Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

National Survey Report of PV Power Applications in Thailand

2015

Energy Absolute Public Company Limited

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Prepared by

-Bureau of Solar Energy Development, Department of Alternative Energy Development and Efficiency (DEDE),Ministry of Energy

-Thailand PV Status Report Committee 2014-2015

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Foreword

The International Energy Agency (IEA), was found in November 1974, it is an independent association within the framework of The Organisation for Economic Cooperation and Development (OECD), which carries out a comprehensive programme of energy cooperation among the member countries.

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

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

The programme is monitored by a group of Executive Committee composed of one representative from each participating country or organization. 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

1 INSTALLATION DATA

Thailand has a high growing rate interest in solar power, setting its goal toward The Alternative Energy Development Plan 2015-2036 MW (AEDP2015). The plan aims to increase the use of solar energy with installation capacity of 6,000 MW by 2036.

The initial phase of the grid-connected FiT promotion that measures both ground-mounted and rooftop installation has started this year. As well as, projects under FiT scheme have begun its operation paralleling to the initial phase.

After the second phase of residential-PV rooftop project had been announced last year, the Ministry of Industry made a declaration that rooftop installation do not require to apply for a factory license. However, the PV system installers have to follow the Code of Practice (COP) that issued by ERC.

1.1 Applications for Photovoltaic

Previously, Thailand has experienced a rapid growth in the photovoltaic system in the past 20 years of solar PV usage. In the early stage, the off-grid power supplies in rural area were more focused. Since 2010, the demand for PV installations has escalated due to the decline of manufacturing costs of the PV system and the introduction of incentive program for power generation from renewable energy. The number of commercial solar farms and the popularity of rooftop systems have also been promptly increased. In 2015, solar PV power plant installations had the biggest market, follow by grid-connected rooftop systems and then the off-grid systems.

1.2 Total photovoltaic power installed

In 2015, the accumulated installed capacity of solar power was 1,419.58 MWp, which was the summation of 1,389.55 MWp from grid connected systems and 30.03 MWp from off-grid systems. The grid connected applications consist of power plants and the FiT rooftop systems promoted under a 200 MWp FiT PV rooftop program. Annual installation for 2015 was 121 MWp. The evolution of cumulative and annual installation PV capacities from 2002-2015 is shown in Figure 1

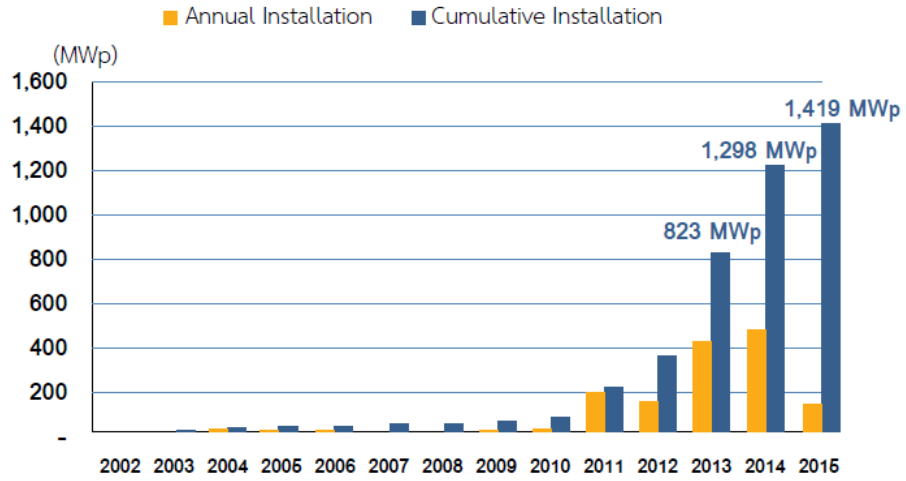


Fig. 1: Cumulative and annual PV systems installation in Thailand until 2015

Table 1: PV power installed during 2015

AC			MW installed in 2015 (mandatory)	MW installed in 2015 (optional but HIGHLY NEEDED)	AC or DC
Grid-connected	BAPV	Residential	-	**n/a**	
		Commercial		-	
		Industrial		-	
	BIPV (if a specific legislation exists)	Residential	-	-	
		Commercial		-	
		Industrial		-	
	Ground-mounted (Rooftop included)	cSi and TF	-	**120.78**	DC
		CPV		-	
Off-grid		Residential		n/a	
		Other*		0.3	DC
		Hybrid systems		n/a	
		Total	**121.08**		**DC**

