Technology Collaboration Programme
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International Energy Agency
Photovoltaic Power Systems Programme

Task 1 Strategic PV Analysis and Outreach

PVPS

National Survey Report of PV Power Applications in THAILAND

2021

Department of Alternative
Energy Development and Efficiency
MINISTRY OF ENERGY

What is IEA PVPS TCP?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD). The Technology Collaboration Programme (TCP) was created with a belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of 6.000 experts across government, academia, and industry dedicated to advancing common research and the application of specific energy technologies.

The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the TCP's within the IEA and was established in 1993. The mission of the programme is to "enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems." In order to achieve this, the Programme's participants have undertaken a variety of joint research projects in PV power systems applications. The overall programme is headed by an Executive Committee, comprised of one delegate from each country or organisation member, which designates distinct 'Tasks,' that may be research projects or activity areas.

The IEA PVPS participating countries are Australia, Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, and the United States of America. The European Commission, Solar Power Europe, the Smart Electric Power Alliance (SEPA), the Solar Energy Industries Association and the Cop- per Alliance are also members.

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What is IEA PVPS Task 1?

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 2020. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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COVER PICTURE

The 45 MW (AC) world-largest Floating PVs (FPVs) System integrated with hydropower at Sirindhorn dam at Ubonratchathani province of Thailand in near-complete phase as part of the 2,725 MW (AC) plan of FPVs installation of Thailand by 2037.

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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 2020 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2020, although commissioning may have taken place at a later date.

1.1 Applications for Photovoltaics

In 2020 the development of PV systems for electricity generation in Thailand continued to grow in decentralized sector, where the BAPV in industrial and commercial showed the most prominent growth in PV installation. In terms of national target, by 2037, Thailand aimed to commission new power plant capacity at 56 431 MW in which 18 696 MW of this would come from renewable electricity power plant. In addition, the target of new solar PV power plant capacity target in 2037 was set at 8 740 MW, plus additional 550 MW capacity target of solar PV hybrid with other renewable energy source according to community power plant project. Moreover, Thailand also established 2 725 MW solar PV floating target hybrid with large hydropower dams by 2037.

Thailand cumulative PV installed capacity was at 3 939,8 MWp, consisting of 3 933,7 MW of grid-connected PV systems and 6,1 MWp of off-grid PV systems. Most of the total installed capacity was ground-mounted PV systems.

In 2020, Thailand annual grid-connected systems installation was 143,64 MWp. Data showed that rooftop PV systems for the commercial was dominated the sector with 127,25 MW of installation. In addition, there was 12,69 MW of floating PV systems and 3,7 MW of ground mounted systems installed in 2020. When incorporating 80 kW off-grid installation in 2020, total annual PV installation of Thailand stood at 143,72 MW. The constructions for floating PVs system with the installation capacity of 58,8 MWp (45 MW_{AC}) hybridized with regular hydropower generation at Sirindhorn Dam, Ubonratchathani province had been completed and the system came online since November 2021.

1.2 Total photovoltaic power installed

Data collection for the PV installed capacity of Thailand in this report used the secondary data from the Office of Energy Regulatory Commission (OERC) which were collected from the Electricity Generating Authority of Thailand (EGAT), Provincial Electricity Authority (PEA) and Metropolitan Electricity Authority (MEA).

Centralized: any PV installation which only injects electricity and is not associated with a consumer (no self-consumption). In Thailand, these are mostly ground-mounted PV systems with the power purchasing agreement (PPA) in utility applications.

Decentralized: any PV installation which is embedded into a customer's premises. In Thailand, these are comprised of rooftop PV systems, ground-mounted PV systems and floating PV systems. The implementation can be done in both self-consumption with the ability to sell the excess electricity back to the grid, and with the private power purchase agreement (private-PPA) aspects.

Table 1: Annual PV power installed during calendar year 2020

		Installed PV capacity in 2020 [MW]	AC or DC
	Decentralized	139,94	DC
	Centralized	3,7	-
	Off-grid	80 kW	DC
	Total	**143,72**	DC

Table 2: PV power installed during calendar year 2020

			Installed PV capacity [MW]	Installed PV capacity [MW]	AC or DC
Grid-connected	BAPV	Residential	127,25	2,22	DC
		Commercial		125,03	DC
		Industrial			
	BIPV	Residential	-	-	-
		Commercial		-	-
		Industrial		-	-
	Utility-scale	Ground-mounted	16,39	3,7	DC
		Floating		12,69	DC
		Agricultural		-	-
Off-grid		Residential	80 kW	n/a	DC
		Other		15 kW	DC
		Hybrid systems		65 kW	DC
Total			143,72		DC

