Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

National Survey Report of PV Power Applications in Thailand
2014

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Prepared by

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-Thailand PV Status Report Committee 2014-2015

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Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Co-operation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its member countries

The IEA Photovoltaic Power Systems Programme (IEA-PVPS) is one of the collaborative R & D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

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

The overall programme is headed by an Executive Committee composed of one representative from each participating country or organization, while the management of individual Tasks (research projects / activity areas) is the responsibility of Operating Agents. Information about the active and completed tasks can be found on the IEA-PVPS website www.iea-pvps.org

Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. An important deliverable of Task 1 is the annual "*Trends in photovoltaic applications*" report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the country National Survey Report for the year 2014. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

The PVPS website www.iea-pvps.org also plays an important role in disseminating information arising from the programme, including national information.

1 INSTALLATION DATA

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries. Other applications such as small mobile devices are not considered in this report.

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

1.1 Applications for Photovoltaics

The applications of photovoltaic in Thailand have started more than 30 years ago in the rural areas. There were PV water pumping, PV for electricity supply to rural schools, PV hybrid systems for the operation in national forests and parks and wild life sanctuaries, and solar home systems for households. All PV units were provided by government budgets.

Thailand started the official renewable energy plan with an incentive program since 2007, namely the 15-Year REDP (Renewable Energy Development Plan). The growth of PV power systems have continuously been increased since 2010. In 2012, the 10-Year Alternative Energy Development Plan (AEDP) was enforced and the renewable energy targets were increased.

Since 2013 the applications of PV power systems, both PV power plants and PV rooftop systems, were introduced to urban area due to the national incentive program, namely rooftop feed-in Tariff. In 2014 Annual installations of PV power plants and rooftop system were reported as 437.65 add 37.06 MW and total PV installation as 1,298.51 MW, respectively.

The commissioning operating date (COD) of the 1st phase of PV rooftop systems to be qualified for the FiT incentive program was extended to the end of June 2015. The 2nd phase began in February 2015, with 6.85 THB/kWh for Residential system (<10 kWp) only, and must be commissioned by the end of December 2015.

1.2 Total photovoltaic power installed

The publicly available data of installed PV systems in Thailand are provided by three power utilities: EGAT, PEA, and MEA, and the office of Energy Regulatory Commission (ERC). The online data hosted by the ERC, have been collected from the three utilities.

Note: There are two electricity distribution utilities namely, Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA), with the service territories in Bangkok metropolitan area and the rest of the country, respectively. The power generation and transmission services are provided by the Electricity Generating Authority of Thailand (EGAT).

Table 1: PV power installed during calendar year 2014

AC			MW installed in 2014 (mandatory)	MW installed in 2014 (optional)	AC or DC
Grid-connected	BAPV	Residential		2.10	
		Commercial		4.25	
		Industrial		30.71	
	BIPV (if a specific legislation exists)	Residential		-	
		Commercial		-	
		Industrial		-	
	Ground-mounted	cSi and TF		437.65	
		CPV		-	
Off-grid		Residential		*	
		Other		*	
		Hybrid systems		*	
		Total	474.71		DC

*Remark: * The amount of off-grid of PV system installation capacity is 29.15 MW in 2014; the exacted kW of installation during 2014 is not available.*

Table 2: Data collection process:

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	n/a
Is the collection process done by an official body or a private company/Association?	The collection process was done by an official body.
Link to official statistics (if this exists)	www.dede.go.th, www.erc.or.th

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

MW-GW for capacities and GWh-TWh for energy	2014 numbers	2013 numbers
Total power generation capacities (all technologies)	35,668.03 MW	33,379 MW
Total power generation capacities (renewables including hydropower)	4,494 MW	3,788 MW
Total electricity demand (= consumption)	168,656 GWh	170,100 GWh

MW-GW for capacities and GWh-TWh for energy	2014 numbers	2013 numbers
New power generation capacities installed during the year (all technologies)	1,987.03 MW	779 MW
New power generation capacities installed during the year (renewables including hydropower)	706 MW	1,001 MW
Total PV electricity production in GWh-TWh	1,928 GWh	943 GWh
Total PV electricity production as a % of total electricity consumption	1.14 %	0.55 %

Table 4: Other informations

	2014 Numbers
Number of PV systems in operation in your country (a split per market segment is interesting)	1,232.30 MW of PV power plants, 29.15 MW of off-grid systems.
Capacity of decommissioned PV systems during the year in MW	None of decommissioned PV systems during the year.
Total capacity connected to the low voltage distribution grid in MW	2.10 MW of residential and 34.96 MW of commercial/factory, it total to 37.06 MW.
Total capacity connected to the medium voltage distribution grid in MW	998.98 MW of PV power plants (< 10 MW of installed capacity).
Total capacity connected to the high voltage transmission grid in MW	233.32 MW of PV power plants (> 10 MW but not exceeding 90 MW of installed capacity).