Note *Other: Off-grid installation for remote area only*

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 MEA, PEA and EGAT. Then it was submitted to ERC for compilation. DEDE collected the data from the above agencies and produced a yearly electricity statistic report.
Link to official statistics (if this exists)	http://www.erc.or.th,www.dede.go.th

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

MW-GW for capacities and GWh-TWh for energy	2015 numbers	2014 numbers
Total power generation capacities (all technologies)	45,115.908 MW	38,906.625 MW
Total power generation capacities (renewables including hydropower)	7,962.79 MW	4,494.03 MW
Total electricity demand (= consumption)	174,833 GWh	168,685 GWh
New power generation capacities installed during the year (all technologies)	6,209.283 MW	1,987.03 MW
New power generation capacities installed during the year (renewables including hydropower)	3,468.76 MW	706 MW
Total PV electricity production in GWh-TWh	2,375.83 GWh	1,928 GWh
Total PV electricity production as a % of total electricity consumption	1.36%	1.14%

Table 4: Other information

	2015 Numbers
Number of PV systems in operation in your country (a split per market segment is interesting)	1,389.55 MWp on-Grid (PV power Plant, PV Rooftop and CSP) 30.03 MWp off Grid
Capacity of decommissioned PV systems during the year in MW	No decommissioned PV system
Total capacity connected to the Low and medium voltage distribution grid in MW	988 MWp of PV power plants (< 10 MWp of installed capacity)
Total capacity connected to the high voltage transmission grid in MW	401 MWp of PV power plants (> 10 MWp but not exceeding 90 MWp 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
2005*	-	22.11	-	1.46
2006	-	6.55	-	0.09
2007	-	0.24	-	1.74
2008	-	0.44	-	0.45
2009	-	0.15	-	9.62
2010	-	0.16	-	5.89
2011	-	0.23	-	193.23
2012	-	0.31	-	144.89
2013	-	-0.46**	-	436.69
2014	-	0	-	474.71
2015	-	0.3	-	120.78
TOTAL (MW)		30.03		1,419.58

Note: **Accumulate Data*

***Some of off grid systems were decommissioned*

2 COMPETITIVENESS OF PV ELECTRICITY

A survey has been conducted to assure that the average prices (module and system prices) have been obtained. The contributors were PV power plant owners, project developers, and engineering procurement & construction (EPC) contractors.

2.1 Module prices

The main components of the PV systems; PV modules and inverters are mostly imported from China (poly-Si), Germany (mono-Si and poly-Si), Japan (both poly-Si and CIGS) and Taiwan (a-Si). The prices of the PV module are based on the size of installation capacity, which is 20-30 THB/W.

Table 6: Module prices from 2011-2015

Year	2011	2012	2013	2014	2015
Standard module crystalline silicon price(s): Typical (THB/W)	n/a	70-80	50-60	35-50	25-40
Best price (THB/W)	n/a	50-60	35-45	20-25	

2.2 System prices

Turnkey prices per watt of PV systems at various categories are provided in Table 7. The PV system prices depend on the system size and type of installation, such as the rooftop system and the ground mounting system. In 2015, the PV rooftop price was in the range of 60 – 75 THB/W depending on the product's guarantee and after sale service contracts. However, the PV ground mounting system was in the range of 41-54 THB/W, mostly leaning on the warranty of the equipment or systems.