Table 3: Data collection process

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	-
Is the collection process done by an official body or a private company/Association?	The data is collected by official bodies primarily from (1) Office of Energy Regulatory Commission (OERC) and (2) Department of Alternative Energy Development and Efficiency (DEDE) Ministry of Energy.
Link to official statistics (if this exists)	www.erc.or.th, and www.dede.go.th

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

Year	Off-grid [MW] (including large hybrids)	Grid-connected distributed [MW] (BAPV, BIPV)	Grid-connected centralized [MW] (Ground, floating, agricultural…)	Total [MW]
2002	2,57	-	-	2,57
2003	3,13	-	-	3,13
2004	9,07	-	-	9,07
2005	22,11	-	-	22,11
2006	28,66	-	0,1	28,72
2007	28,90	-	1,6	30,53
2008	29,33	-	2,0	31,28
2009	29,49	-	5,4	34,84
2010	29,65	-	21,0	50,66
2011	29,58	-	174,0	203,62
2012	30,19	-	406,5	436,64
2013	29,73	-	954,8	984,5
2014	29,15	-	1 342,2	1 371,39
2015	29,64	130	1 952,0	2 111,61
2016	33,8	135,63	2 861,1	3 030,48
2017	34,14	365,17	2 915,0	3 314,27
2018	30,14	599,43	3 060,2	3 689,8
2019	5,8*	717,32	3 072,8	3 795,87
2020	6,11*	857,26	3 076,5	3 939,82

Remark: * Excluding 24,38 MWp of Solar Home System project implemented since 2005.

Table 5: Other PV market information

	2020
Number of PV systems in operation in your country (a split per market segment is interesting)	n/a
Decommissioned PV systems during the year [MW]	n/a
Repowered PV systems during the year [MW]	n/a

Table 6 is the information about broader national energy market from 2017 to 2020 as follows.

Table 6: PV power and the broader national energy market

	2020	2019	2018	2017
Total power generation capacities [MW]	45 480	45 297	43 374	42 443
Total renewable power generation capacities (including hydropower) [MW]	12 004,62	11 852,04	11 368,94	n/a
Total electricity demand [GWh]	187 046	192 960	187 832	185 124
New power generation capacities installed [MW]	183	1 923	941	877
New renewable power generation capacities (including hydropower) [MW]	152,58	483,1	n/a	n/a
Estimated total PV electricity production (including self-consumed PV electricity) in [GWh]	5 867,18	5 652,81	5 494,85	4 935,61
Total PV electricity production as a % of total electricity consumption	3,13 %	2,93 %	2,93 %	2,67%
Average yield of PV installations (in kWh/kWp)	1 489,2	1 489,2	1 489,2	1 489,2

1.3 Key enablers of PV development

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2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

The module prices were collected in the local market that the lowest price and highest price of standard module crystalline silicon were 0,24 – 0,33 and 0,40 – 0,58 USD/Wp, respectively. The lowest price for large scale order was ground mounted PV power plant and the highest price for small scale order was rooftop PV systems. However, most of PV module in local market was imported while PV module of local manufactured has higher price. The exchange rate as of 22th Nov 2021 was 1 USD = 32,68 THB.

Table 7: Typical module prices [USD/Wp)

Year	Lowest price of a standard module crystalline silicon	Highest price of a standard module crystalline silicon	Typical price of a standard module crystalline silicon
2020	0,29	0,49	0,31

2.2 System prices

Table 8 show typical systems prices of residential, commercial, and industrial BAPV as well as small ground mounted PV system in Thailand. The range of systems price of residential was 1,07 – 1,38 USD/W. While the commercial, and industrial BAPV system prices were 0,77 – 0,92 USD/W. For small ground mounted PV system price was 0,61 - 0,77 USD/W. The price for large ground mounted PV system was not available due to no installation in 2020. The data was provided by local manufacturers who offered PV system installation services. The exchange rate as of 22th Nov 2021 was 1 USD = 32,68 THB.

Table 8: Turnkey PV system prices of different typical PV systems

Category/Size	Typical applications and brief details	Current prices [USD/W]
Residential BAPV 5-10 kW	Grid-connected, roof-mounted, distributed PV systems installed on the roof to produce electricity to grid-connected households.	1,23
Small commercial BAPV 10-100 kW	Grid-connected, roof-mounted, distributed PV systems installed mostly on small size commercial building or industry plants rooftop.	0,84
Large commercial BAPV 100-250 kW	Grid-connected, roof-mounted, distributed PV systems installed mostly on larger size commercial building or industry plants rooftop.	