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

Sub-market	Stand-alone domestic	Stand-alone non-domestic	Grid-connected distributed	Grid-connected centralized	TOTAL (MW)
2002	n/a	2.57	n/a	0.32	2.89
2003	n/a	3.13	n/a	1.10	4.22
2004	n/a	9.07	n/a	1.76	10.83
2005	n/a	22.11	n/a	1.77	23.88
2006	n/a	28.66	n/a	1.86	30.52

Sub-market	Stand-alone domestic	Stand-alone non-domestic	Grid-connected distributed	Grid-connected centralized	TOTAL (MW)
2007	n/a	28.90	n/a	3.61	32.51
2008	n/a	29.34	n/a	4.06	33.39
2009	n/a	29.49	n/a	13.67	43.17
2010	n/a	29.65	n/a	19.57	49.22
2011	n/a	29.88	n/a	212.80	242.68
2012	n/a	30.19	n/a	357.38	387.57
2013	n/a	29.73	0.28	793.79	823.80
2014	n/a	29.15	37.06	1,232.30	1,298.51

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Main components of the PV systems, PV modules and inverters, are imported. The imported PV modules mostly came from Japan (both poly-Si and CIGS), Germany (mono-Si and poly-Si), China (poly-Si), and Taiwan (a-Si). The average price data were collected from PV power plant owners, local PV module manufactures and developers. In 2014, PV module price was 20-50 THB/W. This price was established on the size of installation capacity.

Table 6: Typical module prices for a number of years

Year	2011	2012	2013	2014
Standard module price(s): Typical (THB/W)	n/a	70-80	50-60	35-50
Best price (THB/W)	n/a	50-60	35-45	20-25
PV module price for concentration (if relevant)	-	-	-	-

2.2 System prices

Turnkey prices per W of PV systems at various rating are provided in Table 7. The survey of average price has been obtained from PV power plant owners, project developer, and engineering procurement and construction (EPC) contractors.

The PV system prices in 2014 depend on the system size and type of installation such as, rooftop system and ground mounting system. The PV rooftop price is in the range of 60 – 100 THB/W depending on the product gaurantee and after sale service contracts, while the PV ground mounting system is in the range of 40 – 60 THB/W, mostly depending on the warranty of the product output.

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

Category/Size	Typical applications and brief details	Current prices per W
OFF-GRID Up to 1 kW	PV system installed to provide power to a household or village, including used for a variety of industrial and agricultural applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc., that are not connected to the utility grid.	65* – 85*
OFF-GRID >1 kW		
Grid-connected Rooftop up to 10 kW (residential)	Residential is a place of household and other dwelling places, temples and other religion places of worship, including its compound. Tariff is applicable through a single Watt-hour meter.	60 – 100
Grid-connected Rooftop from 10 to 250 kW (commercial)	Commercial and industrial is a place of business, industrial, government institutions and state enterprise, as well as the foreigner entities and international organisations including its compound, as well as any hotel and other businesses providing lodging accommodation to their customers including its compound. Tariff is applicable through a single Watt-hour meter. The criteria of each schedule depend on the maximum 15-minute integrated demand.	50 – 85
Grid-connected Rooftop above 250kW (industrial)		55-75
Grid-connected Ground-mounted above 1 MW	PV system installed to supply electricity to the grid with generating capacity more than 1 MW but not exceeding 90 MW.	40 – 60
Other category existing in your country (hybrid diesel-PV, hybrid with battery…)	-	n/a

*Remark: *A main component of an off-grid PV system consists of PV module; inverter and battery, this price is more than 1 kW of capacity, only PV module and inverter including wages.*

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

Price (THB)/Wp	2013	2014
Residential PV systems < 10 kWp	90-150	75-80
Commercial and industrial		60-65
Ground-mounted	60-100	40-60

2.3 Financial Parameters and programs (leasing…)

There are two major types of PV applications, namely, PV power plants (1 – 90 MW of installed capacity) and PV rooftop systems (not more than 1 MW of installed capacity). In 2014, of all current schemes of financial support from banks, a long term soft loan with the difference conditions has widely been adopted (more detail in Thailand PV status report 2012-2013).