Table 7: **Turnkey Prices of Typical Applications – local currency (Thai Baht)**

Category/Size	Typical applications	Current prices per W
OFF-GRID Up to 1 kW	The stand-alone PV system installation with battery for providing power to individual households, school, health clinics and royal projects in the remote non-electrified areas. The power is used for lighting, telecommunication and water pumping etc. These systems are fully supported by Government in order to increase the opportunity and quality of rural communities.	195* – 210*
OFF-GRID >1 kW		
Grid-connected Rooftop up to 10 kW (residential)	PV system installation on the roof of households, dwelling places and religion places.	60 – 75
Grid-connected Rooftop from 10 to 250 kW	PV system installation with the range of 10-250 kWp and > 250-1,000 kW for businesses, industrials, government institutions, state enterprises, foreigner entities, international organisations and hotels.	50-55
Grid-connected Rooftop above 250kW		
Grid-connected Ground-mounted above 1 MW	PV system installed to supply electricity to the grid with generating capacity more than 1 MWp but not exceeding 90 MWp.	41-54
Other category existing in your country (hybrid diesel-PV, hybrid with battery…)	Hybrid systems, commonly used in remote areas, include PV-wind-diesel generators and PV- micro hydro - diesel generators.	n/a

Note: **The main components of the off-grid PV system consist of PV module, inverter, battery and wages. This price is for more than 1 kWp of installed capacity.*

Table 8: National trends in the current system prices for different applications in Thai currency (Baht)

Price (THB)/Wp	2013	2014	2015
Residential PV systems < 10 kWp	90-150	65-100	60-75
Commercial and industrial		60-65	50-55
Ground-mounted	60-100	40-60	41-54

2.3 Cost breakdown of PV installations

The cost breakdown of PV installations in 2015 is presented in tables 9.

Residential PV System < 10 kW:

Table 9: Cost breakdown for a residential PV system – local currency (Thai Baht)

Cost category	Average (THB/W)	Low (THB/W)	High (THB/W)
Hardware			
Module	27.5	25	30
Inverter	12	10	14
Other (racking, wiring etc.)	11	10	12
Soft costs			
Installation	11	10	12
Customer Acquisition			
Profit	4	3	5
Other (permitting, contracting, financing etc.)	2	2	2
Subtotal Hardware	50.5	45	56
Subtotal Soft costs	17	15	19
Total	67.5	60	75

Utility-scale PV systems > 1 MW:

Table 10: Cost breakdown for the utility-scale PV system – local currency

Cost Category	Average (THB/W)	Low (THB/W)	High (THB/W)
Hardware			
Module	22	20	25
Inverter	5	4	6
Other (racking, wiring, etc.)	5	4	6
Soft cost			
Installation Labour	9	8	10
Customer acquisition			
Profit	4	3	5
Others (contracting, permitting, financing etc.	2	2	2
Subtotal Hardware	32	28	37
Subtotal - Soft cost	15	13	17
Total Installed Cost	47	41	54

2.4 Financial Parameters and specific financing programs

There are two major types of PV applications, ground-mounted PV power plant (Up to 90 MWp of installed capacity) and PV rooftop system (not more than 1MWp of installed capacity). Currently, the financial supports are from banks and long-term soft loan with difference conditions apply.

Moreover, DEDE has allocated 500 million baht from Energy Conservation Promotion Fund (ENCON Fund), in the fiscal year of 2015 (from April 2015 to March 2017), in order to top up "ESCO Revolving Fund". The aim is to encourage private investors in renewable energy and energy efficiency projects to invest furthermore on solar PV. The Energy for Environment Foundation and The Energy Conservation Center of Thailand are the fund manager of the project.

Table 11: PV financing scheme "ESCO Revolving Fund"

Average rate of loans– residential installations	N/A
Average rate of loans – commercial installations	3.5% (Flat rate)
Average cost of capital – industrial and ground-mounted installations	<50 MB

2.5 Specific investments programs

None

2.6 Additional Country information

The total population in Thailand was 65.73 million people in 2015, an increase of 0.6 million from the previous year. The electricity tariff consists of 2 parts, base tariff and automatic tariff adjustment (Ft). The base tariff is a reflection on the cost of investment in power plants, transmission and distribution systems (including fuel, operation and maintenance (O&M)) (see Table 12). The base tariffs are categorized depending on customers' category. The Ft is adjusted every four months based on the adjustment of the fuel price, power purchasing price and government policy such as renewable energy incentive. The electricity generation utility passes on the cost to the distribution utilities, which later pass the burden to the consumers.

Table 12: Country information

Retail Electricity Prices for a household (range)

RESIDENTIAL SERVICE
APPLICABILITY
This schedule of tariff is applicable to household and other dwelling places, temples and other religion places, including its compound, through a single Watt-hour meter.