Industrial BAPV >250 kW	Grid-connected, roof-mounted, distributed PV systems installed mostly on larger size commercial building or industry plants rooftop.	
Small centralized PV 1-20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power station. This included SPP (Small Power Producers, 10-90 MW) and VSPP (Very Small Power Producer, 1-10 MW) utility.	0,69
Large centralized PV >20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power station. This included SPP and IPPs (Independent Power Producers, >90 MW) utility. However, there was no large-scale PV utility installation in 2020 in Thailand as the government tended to promote more on decentralized PV systems.	N/A

Table 9: National trends in system prices for different applications

Year	Residential BAPV Grid-connected, roof-mounted, distributed PV system 5-10 kW **[USD/W]**	Small commercial BAPV Grid-connected, roof-mounted, distributed PV systems 10-100 kW **[USD/W]**	Large commercial BAPV Grid-connected, roof-mounted, distributed PV systems 100-250 kW **[USD/W]**	Centralized PV Grid-connected, ground-mounted, centralized PV systems 10-50 MW **[USD/W]**
2020	1,23	0,84		No installation

2.3 Financial Parameters and specific financing programs

The energy conservation with PV rooftop systems was very popular in the commercial and industrial company. Commercial bank had the promotion of green energy and for SMEs (Small and Medium Enterprises). In general, the rate of loans was 3-5 % per year.

Table 10: PV financing information in 2020

Different market segments	Loan rate [%]
Average rate of loans – residential installations	3 – 5 %
Average rate of loans – commercial installations	
Average cost of capital – industrial and ground-mounted installations	

2.4 Specific investments programs

In 2020 the decentralized rooftop PV systems installation were carried out by private sectors under various business models, and utilities, i.e. the Provincial Electricity Authority (PEA) and the Metropolitan Electricity Authority MEA. This resulted in more installation of PV rooftop systems in commercial, and industrial sectors of Thailand in 2020. The implementation of this scheme was aimed for both self-consumptions and with PPA/private PPA aspects.

Since 2019, Thailand has launched the promotion of solar rooftop systems installation for Thai People Incentive Program for residential household for self-consumption purpose with the measure to sell the excessed electricity back to the grid. These projects were conducted by PEA and MEA.

Commercial and industrial PV systems were carried out by private sectors that could be via renting and leasing PV systems. The power purchasing contract was developed and signed between the land/building owner and the systems owner/investors.

2.5 Additional Country information

Table 11 shows the retail electricity prices for household, commercial and industrial company. The exchange rate as of 22th Nov 2021 was 1 USD = 32,68 THB.

Table 11: Country information

Retail electricity prices for a household [USD/W] Note: Time of Use Rate for a household, voltage level 1 refers to <12 kV for MEA and < 22 kV for PEA while voltage level 2 refers to 12-24 kV for MEA and 22-33 kV for PEA.	Normal Rate for a household: Energy consumption ≤150 kWh/month: Energy charge: 0,071 - 0,13 USD/kWh, (progressive rate) Monthly service fee: 0,25 USD/month Energy consumption >150 kWh/month: Energy charge: 0,099 – 0,13 USD/kWh, (progressive rate) Monthly service fee: 1,16 USD/month Time of Use rate for a household: Voltage Level 1: Energy charge: 0,08 (Off Peak) – 0,18 (On Peak) USD/kWh, Monthly service fee: 1,16 USD/month Voltage Level 2: Energy charge: 0,079 (Off Peak) – 0,16 (On Peak) USD/kWh, Monthly service fee: 9,5 USD/month
Retail electricity prices for a commercial company [USD/W] Small General Service: (A maximum of 15-minute integrated demand of less than 30	Normal Rate of Small General Service: Voltage Level 1: Energy charge: 0,099-0,13 USD/kWh, (progressive rate) Monthly service fee: 1,40 USD/month Voltage Level 2: Energy charge: 0,12 USD/kWh,

