind, solar, and small hydro excluding oil, natural gas, coal and nuclear. (2) SPP includes the electricity generating projects using following sources • Agricultural residues or wastes from industry or agriculture • Processed products from agricultural residues or wastes from industry or agriculture • Garbage • Wood from reforestation

Very Small Power Producer (VSPP)	VSPP is a private or state enterprise generating electricity with generation capacity, not more than 10 MW using the following non-conventional energy sources. • Renewable energy sources such as wind, solar, small hydro, micro hydro and biogas. • Agricultural residues or wastes from industry or agriculture, processed products from agricultural residues or wastes from industry or agriculture, garbage, wood from reforestation.

ACRONYMS

BOI	Board of Investment
BRU	Burriram Rajabhat University
CMRU	Chiang Mai Rajabhat University
CMU	Chiang Mai University
CU	Chulalongkorn University
DEDE	Department of Alternative Energy Development and Efficiency
EGAT	Electricity Generating Authority of Thailand
EPPO	Energy Policy and Planning Office
KU	Kasetsart University
KKU	Khon Kaen University
KMITL	King Mongkut's Institute of Technology Ladkrabang
KMUTT	King Mongkut's University of Technology Thonburi
MEA	Metropolitan Electricity Authority
MU	Mahidol University
NPU	Nakhon Phanom University
NU	Naresuan University
NIDA	National Institute of Development Administration
NRCT	National Research Council of Thailand
NSTDA	National Science and Technology Development Agency
OERC	Office of Energy Regulatory Commission
PCRU	Phetchabun Rajabhat University
PEA	Provincial Electricity Authority
RMUTK	Rajamangala University of Technology Krungthep
RMUTL	Rajamangala University of Technology Lanna
RMUTSB	Rajamangala University of Technology Suvannabhumi
RMUTT	Rajamangala University of Technology Thanyaburi
SCOD	Scheduled Commercial Operation Date
SNRU	Sakon Nakhon Rajabhat University
SU	Silpakorn University
SWU	Srinakharinwirot University
SUT	Suranaree University of Technology
TSRI	Thailand Science Research and Innovation (former Thailand Research Fund, TRF)
UBU	Ubon Ratchathani University
UBRU	Ubon Ratchathani Rajabhat University
UP	University of Phayao

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