Table 9: PV financing scheme

Average Cost of capital per market segment	n/a
Description of a specific PV financing scheme (leasing, renting…)	n/a

2.4 Additional Country information

The total population in Thailand was 65.12 million people in 2014, an increase of 0.49 million from the year before (Source: Royal Thai Government Gazette). The energy consumption per capita is 2,589 kWh. The electricity tariff is consisted of 2 parts, base tariff and automatic tariff adjustment (Ft). The base tariff is a reflection of the cost of investment of power plants, transmission and distribution systems, including fuel and operation and maintenance (O&M) (see Table 12). The base tariffs are categorized dependent on types of customers. The Ft is an adjustment of the fuel and electricity purchasing prices reflecting the price changes of fuel. The electricity generation utility passes on this cost to distribution utilities that then pass it on to consumers. Sometimes, the expenses from government policies are integrated into the Ft. The Ft is adjusted every 4 months.

Table 11: Country information

Retail Electricity Prices for a household (range)	2.25 – 3.25 THB/kWh of average normal tariff, a progressive rate, and 2.59 – 3.54 THB/kWh of time of use tariff, averaging over peak and off peak period.
Retail Electricity Prices for a commercial company (range)	Small general service: 2.50 – 3.46 THB/kWh of average normal tariff, a progressive rate and 2.59 – 3.54 THB/kWh of time of use tariff, averaging over peak and off peak period, similar to the electricity rate for a household. There are two types of charge for medium general services, normal tariff with two-part tariff and time of use tariff. There are 175.70 – 221.50 THB/kW for average demand charge of normal tariff with two-part tariff and 1.70 – 2.68 THB/kWh for average energy charge. For time of use tariff, 74.14 – 210 THB/kW of demand charge and average energy charge on peak and off-peak are 2.72 – 3.70 and 1.20 - 2.18 THB/kWh, respectively.
Retail Electricity Prices for an industrial company (range)	Large general service: demand charge of Time of Day Tariff (on peak/partial peak) is 224.30/29.91 – 332.71/68.22 THB/kW (i.e. 1.70 – 2.68 THB/kWh). Time of use tariff rate is similar to the electricity prices for medium general service. For specific business service, there are normal tariff with two-part tariff and time of use tariff, similar to the medium general service. The rates are 220.56 – 276.64 THB/kW for energy charge and 1.70 – 2.68 THB/kWh for average energy charge.
Population at the end of 2014 (or latest known)	65,124,716

Country size (km^2)	513,120 km^2
Average PV yield (according to the current PV development in the country) in kWh/kWp	1,520 kWh/kWp (higher average PV yield due to excess installation capacity allowance up to 20% of register capacity before 2015)
Name and market share of major electric utilities.	(1) Electricity Generating Authority of Thailand (2) Provincial Electricity Authority (3) Metropolitan Electricity Authority

3 POLICY FRAMEWORK

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

3.1 Direct support policies

Table 12: PV support measures (summary table)

	On-going measures	Measures that commenced during 2014
Feed-in tariffs (gross / net?)	PV rooftop systems	Ground mounting PV systems
Capital subsidies for equipment or total cost	PV units for electricity supply to remote areas and 100% subsidized by government agencies, are introduced to rural schools, border patrol police school and community learning centers as well as national parks and national forest as the hybrid PV systems. The other PV applications are battery charging systems and solar water pumping systems.	-
Green electricity schemes	-	-
PV-specific green electricity schemes	-	-
Renewable portfolio standards (RPS)	-	-
PV requirement in RPS	-	-
Investment funds for PV	-	-

Income tax credits	-	-
Prosumers' incentives (self-consumption, net-metering, net-billing…)	-	-
Commercial bank activities e.g. green mortgages promoting PV	RE financial consultant and long term soft loan	-
Activities of electricity utility businesses	-	-
Sustainable building requirements	-	-

3.2 Direct Support measures

3.2.1 Support measures exiting in 2014

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

The updated target of PV system installation according to the 10-year Alternative Energy Development Plan (AEDP 2012-2021) is 3,000 MW as of July 2013. The 1st phase of PV rooftop systems with FiT scheme have been carried out from last year, the deadline for COD was extended to the end of June 2015. The National Energy Policy Committee (NEPC) Resolution had launched a new FiT scheme for PV power plants. The new FiT is applied for the PV power plants that had submitted the applications but not received power purchasing agreement (PPA) or namely former adder. The NEPC had suspended all new applications in June 2010 and the adder scheme for PV systems had been phased out. The 2nd phase of PV rooftop systems with new FiT rate for residential (< 10 kWp) only with the aim to achieve the 100 MWp target. In addition, the target of PV installation is expanded to 3,800 MW in 2015, due to potential of green investors and high solar irradiation source.