kW through a single Watt-hour meter) Voltage Level: 1 refer to < 12 kV for MEA and < 22 kV for PEA. 2 refer to 12-24 kV for MEA and 22-33 kV for PEA. Medium General Service: (A maximum of 15-minute integrated demand from 30 to 999 kW and the energy consumption for three consecutive months through a single Watt-hour meter are not exceeding 250,000 kWh per month) Voltage Level: 1 refer to < 12 kV for MEA and < 22 kV for PEA. 2 refer to 12-24 kV for MEA and 22-33 kV for PEA. 3 refer to > 69 kV for both MEA and PEA.	Monthly service fee: 9,50 USD/month Time of Use Tariff of Small General Service: Voltage Level 1: Energy charge: 0,08 (Off Peak) – 0,18 (On Peak) USD/kWh, Monthly service fee: 1,40 USD/month Voltage Level 2: Energy charge: 0,079 (Off Peak) – 0,16 (On Peak) USD/kWh, Monthly service fee: 9,50 USD/month Normal Rate of Medium General Service: Voltage Level 1: Demand charge: 6,74 USD/kWh, Energy charge: 0,097 USD/kWh, Voltage Level 2: Demand charge:5,97 USD/kWh, Energy charge: 0,096 USD/kWh, Voltage Level 3: Demand charge: 5,35 USD/kWh, Energy charge: 30,095 USD/kWh, *Monthly service fee of all voltage level: 9,50 USD/month Time of Use Tariff of Medium General Service: Voltage Level 1: Demand charge: 6,39 (On Peak) USD/kWh, Energy charge: 0,08 (Off Peak) – 0,13 (On Peak) USD /kWh, Voltage Level 2: Demand charge: 4,05 (On Peak) USD /kWh, Energy charge: 0,079 (Off Peak) – 0,13 (On Peak) USD /kWh, Voltage Level 3: Demand charge 2,26 (On Peak) USD /kWh, Energy charge: 0,079 (Off Peak) – 0,12 (On Peak) USD /kWh, *Monthly service fee of all voltage level: 9,50 USD/month
Retail electricity prices for an industrial company [USD/W] (A maximum of 15-minute integrated demand exceeds 1 000 kW, or the energy consumption for three consecutive months through	Time of Day Tariff: TOD Voltage Level 1: Demand charge: 2,08 (Partial Peak) – 10,12 (On Peak) USD/kWh, Energy charge: 0,097 USD/kWh, Voltage Level 2: Demand charge: 1,79 (Partial Peak) – 8,67 (On Peak) USD/kWh, Energy charge: 3,1471 USD/kWh,

a single Watt-hour meter exceeds 250 000 kWh per month) Voltage Level: 1 refer to < 12 kV for MEA and < 22 kV for PEA. 2 refer to 12-24 kV for MEA and 22-33 kV for PEA. 3 refer to > 69 kV for both MEA and PEA.	Voltage Level 3: Demand charge: 0,91 (Partial Peak) – 6,83 (On Peak) USD/kWh, Energy charge: 0,095 USD/kWh, *Monthly service fee of all voltage level: 9,50 USD/month Time of Use Tariff: TOU Voltage Level 1: Demand charge: 6,39 USD/kWh, Energy charge: 0,08 (Off Peak) – 4.3297 (On Peak) USD/kWh, Voltage Level 2: Demand charge:4,05 USD /kWh, Energy charge: 0,079 (Off Peak) – 0,13 (On Peak) USD /kWh, Voltage Level 3: Demand charge: 2,26 USD /kWh, Energy charge: 0,079 (Off Peak) – 0,12 (On Peak) USD/kWh, *Monthly service fee of all voltage level: 9,50 USD/month
Liberalization of the electricity sector	Large scale of electricity generation is monopoly by the utility, but nowadays the electricity generation by distributed generation such as solar rooftop system has the liberty. They need to register with official of Energy Regulatory Commission (OERC) to obtain the production licensing and the distribution licensing for prosumer that own the PV systems capacity is larger than 1 000 kVA. So, the PV system capacity is less than 1 000 kVA, the production licensing is excepted but they should notify to OERC.

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.

Table 12: Summary of PV support measures

Category	Residential		Commercial + Industrial		Centralized	
Measures in 2020	**On-going**	**New**	**On-going**	**New**	**On-going**	**New**
Feed-in tariffs	Yes	Yes	Yes	Yes	Yes	-
Feed-in premium (above market price)	Yes	-	Yes	-	-	-
Capital subsidies	-	-	-	-	-	-
Green certificates	-	-	-	-	-	-
Renewable portfolio standards with/without PV requirements	-	-	-	-	-	-
Income tax credits	-	-	-	-	-	-
Self-consumption	Yes	Yes	Yes	Yes	-	-
Net-metering	-	-	-	-	-	-
Net-billing	Yes	Yes	Yes	-	-	-
Collective self-consumption and delocalized net-metering	-	-	-	-	-	-
Sustainable building requirements	-	-	-	-	-	-
BIPV incentives	-	-	-	-	-	-
Other	-	-	-	-	-	-

3.1 National targets for PV

According to Thailand Power Development Plan 2018-2037 (Revision 1) and Alternative Energy Development Plan 2018, Thailand aims to achieve **new** PV install capacity of 9 290 MWp (new PV 8 740 MWp and new PV hybrid 550 MWp) as well as the 2 725 MW (AC) of floating PV systems by 2037. This will contribute to around half of all electricity produced from renewable energy sources at 2037. When incorporating the project that already got the PPA of 2 849 MWp today, the **total** install capacity of PV system at 2037 is expected to achieve 12 139 MWp.