RESIDENTIAL SERVICE

- Normal rate

Unit (kWh/month)	Energy charge (THB/kWh)	Monthly service fee (THB/month)
consumption ≤150	2.3488-4.4217 (a progressive rate)	8.19
consumption >150	3.2484-4.4217 (a progressive rate)	38.22

-Time of use rate

Voltage Level	Energy charge (THB/kWh)		Monthly service fee (THB/month)
	On Peak	Off Peak	
12-24 kV	5.1135	2.6037	312.24
<12 kV	5.7982	2.6369	38.22

Retail Electricity Prices for a commercial company (range)

Small General Service

APPLICABILITY

This schedule of tariff is applicable for business enterprise, residence, industrial, government institutions and state enterprise etc. Including its compound, with a maximum of 15-minute integrated demand of less than 30 kilowatt through a single Watt-hour meter.

Small General Service

- Normal rate

Voltage Level	Energy charge (THB/kWh)	Monthly service fee (THB/month)
12-24 kV	3.9086	312.24
<12 kV	3.2484-4.4217 (a progressive rate)	46.16

-Time of use rate

Voltage Level	Energy charge (THB/kWh)		Monthly service fee (THB/month)
	On Peak	Off Peak	
12-24 kV	5.1135	2.6037	312.24
<12 kV	5.7982	2.6369	46.16

Medium General Service

This schedule of tariff is applicable for business, industrial, government institutions and state enterprise. As well as foreigner entities and international organisations including its compound, with a maximum of 15-minute integrated demand from 30 to 999 kilowatts.Which the average energy consumption for three (3) consecutive months through a single Watt-hour meter not exceeding 250,000 kWh per month.

Medium General Service

- Normal rate

Voltage Level	Demand charge (THB/kW)	Energy charge (THB/kWh)	Monthly service fee (THB/month)
> 69 kV	175.70	3.1355	312.24
12-24 kV	196.26	3.1729	312.24
<12 kV	221.50	3.2009	312.24

-Time of use rate

Voltage Level	Demand charge (THB/kW)	Energy charge (THB/kWh)		Monthly service fee (THB/month)
		On Peak	Off Peak	
> 69 kV	74.14	4.1283	2.6107	312.24
12-24kV	132.93	4.2097	2.6295	312.24
<12 kV	210.00	4.3555	2.6627	312.24

Retail Electricity Prices for an industrial company (range)

Large General Service

This schedule of tariff is applicable for business, industrial, government institutions, state enterprise, foreign entities and international organisations including its compound, with a maximum of 15-minute integrated demand over1,000 kilowatt, or the energy consumption for three (3) average consecutive months

Large General Service

- Time of day Rate

Voltage Level	Demand charge (THB/kW)		Energy charge (THB/kWh)	Monthly service fee (THB/month)
	On Peak	Partial Peak		
> 69 kV	224.30	29.91	3.1355	312.24
22-33 kV	285.05	58.88	3.1729	312.24
<22 kV	332.71	68.22	3.2009	312.24

<table>
<tr><td>through a single Watt-hour meter exceeds 250,000 kWh per month.</td><td>-Time of use rate
<table>
<tr><th rowspan="2">Voltage Level</th><th rowspan="2">Demand charge (THB/kW)</th><th colspan="2">Energy charge (THB/kWh)</th><th rowspan="2">Monthly service fee (THB/month)</th></tr>
<tr><th>On Peak</th><th>Off Peak</th></tr>
<tr><td>> 69 kV</td><td>74.14</td><td>4.1283</td><td>2.6107</td><td>312.24</td></tr>
<tr><td>12-24kV</td><td>132.93</td><td>4.2097</td><td>2.6295</td><td>312.24</td></tr>
<tr><td><12 kV</td><td>210.00</td><td>4.3555</td><td>2.6627</td><td>312.24</td></tr>
</table></td></tr>
<tr><td>Population at the end of 2014 (or latest known)</td><td>65,729,098people</td></tr>
<tr><td>Country size (km^2)</td><td>513,120 km^2</td></tr>
<tr><td>Average PV yield (according to the current PV development in the country) in kWh/kWp</td><td>1,673 kWh/kWp
(higher average PV yield due to excess installed capacity allowance up to 20% of register capacity for certain projects before 2015)</td></tr>
<tr><td>Name and market share of major electric utilities.</td><td>(1) Electricity Generating Authority of Thailand
(2) Provincial Electricity Authority
(3) Metropolitan Electricity Authority</td></tr>
</table>