The FiT scheme with 25-years supporting duration for PV rooftop and ground mounting systems has been adopted with adjusted rates. The rates of PV rooftop and ground mounting systems are 6.01 – 6.85 THB/kWh and 5.66 THB/kWh, respectively. The first phase of PV rooftop has suffered from barriers related to regulations. Consequently, the deadlines of installation and commercial operation date (COD) have been postponed to the end of June 2015.

The other ground mounting PV systems with FiT are of government and agriculture cooperative programs. An 800 MW of installation capacity was changed from ground mounted units for community. The FiT is 5.66 THB/kWh for the duration of 25 years.

3.2.2 Support measures phased out in 2014

The adder or feed-in premium was the incentive scheme paid on top of normal tariff for 10 years and finished in the end of 2013. The adder program was originally rated at 8.00 THB/kWh in 2007. In 2012, the rate was reduced to 6.50 THB/kWh where the 10-year support duration remained intact. The adder was replaced by the FiT scheme for PV. It is expected that the FiT scheme will be applied to all renewable energy sources.

3.2.3 New support measures implemented in 2014

The new phase of FiT of about 1,000 MW targeted for ground mounting PV systems with 5.66 THB/kWh for 25 years was approved by NEPC in August 2014. The FiT program is a replacement

of the terminated adder program. In addition, a support program of 800 MW of ground mounting PV systems targeted for the government and agricultural cooperatives has been launched in 2014. The capacity of system is not over than 5 MW per unit. This program is a replacement of the 800 MW of community ground mounting PV system.

Table 13: New Feed-in Tariff of solar power in 2014

Type of PV system	Installed capacity (MW or kW)	FiT rated (Baht/kWh)	Capacity Factor** (%)	Supporting duration (year)
PV rooftop	Residential (≤ 10 kWp)	6.85*	14.84	25
	Small and medium general service (>10 – 250 kWp)	6.40*		
	Large general service and specific business service (>250 – 1,000 kWp)	6.01*		
Ground mounting system	≤ 90 MWp for the government and agricultural cooperatives and for former adder program	5.66	16	25

*Remark: * FiT Premium (0.5 Baht/kWh) plus normal FiT rated, only for Southern border province, and 4 districts (Jana, Thapa, Sabayoi and Natawee) in Songkla province. ** Capacity Factor or CF expresses the percentage of the total energy produced annually compare with a multiple of installed capacity and number of hours in a year. All exceeding kWh will be remunerated with a 12 months average of the wholesale electricity rate that EGAT sells to PEA plus fuel tariff surcharge average wholesale (averaged Ft).*

3.2.4 Measures currently discussed but not implemented yet

Due to a high potential of solar irradiation in Thailand, the PV sector in Thailand has experienced on continues growth. The 2nd phase of PV rooftop system incentive began early February 2015. The purpose of the program was to facilitate the 100 MW installation of residential sector under the previous PV rooftop program target of 200 MW. Then about 1,000 MW of PV power plants for former adder applicants and 800 MW of the government and agricultural cooperation will be implementing in 2015. Moreover, a new scheme for PV rooftop system, namely "QuickWin Solar", has been under consideration.

3.2.5 Financing and cost of support measures

The cost of PV incentives is paid by electricity consumers. The FiT incentive scheme for PV system has been implemented in 2013 with the target installation of 200 MW of PV rooftop systems. The adder incentive scheme paid on top of normal tariff was finished in the end of 2013. Starting from 2014, the FiT scheme has been the current incentive applied for ground mounted and rooftop PV systems.

3.3 Indirect policy issues

PV power plants in Thailand have been growing due to the national policy and market drive. At the same time, the indirect policies which influence the implementation of PV systems in 2014 are:

- The Department of industrial works (DIW) has announced an amendment of the ministerial regulation for factory operation on item 88 in the royal gazette. PV power systems with the capacity less than 1,000 kWp, installing on the rooftop, deck and integrated to the building, are not considered as the factory. In addition, PV rooftop system owners have to register to Energy Regulatory Commission (ERC) to participate in the FiT incentive scheme.

- The lesson learnt from PV power plants have been beneficial for ERC and power utilities who are directly involved the operation of PV power plants. In May 2014, the Code of Practice (COP) for PV power systems was released by ERC. The CoP for PV power systems provide recommended processes for project preparation, installation and operation as well as environmentally friendly end-of-life management.

- To promote the domestic PV industry, the Board of Investment (BOI) have announced an incentive to waive the import duty on machinery and 8 year corporate income tax with 100 % of investment cost (exclude) land and working capital).