3.2 Direct support policies for PV installations

3.2.1 The Energy Plans of Thailand

There are two main plans involved in managing the direction of energy and renewable energy in Thailand: Power Development Plan 2018-2037 (PDP 2018) revision 1 and the Alternative Energy Development Plan 2018-2037 (AEDP 2018). The PDP2018 has set the target of new power plant capacity at 56 431 MW by 2037, with the target of new renewable energy plant construction at 18 696 MW (which will account for around 34,23% of total electricity demand of Thailand in 2037). Of this target, PV sector will dominate the majority of renewable electricity at 9 290 MWp (8 740 MWp new PV systems and 550 MWp new PV hybrid systems), which is accounted for around half of total renewable energy capacity at the end of the plan, as well as the 2 725 MW (AC) target of installing floating PV systems over 9 major dams of Thailand.

3.2.2 The Solar for Thai People Incentive Program

The Solar for Thai People Incentive Program continues the supporting scheme from previous years where residential electricity users (single home, non-collective) can apply for the program to install PV systems on their rooftop area and be able to serve the role of electricity producers (thus, as prosumers). The program started since 2019 with the primary objective of utilizing electricity produced from PV system for self-consumption, while the excessed electricity from own use can be sold back to the grid at the FiT rate of 2,20 THB/kWh (equivalent to around 0,067 USD/kWh). The target of this program is 50 MWp PV installation per year and will receive the FiT for 10 years. However, the reception of this program is yet to be widely accepted as less than 5 MWp had been achieved since the first phase of this program in 2019.

In 2020, the National Energy Policy Council (NEPC) resolution had approved the extension of implementation of this program to be used in academic institutes, hospitals, and agricultural water pumping systems in 2021. This pilot program will focus on the self-consumption of such utilization, with the FiT of selling the excess electricity to the grid of 0,03 USD/kWh (1 THB/kWh). The target of this program was also set at 50 MWp of PV install capacity (20 MWp for hospital, 20 MWp for academic institutes, and 10 MWp for agricultural pumping), for the system size of more than 10 kWp but less than 200 kWp with 10 years FiT contract.

3.3 Self-consumption measures

Table 13: Summary of self-consumption regulations for small private PV systems in 2020

PV self-consumption	1	Right to self-consume	Yes
	2	Revenues from self-consumed PV	Saving on electricity bill (net billing scheme)
	3	Charges to finance Transmission, Distribution grids & Renewable Levies	none
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Solar for Thai People Incentive Program FiT of **0,067** USD/kWh for

			(Household) FiT of **0,03** USD/kWh for hospital, academic institutes, and agricultural water pumping. (pilot)
	5	Maximum timeframe for compensation of fluxes	N/A
	6	Geographical compensation (virtual self-consumption or metering)	N/A
Other characteristics	7	Regulatory scheme duration	N/A
	8	Third party ownership accepted	No
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Grid code of allowing less than 15% electricity from RE for local transformer capacity in that area
	10	Regulations on enablers of self-consumption (storage, DSM…)	None
	11	PV system size limitations	Solar for Thai People Incentive Program Household: Less than 10 kWp/household Hospital, academic institutes, and agricultural water pump: more than 10 kWp but less than 200 kWp
	12	Electricity system limitations	N/A
	13	Additional features	-

3.4 Collective self-consumption, community solar and similar measures

None

3.5 Tenders, auctions & similar schemes

None

3.6 Other utility-scale measures including floating and agricultural PV

Thailand PDP 2018 (revision 1) had set the target of 2 725 MW_{AC} floating PVs (FPVs) by 2037 that will be functionally integrated with 9 hydropower dams of Electricity Generating Authority of Thailand (EGAT). In 2020, the construction of the 45 MW_{AC} (58.8 MWp) FPVs system integrated with EGAT Sirindhorn dam hydropower was completed and the system went online in November 2021. This project exploited double-glasses PV technology to maximize the efficiency and performance on water as well as incorporates the energy management system (EMS) that will integrally function with traditional hydropower system to ensure improved capacity, stability and security of electricity production. EGAT will increase the proportion of renewable energy of the country by developing 16 FPVs-Hydro Solar Hybrid Projects within the area of 9 EGAT dams with the total capacity of 2 725 MW (AC) at the end of the plan in 2037.