Note: 1) Time of Use Peak Time 09.00-22.00 (Mon-Fri)
Off Peak 22.00-09.00 (Mon-Fri),
00.00-24.00 (Sat-Sun, National Labour Day and public holiday)
2) Time of Day Rate Peak Time 18.30-21.30 (Everyday)
Partial 08.00-18.30 (Everyday: only the amount of demand that is in excess of the On-Peak)
Off Peak 21.30-08.00 (Everyday)

3 POLICY FRAMEWORK

The aim of this chapter is to describe the direct and indirect support on policies for developing the PV project implementations. The latest Alternative Energy Development Plan 2015-2036 (AEDP 2015), proposed by the Department of Alternative Energy Development and Efficiency (DEDE) was approved by the National Energy Policy Council (NEPC) on 17 September 2014. The target is set to 30% share of renewable energy (RE) in total final energy consumption by 2036. Under the AEDP plan, total installed generation capacity from renewable energy (including large hydropower) is 19,635 MW by 2036. Within the next 20 years, Thailand aims to reach 6,000 MW of total installed solar PV capacity which is nearly double from the target set in the previous plan.

3.1 Direct support policies for PV installations

3.1.1 New, existing or phased out measures in 2015

3.1.1.1 Description of support measures excluding BIPV, and rural electrification

This year, three FiT rates have been announced in three different programs. The first program is the 2nd phase of PV rooftop, the program aims to fill up the total target of 100 MW. The second program is the FiT of 5.66 THB/kWh of 800 MW PV ground-mounting

(under 5 MW each) for The Governmental Agency and Agricultural Cooperatives Program. In 800 MW PV ground-mounting program, it has been divided into 2 phases due to the grid availability. The first phase is 600 MW and the second phase is soon to be announced after the committee meeting. The last program is the PV ground-mounted power plant program under 90 MW, applied for application submitted under the old Adder scheme and halted in 2010. All of these applicants must accept the new FiT rate of 5.66 THB/kWh for 25 years instead of the old Adder rate and must be COD by the end of 2015. It is expected that nearly 1,000 MW will be COD under this latest program.

3.1.1.2 BIPV development measures

The BIPV has not yet occurred visibly. However, in the ministerial regulations of Building Energy Code B.E.*2552* under The Energy Conservation Promotion Act B.E.2535, mentions that there is a possibility of using renewable energy in building as optional to the off-set of energy consumption in building. The solar energy is mentioned as one of the promising solution and this could be an opportunity to promote the BIPV in the future.

3.1.1.3 Rural electrification measures

DEDE has subsidized 100% of PV off-grid or stand-alone system installations in the remote areas that have no access to electricity. The focus are on rural schools, community learning centers, royal initiatives projects, health promoting hospitals, national parks and conserved national forests**.** The features of these systems are summarized below:

- For rural schools, a 3 kWp solar power generation systems were installed in 10 small size schools, which make a summation of 30 kWp.

- Increasing the existing 3 kW solar power generation systems in 5 large size rural schools by another 3 kW system, making a total capacity of 15 kWp.

- For community learning centers, 20 community learning centers were installed with PV system. Each learning center installed the capacity of 1.5 kWp each, making a total capacity of 30 kWp.

- For royal initiatives projects, the solar energy system has installed a total of 31.5 kWp in 10 sites with various applications and capacities for water pumping system, stand-alone system and solar home etc.

- For health promoting hospitals, the 3 kWp of solar power generation system was installed in 5 rural hospitals making a total capacity of 15 kWp.

- For national parks and conserved national forests, a total of 30 kWp solar power generation system were installed into 10 locations with 3 kWp installed at each site.

- For military operation bases at the border areas, the power generation was installed into 42 sites with a total capacity of 126 kWp. The solar PV system is used for lighting and communication purpose.