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

R&D activities are divided into 4 groups, solar cells and related materials, PV components, PV applications and PV policy. The topics of solar cells and related materials include silicon ingot, TCO glass, thin film Si and CIGS, and organic and dye sensitizing. PV component topics focus on grid and stand-alone hybrid systems inverters. PV applications topics consist of PV power systems evaluation, PV hybrid systems and techno socio-economic management of PV systems in rural areas. Recent research efforts on PV policy have provided the Thailand solar PV roadmap initiative.

The research activities were carried out by the private sector to improve their productivity both solar cells and module production as well as PV power systems evaluation, whilst the research activities of universities and government research institutes worked towards building a knowledge base, e.g. on analyzing the performance and degradation of PV systems under tropical condition.

However, the installation of 1,300 MW of PV power plants could affect the environment in terms of electric waste. The National Research Council of Thailand has a plan on funding projects such as PV recycle and the best practise to maintenance PV power plants. These projects will be supported by EGAT and NRCT for research and development (EGAT and TRF Joint Research Fund Program). Moreover, an EGAT's PV power plant project of 5 MW capacities is under construction where RE system demonstrations and RE learning centre, a combination of renewable energy power generation from solar-wind-biogas to produce the energy, are included. PEA also has a plan to build a smart house to demonstration the smart life with RE.

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

EGAT has more than 25 years in the experience of renewable energy application and PV power generation demonstration project. In 2014, EGAT has started the renewable energy learning centre project at AmphoeThap Sakae in PrachuapKhiri Khan Province. There are 5 MW of PV systems, 250 kW of wind Turbine and 500 kW of biogas power generation from Napier grass. The budget of the project is 631.48 million THB in total. The Department of Alternative Energy Development and Efficiency (DEDE) has 13 projects of PV system in government offices in all regions throughout Thailand, consisting of ground mounted system and rooftop system to demonstrate the electricity self-production project with 379.99 million THB of total budget.

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

	R & D	Demo/Field test
National/federal	-	1,011.47 million THB
State/regional	-	-
Total	1,011.47 million THB	

5 INDUSTRY

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

Thailand has plenty of metallurgical grade of silicon for export. Most local module manufactures import wafers and cells. No production information of feedstocks, ingots and wafers is available.

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

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

Four local manufactures of PV modules in Thailand have been established to support the national policy to make the better life for the rural people ten years ago. Later, the PV installation is in the stagnant situation. Until the PV power plant growth in 2011, two new local manufacturers have been in operation. In 2013, Thailand had a total of 6 local module manufactures. Currently there are only 5 local PV module manufacturers left because Sharp Thai had broken off the production line in 2014. Moreover, two manufacturers that produce cell and module are Solartron and Ekarat Engineering. Two new module manufactures will be starting the operation in 2015.

Total PV cell and module manufacture together with the production capacity information is summarised in Table 15 as below.

Table 15: Production and production capacity information for 2014

Cell/Module manufacturer (or total national production)	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
1 Bangkok Solar	mc-Si	-	-	-	-
2 Ekarat Engineering	mc-Si	12	10	-	50
3 Full Solar	mc-Si	-	0.8	-	25
4 Solartron	mc-Si	45	55	70	70
5 Solar Power Technology	mc-Si	-	2	-	25
Total		*57*	*67.8*	*70*	*170*
Thin film manufacturers					
1 Bangkok Solar	a-Si	-	2	-	65
Total		-	*2*	-	*65*
Cells for concentration					
-	-	-	-	-	-
TOTALS		**57**	**69.8**	**70**	**235**

5.3 Manufacturers and suppliers of other components

Thailand has a local manufacture of balance of systems (BOS), namely, Leonics, also famous in Malaysia market. Since 2013 the government has announced the 200 MW targets of PV rooftop systems with FiT through 25-year support duration. In 2014, the BOS market of PV rooftop systems has been an imported market. A new comer of the local BOS manufacture is Thai Tabuchi Electric in 2014. There are 36 companies of BOS, recommended for grid connection under 200 MW of PV rooftop systems.

6 PV IN THE ECONOMY

Thailand has the production of cell and module and inverter as local manufacture. The government supports the PV applications by subsidy and incentive programs. Research activities on cell and module production were carried out by private companies to improve their productivity while the research activities and government research institutes worked toward building a knowledge base, particularly PV system applications, PV monitoring as well as the new material of cell and module.