Moreover, IRPC – an industry player in Thailand petrochemical business – also installed the 12,5 MW floating PV system in 2020, with its prominent application of IRPC-invented HDPE plastic buoys that offered strength against impacts and corrosion, UV-resistant, and environmental-friendly (food-graded materials test passed by US FDA). This is currently the largest floating PVs systems in south-east Asia.

Thailand also applied solar pumping for agricultural purposes for quite a long time but only in small scale through various support projects and Royal Initiatives.

3.7 Social Policies

None

3.8 Retroactive measures applied to PV

None

3.9 Indirect policy issues

3.9.1 Rural electrification measures

Thailand has 99,8% electricity access but there are some parts of the region that are difficult in connecting to the grid, such as in high mountain or country border. Thailand had implemented a number of solar PV off-grid projects in the Royal Initiatives area, local community learning center, remote school, local hospitals, protected forest area, and border school to enable the access to electricity where grid access was not applicable. The total combined power production from solar PV off-grid from the Ministry of Energy during 1993 to 2020 was reported around 3 974 kW.

3.9.2 Support for electricity storage and demand response measures

none

3.9.3 Other support measures

None

3.10 Financing and cost of support measures

The Board of Investment (BOI) ongoing campaign on investment promotion measures to increase production efficiency had extended from 2017 to 2020. This measure allowed the Industry and SMEs to install solar rooftop on their area to save cost on their electricity bills. The benefits from this measure included a) tax exemption for imported machineries (10% import tax and 7% VAT) and b) 3 years income tax exemption with the amount equal to 50% of investment costs.

4 INDUSTRY

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

PV manufacture in Thailand had no production of feedstocks, ingots, and wafers. The wafers were imported for cell production while the cells were also imported to fabricate the modules.

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

Module manufacturing was defined as an industry where the processes of the production of PV modules (the encapsulation) are 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.

There were total 15 PV module manufactures in 2020 in Thailand, which were responsible for cell and module production and module fabrication. By estimates, total module production was 3 938 MW, and maximum production capacity was 7 078 MW/yr. There were 7 of 15 manufactures are foreign investors and their main PV module productions were subjected for export. Note that cell production information was not available for Thailand, while most of module production information was achievable due to market competition. Total PV cell and module manufactures, together with production capacity information, were summarized in Table 14.

Table 14: PV cell and module production and production capacity information for 2020

Cell/Module manufacturer (or total national production)	Technology (sc-Si, mc-Si, a-Si, CdTe, CIGS)	Total Production [MW]		Maximum production capacity [MW/yr]	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Canadian Solar Manufacturing (Thailand) Co., Ltd	sc-Si, mc-Si	n/a	2 000	n/a	3 600
Gintech (Thailand) Co., Ltd.	sc-Si, mc-Si	n/a	1 600	n/a	n/a
Jetion Solar (Thailand) Co., Ltd.	sc-Si, mc-Si	n/a	200	n/a	200
Solartron Public Co., Ltd.	sc-Si, mc-Si	n/a	100	n/a	700
Talesun Technology (Thailand) Co., Ltd.	sc-Si, mc-Si	n/a	n/a	n/a	1 500

Trina Solar Science & Technology (Thailand) Co., Ltd.	sc-Si, mc-Si	n/a	n/a	n/a	n/a
Yingli Green Energy Holding Co., Ltd.	sc-Si, mc-Si	n/a	n/a	n/a	500
Ekarat Solar Co., Ltd.	mc-Si	n/a	9	n/a	15
Full Solar Co., Ltd.	sc-Si, mc-Si	n/a	10	n/a	50
G.K.Assembly Co., Ltd.	mc-Si	n/a	n/a	n/a	n/a
Irradiance Solar Co., Ltd.	mc-Si	n/a	1,5	n/a	3
Pornjaroen Tempered Safety Glass Co., Ltd.	sc-Si, mc-Si	n/a	2,5	n/a	2,5
Schetten Solar (Thailand) Co., Ltd.	sc-Si, mc-Si	n/a	10	n/a	500
Solar Power Technology Co., Ltd.	sc-Si, mc-Si	n/a	5	n/a	7,5
Total		**n/a**	**3 938**	**n/a**	**7 078**

4.3 Manufacturers and suppliers of other components

There were 6 local inverter manufacturers in Thailand, which were P.Y. Enginerring Co., Ltd., Chuphotic Co., Ltd., Daddee Power Group Co., Ltd., Delta Electronics (Thailand) Public Co., 599Ltd., Leonics Co., Ltd. and Thai Tabuchi Electric Co., Ltd.