3.1.1.4 Support for electricity storage and demand response measures

Currently, many organizations are doing research and development in electricity energy storage. Additionally, a grant support will be provided to the smart grid pilot projects in a short term (B.E. 2560-2564). One of the primary objectives is to help to increase higher renewable electricity penetration in the electricity system, which include the PV system in the future.

Furthermore, there are supports for infrastructure investment in transmission and distribution of electricity system in the long term phase of a smart grid plan.

In addition, two demand response programs were conducted this year by ERC during the gas pipeline disruption in Myanmar. The first program was targeted at 500 MW, it was launched for three periods (10.00 am. – 12.00 pm., 14.00 – 17.00 pm. and 19.00 – 22 .00 pm.) for four days on April 2015. The second program was targeted at 100 MW, operated for 3 hours in the evening (18.30 – 21.30 pm) in July 2015 and for five days at 14 southern provinces. The compensation rate was paid at 3 Bath/kWh and 3.40 Bath/kWh for the first and second phase respectively to industrial enterprises, department stores, hotels and hyper marts.

Table 13: PV support measures (summary table)

	On-going measures residential	Measures that commenced during 2015 - residential	On-going measures Commercial + industrial	Measures that commenced during 2015 – commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2015 – ground mounted
Feed-in tariffs	Yes	Yes	-	-	Yes	Yes
Feed-in premium (Adder Program) (above market price)	Yes	-	Yes	-	Yes	-
Capital subsidies	-	-	-	-	-	-
Green certificates	-	-	-	-	-	-
Renewable portfolio standards (RPS) with/without PV requirements	-	-	-	-	-	-
Income tax credits	-	-				
Self-consumption	-		-		-	-
Net-metering	-	-	-	-	-	-
Net-billing	-	-	-	-	-	-
Commercial bank activities e.g. green mortgages promoting PV	Yes	Yes	Yes	Yes	Yes	Yes
Activities of electricity utility businesses	-	-	-	-	-	-
Sustainable building requirements	-	-	-	-	-	-
BIPV incentives	-	-	-	-	-	-
Other (Exemption of import duty for machinery by BOI)	-	-	Yes	Yes	Yes	Yes

3.2 Self-consumption measures

In 2015, the "Quick Win Program" was deliberated; it is a PV rooftop project for households, buildings and factories. The decision will be made in early 2016 to launch the pilot target of the 100 MWp during 2016-2017. The 100 MWp was allocated for the residential sector, less than 10 kW, for 20 MWp and commercial sector-more than 10 kW but less than 1,000 kW for total 80 MWp. The excess electricity to the grid will not be paid. The objectives of pilot project are to reduce peak power load during daytime and to study and monitor the impact to the utilities, electricity system and investors for certain period. The result of the pilot project will be used as recommendation for real implementation of self-consumption and/or net-metering measures for the future.

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

3.3 Tenders, auctions & similar schemes

The competitive bidding method has been employed as a selection process for FiT application instead of first-come first-serve for some renewable energy such as biomass and biogas but not yet for solar PV.

For solar photovoltaic installations, FiT rates have been offered for solar rooftop and ground-mounted projects, guaranteed for a 25-year period as shown below:

Installed Capacity	FiT Rate (year 2014-2015)	
	FiT Rate (THB/kWh)	Supporting Period (Years)
Solar Farm		
≤ 90 MWp	5.66	25
PV Rooftop (Residential)		
≤ 10 kWp	6.85	25
PV Rooftop (Business/Industrial)*		
> 10 – 250 kWp	6.40	25
> 250 – 1,000 kWp	6.01	25
Ground Mounted PV (Governmental Agency and Agricultural Cooperatives)		
≤5 MWp	5.66	25

* Only FiT rate was announced

3.4 Direct Support measures

-None-

3.5 Financing and cost of support measures

This year, 2016, there are three programs for the promotion of solar PV installation. The first scheme was applied for the solar farm under the Adder scheme which the applications had been submitted before June 2010, and the applications were halted. The project owners had to accept the FiT rate of 5.66 baht/kWh for twenty-five years instead of Adder rate of 6.50 baht/kWh for ten years. The second scheme, which is the second phase of PV rooftop program for residential installation size less than 10 kWp has been given with the FiT rate of 6.85 THB/kWh and setting the commercial operation date by the end of this year. The last program is the 1st phase of PV ground-mounted on The Governmental Agency and Agricultural Cooperatives with installed capacity not more than 5 kWp at the FiT rate 5.66 baht/kWh for twenty-five years. FiT is financed through a levy on the electricity bills (Ft rate) for all electricity consumers.