6.1 Labour places

PV activities in Thailand are shared in renewable energy sector then the labour places are not clear to identify. Public research and development not including private companies are National Science and Technology Development Agency (NSTDA), National Research Council of Thailand (NRCT) and The Thailand Research Fund (TRF) as well as the universities. Manufacturing of products through the PV value chain from cell and module to systems including company R&D is totaled of more than 102 companies including local manufacturers, dealer, international joint venture, installer, project developer, and etc.

6.2 Business value

The estimation of the value of the PV business in Thailand is shown in table 16 using the prices of typical application in Table 7. The value of grid-connected centralized PV business is 26,259 million THB from 437.65 MW. Grid-connected distributed capacity installation in 2014 is 37 MW then its PV business is 3,145 million THB. The grid-connected PV system is the main business activity and it is worth about 29,404 million THB.

Table 16: Value of PV business

Sub-market	Capacity installed *in 2014* (MW)	Price per W *(from table 7)*	Value	Totals
Off-grid domestic	-	n/a	*n/a*	-
Off-grid non-domestic	-	n/a	*n/a*	-
Grid-connected distributed	37.06	85	*3,145 million THB*	-
Grid-connected centralized	437.65	60	*26,259 million THB*	-
				29,404 million THB

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

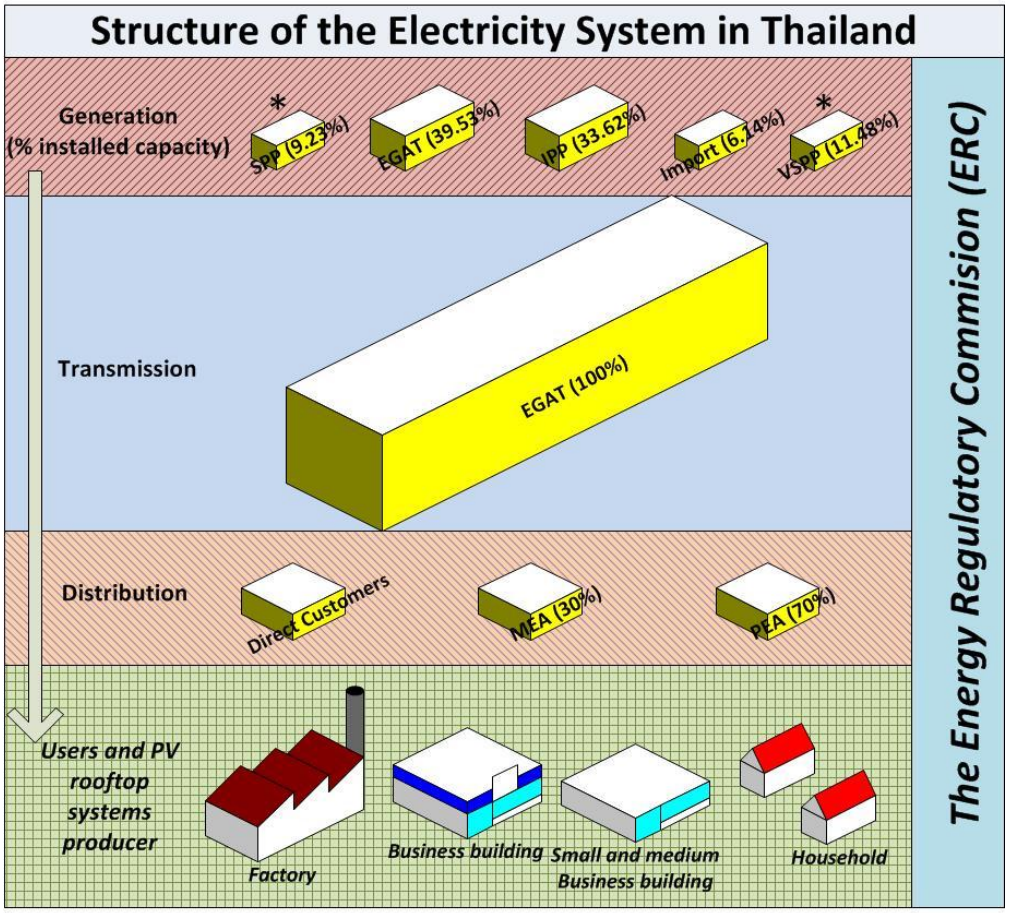
7.1 Structure of the electricity system

The electricity system in Thailand consists of electricity generation, transmission and distribution. Electricity generations include independence power producer (IPP), small power producer (SPP), very small power producer (VSPP), Electricity Generating Authority of Thailand (EGAT), as well as import from neighbouring countries. Transmission systems are undertaken by EGAT. Distribution systems are undertaken by the Metropolitan Electricity Authority (MEA) for Bangkok, Nonthaburi and Samut Prakan and the rest of the provinces by the Provincial Electricity Authority (PEA). ERC is an energy regulation commission unit of electricity system which legislate the energy regulations. In addition, EPPO and DEDE are the policy maker units of electricity system. EPPO take cares all of energy sector meanwhile DEDE take cares of all renewable energy sectors.