When taking price consideration into the account, most PV inverters were found to be imported due to lower cost. However, in the case that the higher cost inverters were chosen, the customer tended to expect superior after-sale service qualities instead.

For battery energy storage, there were 3 manufacturers in Thailand, which were Amita Technology (Thailand) Co., Ltd. (ATT) cooperate with Energy Absolute Public Co. Ltd. (EA), Global Power Synergy Public Company Limited (GPSC) and Rojana Industrial Park Public Co., Ltd. cooperate with EVLOMO (US) Co., Ltd.

The market of PV supporting structures is related to the steel manufacturing industry that has no upstream manufacturers. Most of them started at the electric arc furnace (EAF) in order to produce the steel. Steel and iron manufactures represented two main industries in Thailand. As a result, the supporting structures supply of PV system is mainly depended on the steel market.

5 PV IN THE ECONOMY

This chapter aims to provide information on the benefits of PV for the economy.

5.1 Labour places

Table 15 shows the estimated labour places that are related to PV activity by categories. Research and development group (not including companies) had about 14 agency and average of 20 labour places each, totalling 280 labour places. The second category was consisted of 24 companies including PV module manufacturers and balance-of-systems components (inverters and energy storage batteries) that the approximate of labour places is about 300 per company, totalling 7 200 labour places. The next category was consisted of around 100 distributors of PV production and installation company that was receiving public interests especially the rooftop PV systems installation program, had about 50 labour places per company, totalling 5 000 available labour places in the market. Moreover, the PV system operation and maintenance in the PV power plants had about 6 000 labour places in total. Then the total of estimated PV-related labour places in 2020 was estimated to create around 18 480 jobs.

Table 15: Estimated PV-related full-time labour places in 2020

Market category	Number of full-time labour places
Research and development (not including companies)	280
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	7 200
Distributors of PV products and installations	5 000
PV power plant operation and maintenance	6 000
Total	**18 480**

5.2 Business value

Table 16 shows estimation of PV business values in 2020, which was around 92 978,9 million THB (2 845,13 million USD), consisting of off-grid, grid-connected distributed and grid-connected centralized systems. The exchange rate as of 22th Nov 2021 was 1 USD = 32,68 THB

Table 16: Rough estimation of the value of the PV business in 2020 (VAT is excluded)

Sub-market	Capacity installed [MW]	Average price [USD/W]	Value [USD]	Sub-market [MUSD]
Off-grid	6,1	0,918	5 599 755,202	5,6

Grid-connected distributed	857,26	27,5	721 378 518,972	721,379
Grid-connected centralized	3 076,5	0,688	2 118 153 304,773	2 118,153
Value of PV business in 2020				2 845,13

6 INTEREST FROM ELECTRICITY STAKEHOLDERS

6.1 Structure of the electricity system

Electricity utilities in Thailand are consisted of the electricity production and electricity distribution sectors.

The electricity production sector consists of the Electricity Generating Authority of Thailand (EGAT), the independent power producers (IPP), the small power producers (SPP), and some imported electricity from neighbour countries. These, included SPP from PV power plants (installed capacity of 10-90 MWp), were regulated by EGAT as well as the electricity transmission systems and infrastructures. Moreover, some direct customers are also be able to sell the electricity back to EGAT.

The distribution sector has two involved distribution utilities that are a) Metropolitan Electricity Authority (MEA) and b) Provincial Energy Authority (PEA). MEA is responsible for 3 province areas - Bangkok and two other adjacent provinces (Nonthaburi and Samut Prakan) - while PEA is responsible for the rest of the country.

In addition, the very small power producers (VSPP), the electricity producers in distributed renewable energy production, in which smaller scale of PV (installed capacity of 1-10 MWp) installation including solar rooftop PV from either household, commercial, or industrial sources were regulated by MEA and PEA.

Moreover, the national energy policy of Thailand is integrally conducted by the National Energy Policy Committee (NEPC), Energy Policy and Planning Office (EPPO) and Office of Energy Regulatory Commission (OERC).