3.6 Indirect policy issues

- Taxes incentives

One of BOI's measures is to promote the improvement of production efficiency for manufacturing by upgrading technology and machinery for energy conservation, alternative energy utilization or the reduction of environmental impacts, as well as to encourage research and development and advanced engineering design involvement. The minimum capital investment requirement for each project must not be less than 1 million Baht (excluding the cost of premise and working capital). For SMEs, the minimum capital investment requirement of each project must not be less than 500,000 Baht (excluding the cost of premise and working capital). The following incentives shall be granted:

- Exemption of import duty for machinery regardless of zone.

- Three years corporate income tax exemption on the revenue of an existing project, accounting for 50 percent of the investment under this measure, excluding the cost of land and working capital.
- Corporate income tax exemption period shall start from the date of revenue derivation after promotion certificate issuance.

All applications need to be submitted by December 31, 2017, and the project implementation must be completed within three years from the date issued on the promotion certificate.

- International policies (COP21)

The Ministry of Natural Resources and Environment addressed the COP of Thailand's Nationally Appropriate Mitigation Actions (NAMAs), which is aimed at reducing the country's emissions at the range of 7 to 20 percent below business as usual (BAU) in energy and transportation sectors in 2020.

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

Presently, R&D activities in Thailand are divided into 4 groups:

1) Solar cells and related materials
2) PV components
3) PV applications
4) PV policy

The priority research topics are still the long-term monitoring and system performance evaluation. Several collaborations with the universities, research institutes and private sector are all working towards long-term monitoring of PV power plant systems such as KMUTT, SERT and NSTDA. In 2015, DEDE also had established the study of monitoring and system evaluation for PV rooftop system and the result of this study will be completed soon.

After the PV roadmap research by DEDE and ERI of CU last year, ERI has been continuing to conduct the policy research on the topic of "Business Model and Financing Structures for a Rapid Scale-up of Rooftop Solar Power System in Thailand" in 2015. The study captures the dynamics of the rooftop solar market through its in-depth review of the emerging models and financial analysis of business models. The result of this study will be able to use for the Quick Win Program soon.

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

In 2015, many research development and demonstration activities of solar power had been done by the universities, research institutes and utilities. For example:

-EGAT and MUT have been initiating a project to study the safety standard and best practice for the installation of floating PV power plants with a research budget of 5.975 million THB.

-NSTDA has focused mainly on the development of solar cell; low temperature coefficient which is suitable for using in high temperature region, wide bandgap thin film silicon solar cell, high efficiency silicon hetero-junction solar cell and perovskite solar cell, etc., with a budget of 2.6-2.9 million THB.

- SERT of NU has conducted the pilot project for solar PV water pumping together with water management system for agriculture application, which supported by DEDE with a budget of 20 million THB.

-DEDE with PTEC of NSTDA have conducted the project for solar PV rooftop installation standard which includes quality and safety for PV system installation with a budget of *7.3* million THB. The project is expected to finalize in late 2016.

-DEDE with NECTEC of NSTDA have conducted the project for testing of solar water pumping installation with high efficiency AC inverters invented locally with a budget of 3.99 million THB.

- DEDE has carried out the study on the end-of-life PV modules management from solar power projects with the budget of 3.8 million THB, in order to provide the best practice guideline to treat the end-of-life PV modules properly with less environmental impact. This study could support a sustainability of Solar Power Generation in Thailand. The project has obtained cooperation from various organizations setting up as a working group.

Furthermore, the Energy Conservation Promotion Fund (ENCON Fund) also has a budget available for investment and implementation of energy conservation and renewable energy projects for government agencies, state enterprises and private companies. In 2015, many demonstration projects were realized with ENCON Fund budgeting of more than 2,000 million THB. Examples are Campus Power Project, which can be either energy efficiency improvement such as introducing of LED and high efficiency air-conditioning etc. or power generation from PV with Building Energy Management Systems (BEMS) system. There are also projects of solar PV water filtration systems in three southern provinces where PV can play its role in the sanitary application.