In addition, ERC has an obligation to monitor and promote renewable energy for the purpose of energy security of the nation. A working group consisted of experts from ERC, EGAT, MEA and PEA, has been formed within the sub-committee of electricity system generation, energy network system and system operator monitoring.

The duty of this sub-committee is to maintain and prepare regulations of the connection to energy network system, service charge of energy network system and energy network system operation. The regulations are subjected to revision to accommodate changes in energy situation both grid and distribution codes, particularly the increasing share of renewable energy in electricity system generation.

The regulation of connection of renewable energy resources to distribution grids of PEA and MEA has been drafted. Furthermore, the working group has the duty to consider a guideline to feeder management and monitoring of FiT implementation and the reversed current in the electricity system.



*Remark: * Including PV power systems and this data was provided by DEDE and EGAT, update status as of December 2014.*

7.2 Interest from electricity utility businesses

PV power plants are the key drivers in PV activities a few years ago until 2014. The development of PV activities with the lesson learnt and the improvement to reach the better way for combination of conventional and renewable energy utilization. The technical barrier is the weak of distribution network which was approved by government to build the stronger distribution network to support the renewable energy utilization in the near future. The other barriers are the regulations which concern the electricity producer, the building, country planning, environment and etc.

8 STANDARDS AND CODES

The Thai Industrial Standards Institute, TISI, has announced the TISI 1843-2553, TIS 2210-2555 and TIS 2580-2555. The following TISI's standards will be applied to PV system installation in the government projects.

- TIS 2606-2557 (IEC 61727 adopted) and TIS 2607-2557 (IEC62116 adopted) for grid connected system.
- Utilities grid code: the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA)
- TIS 2603-1:2556 (IEC62109-1 adopted) Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
- TIS 2603-2:2556 (IEC62109-2 adopted) Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters

For PV system, the recommendation of PV system installation corresponds with IEC standard, IEC60364-7-712 (TIS 2 5 7 2 -2 5 5 5). This is the same as IEC 62446: Grid connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests and inspection - under the process of TISI announcement. Moreover grid-inverters have to be certified in compliance with each utility codes and one combination of the IEC61727:2004 and IEC62116:2008 or the IEEE1547 and UL1741 or others accepted by the utility.

9 HIGHLIGHTS AND PROSPECTS

PV installation capacity has grown continually especially in the past few years until 2014. Most of the installed systems, both modules and inverters, are imported system. Local manufacturers have experienced a difficulty in their product sales. Whist PV power plant owners met the success story when the plants can operation and commercial. The PV rooftop projects met the problems both the related regulations and the technical issue to connect the PV rooftop system to the grid until the government postponing the commissioning date to June 2015.

The PV module production capacity of local manufacturers is at 235 MW and 60 MW in 2014. An increase in PV module production capacity has been planned. For example, Solartron will increase the production line to 200 MW of capacity. Bangkok Solar will open a new production line of 5 MW of crystalline silicon PV modules; Ekarat Engineering (former Ekarat Solar), FullSolar and SolarPowerTechnology plan to increase the production in 2015 to support the government PV projects.

At the end of 2014, the target of the Alternative Energy Development Plan (AEDP) was approved by the National Energy Policy Committee (NEPC) to increase from 3,000 MW to 3,800 MW in 2015. Thailand is in the process of revising the AEDP, Energy Efficiency Development Plan (EEDP) and Thailand Power Development Plan (PDP) in order to create a harmonious Thai energy blueprint. At the same time, the FiT schemes in PV projects are on-going. There are (1) 800 MW of the ground mounted PV system for government and agriculture cooperative, (2) about 1,000 MW for PV power plant (former ADDER) and (3) the 2nd phase of PV rooftop systems which is not more than 10 kWp of capacity each for the residential to achieve 100 MW of target.

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Definitions, Symbols and Abbreviations

For the purposes of this and all IEA PVPS National Survey Reports, the following definitions apply:

PV power system market: The market for all nationally installed (terrestrial) PV applications with a PV power capacity of 40 W or more.

Installed PV power: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m^2, cell junction temperature of 25°C, AM 1,5 solar spectrum – (also see 'Rated power').