In 2020 the transition of electricity industry was occurring and seemed to be on the onset for the preparation of regulation amendments for prosumer aspect. The private sector tends to exhibit the trend to own both PV systems for self-consumption and be able to own distribution system to response to the liberty of rooftop PV system under national energy reform policy. As a result, in the next few years, the new regulations for wheeling charge will be introduced.

Regarding installing PV rooftop systems in Thailand, those that install PV capacity of more than 1 000 kVA needed to be applied for the licensing of electricity generation from OERC, either for self-consumption or selling electricity back to the grid. However, those that install PV capacity below 1 000 kVA needed to notify OERC for exemption of licensing of electricity generation. Ground-mounted PV and floating PV were needed to apply for licensing of electricity generation for all capacity.

Utility trading in Thailand is currently adopting Enhanced Single Buyer (ESB) scheme, by which EGAT acts as both power producer and electricity purchaser from large scale power producers (Independent Power Producers (IPP) and SPP) while MEA and PEA act as both power distributors for their responsible regions, and power purchaser for VSPP.

In order to support effective power transition of the country towards digitalized economy and decentralized power systems, attempts had been made to amend regulatory and legislation obstacles, as well as grid code adjustment to transform from ESB model into wholesale power market in the future. This would lead to the liberalization of prosumer concept that allow easier trading of electricity between private sectors or between households, as well as the grid access of third-party players (Third Party Access, TPA), with the specified wheeling charges, to support the forthcoming of prosumers in Thailand PV market.

6.2 Interest from electricity utility businesses

In 2020, apart from the Solar for Thai People Incentive Program that offered possibility of households to receive 2,20 THB/kWh FiT incentives for excessed electricity from installed PV rooftop systems operated under regulation of OERC, PEA and MEA, PEA also supported the installation of rooftop PV systems for social community centers under the “60 Years, 60 Cooperations, 60 Giveaways, for never-ending lightings” campaign. This campaign offered free investments from provided investors for those who are direct PEA customers who had more than 1 million THB electricity bills (collective bills applicable, no overdue bills required) with more than 10 000 m^2 roof area to install around 1 MW rooftop PV systems. Moreover, the campaign also supported the installation of PV rooftops for social and community centers, such as academic institutes, religious places/temples, hospitals, or those that contributed the good deeds for local communities.

As Thailand is approaching the concrete expansion of electric vehicles (EVs), the development of electricity demand management system of the country was under development in 2020, where utility players were also key parts of this measures.

7 HIGHLIGHTS AND PROSPECTS

7.1 Highlights

To summarize PV market in Thailand in 2020, Thailand continued to support the installation of PV in various markets, especially those in decentralized or distributed systems, in order to fulfil the PDP2018 rev.1 target of installing new 9 290 MWp of PV system by 2037. The Solar for Thai People Incentive Program started since 2019, with the prospect to use electricity for self-consumption while the excess electricity can be sold back to the utility grid, also received increase FiT rate from 1,68 THB/kWh ($0,0514 USD/kWh) to the new rate of 2,20 THB/kWh ($0,0673 USD/kWh) to attract more installation from residential sectors. This program will also be extended to be implemented in academic institutes, hospitals, and agricultural water pumping systems in 2021, with the FiT rate of 1 THB/kWh ($0,0305 USD/kWh).

In the meantime, the installation of rooftop PV systems in private sectors, such as in commercial buildings and industrial plants, were also developed under various business models by both state-enterprise utility and private investors. This was primarily to reduce the expenses of electricity bills.

Apart from EGAT target of installing 2 725 MW floating PV systems, other players were also interested in developing and implementing floating PVs in their premises to save cost from electricity consumption.

Finally, PV manufacturers in Thailand had seen increased production capacity from foreign investors due to the global market growth, while local manufacturers confronted with high competition with the imported PV module and system equipment.

7.2 Prospects

Solar PV in Thailand will continue to be an important player in energy market as Thailand had set the ambitious target of installing around half of its renewable electricity from PV systems by 2037. With the suitable driving forces from policy implementation and private sector growth, the growth of PV market in the future is expected to be substantial.

With the ongoing trend of self-consuming electricity produced from PV systems installed on the rooftop of the premises, implementing energy storage system is now one of Thailand interests to achieve more reliable source of renewable electricity and match with consumption patterns of electricity users.

Currently, Thailand is also conducting studies on PV module recycling as well as the establishment of pilot PV module recycle plant in order to promote more sustainable use of PV modules, as well as to explore their second life potential.

As per COP26, Thailand will introduce and adopt the carbon neutrality policy in order to achieve carbon zero by 2050 and will be zero emission by 2065, in the light that more PV systems will become a prominent player in this goal.