Rated power: Amount of power produced by a PV module or array under STC, written as W.

PV system: Set of interconnected elements such as PV modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a PV power capacity of 40 W or more.

CPV: Concentrating PV

Hybrid system: A system combining PV generation with another generation source, such as diesel, hydro, wind.

Module manufacturer: An organisation carrying out the encapsulation in the process of the production of PV modules.

Off-grid domestic PV power system: System installed to provide power mainly to a household or village not connected to the (main) utility grid(s). Often a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'. Can also provide power to domestic and community users (plus some other applications) via a 'mini-grid', often as a hybrid with another source of power.

Off-grid non-domestic PV power system: System used for a variety of industrial and agricultural applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc. that are not connected to the utility grid. Usually a means to store electricity is used. Also referred to as 'stand-alone PV power system'.

Grid-connected distributed PV power system: System installed to provide power to a grid-connected customer or directly to the electricity grid (specifically where that part of the electricity grid is configured to supply power to a number of customers rather than to provide a bulk transport function). Such systems may be on or integrated into the customer's premises often on the demand side of the electricity meter, on public and commercial buildings, or simply in the built environment on motorway sound barriers etc. They may be specifically designed for support of the utility distribution grid. Size is not a determining feature – while a 1 MW PV system on a rooftop may be large by PV standards, this is not the case for other forms of distributed generation.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station. The power supplied by such a system is not associated with a particular electricity customer, and the system is not located to specifically perform functions on the electricity grid other than the supply of bulk power. Typically ground mounted and functioning independently of any nearby development.

Turnkey price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid PV system, the prices associated

with storage battery maintenance/replacement are excluded. If additional costs are incurred for reasons not directly related to the PV system, these should be excluded. (E.g. If extra costs are incurred fitting PV modules to a factory roof because special precautions are required to avoid disrupting production, these extra costs should not be included. Equally the additional transport costs of installing a telecommunication system in a remote area are excluded).

Field Test Programme: A programme to test the performance of PV systems/components in real conditions.

Demonstration Programme: A programme to demonstrate the operation of PV systems and their application to potential users/owners.

Market deployment initiative: Initiatives to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives etc. These may be implemented by government, the finance industry, electricity utility businesses etc.

Final annual yield: Total PV energy delivered to the load during the year per kWp of power installed.

Performance ratio: Ratio of the final annual (monthly, daily) yield to the reference annual (monthly, daily) yield, where the reference annual (monthly, daily) yield is the theoretical annual (monthly, daily) available energy per kWp of installed PV power.

Currency: The currency unit used throughout this report is 32.62 THB/US dollars

PV support measures:

Feed-in tariff	an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh that may be higher or lower than the retail electricity rates being paid by the customer
Capital subsidies	direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed PV system cost
Green electricity schemes	allows customers to purchase green electricity based on renewable energy from the electricity utility business, usually at a premium price
PV-specific green electricity schemes	allows customers to purchase green electricity based on PV electricity from the electricity utility business, usually at a premium price
Renewable portfolio standards (RPS)	a mandated requirement that the electricity utility business (often the electricity retailer) source a portion of their electricity supplies from renewable energies
PV requirement in RPS	a mandated requirement that a portion of the RPS be met by PV electricity supplies (often called a set-aside)
Investment funds for PV	share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends
Income tax credits	allows some or all expenses associated with PV

	installation to be deducted from taxable income streams
Compensation schemes (self-consumption, net-metering, net-billing…)	These schemes allow consumers to reduce their electricity bill thanks to PV production valuation. The schemes must be detailed in order to better understand if we are facing self-consumption schemes (electricity consumed in real-time is not accounted and not invoiced) or net-billing schemes (the electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity account is reconciled over a billing cycle). The compensation for both the electricity self-consumed and injected into the grid should be detailed. Net-metering schemes are specific since they allows PV customers to incur a zero charge when their electricity consumption is exactly balanced by their PV generation, while being charged the applicable retail tariff when their consumption exceeds generation and receiving some remuneration for excess electricity exported to the grid
Commercial bank activities	includes activities such as preferential home mortgage terms for houses including PV systems and preferential green loans for the installation of PV systems
Activities of electricity utility businesses	includes 'green power' schemes allowing customers to purchase green electricity, operation of large-scale (utility-scale) PV plants, various PV ownership and financing options with select customers and PV electricity power purchase models
Sustainable building requirements	includes requirements on new building developments (residential and commercial) and also in some cases on properties for sale, where the PV may be included as one option for reducing the building's energy foot print or may be specifically mandated as an inclusion in the building development