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

	R & D	**Demo/Field test**
National/Federal	> 40 million THB	>2,000million THB
State/regional	-	-
Total	>2,040million THB *****	

**Note: ***_Data do not include budget from National Research Council of Thailand (NRCT), Energy Policy and Planning Office (EPPO) and Ministry of Science and Technology(MOST)._
Industry

4.3 Production of feed stocks, ingots and wafers (crystalline silicon industry)

Thailand has plenty of metallurgical grades of silicon for export. Most local module manufacturers import wafers and cell since the local production of feedstock, ingots and wafers are not available.

Table 15: Local production of silicon feedstock, ingot and wafer for the year 2015

Manufacturers	Process & Technology	Total Production	Product destination (if known)	Price (if known)
G.S. Energy	Metallurgical grade	45,000 tonnes/year	N/A	N/A
Siga New Materials	Metallurgical grade	30,000 tonnes/year	N/A	N/A

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

Local module manufacturers have established in Thailand for more than 10 years, in anticipation of government support for comprehensive solar home systems in the rural area. Unfortunately, this initiative stagnated until power plants became popular in 2011. Local manufacturers still have difficulties to be price competitive with imported products due to its smaller production scale.

In 2015, Thailand had 12 module manufacturers, many of them are the investors from China and Taiwan where most of their productions are exported. Total PV cell and module manufacturers with the production capacity are summarized in Table 16.

Table 16: PV cell, module production and production capacity in the year of 2015

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 Ekarat Engineering PCL	mc-Si,sc-Si	15	20	24	60
2 Full Solar	mc-Si	-	2	-	25
3 Solartron	mc-Si	100	80	200	200
4 Solar Power Technology	mc-Si	-	2	-	25
5 Gintech	mc-Si	n/a	n/a	-	1,000
6 G.K.	mc-Si	-	84	-	84
7 Jetion Solar	mc-Si			-	250
8 Schutten Solar	mc-Si	n/a		-	500
9 Sunpower Solar	mc-Si	n/a	n/a	n/a	800
10 Trina Solar	mc-Si	700	500	700	500
11 Yingli Solar	mc-Si	n/a	n/a	n/a	500
Total		*815*	*688*	*924*	*3,944*
Thin film manufacturers					

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
1 Bangkok Solar	a-Si	-	2	-	65
Total		-	*2*	-	*65*
Cells for concentration					
-	-	-	-	-	-
TOTALS		815	690	924	4,009

Note: *Data provided by local manufacturers and BOI*

4.5 Manufacturers and suppliers of other components

Since Thai government had an announcement of the 200 MWp target for rooftop systems in 2013, providing FiT incentives for up to 25 years, it was given a considerable boost to the market for BOS. There are currently around 35-40 companies which have so far entered the Thai market.

Thailand also has local companies related to the balance of systems (BOS). The majority are acting as the distributors for grid connected inverters. There are two local companies that manufacture inverters; Leonics and Thai Tabuchi Electric. Leonics is well known for an off-grid system in South East Asia market from the size of solar home to 5 MW micro-grid system. Thai Tabuchi Electric has just started manufacturing BOS in 2014.

5 PV IN THE ECONOMY

In 2015, Thailand's PV market is still active and the market expansion continues mainly by supporting policy especially Adder and FiT measures and additional on BOI support. Moreover, the Thai government has an ambitious vision to increase self-production and efficient use of energy for public buildings. All supporting policies create business opportunities which are not only attractive for international investment but for local investment as well. This year is one of the most remarkable years for investments in manufacturing of PV cell in additional to PV module plant. For off-grid use, owing to severe drought, solar pumping has become one of the most attractive solutions installed with or without government support.

5.1 Labour places

Labour places have been increasing but seem to be temporary due to the PV ground-mounted power plant with FiT scheme program which COD was scheduled for the end of 2015. A new trend has been observed for research and development not directly on PV research but for the use of PV as part of smart grid especially in energy management.

a) With the government support for energy efficiency and the release of Smart Grid Master Plan, the use of PV as part of these topics has become more important. Several universities have shown interest to conduct research on smart building with PV installation as part of power generation.

b) Information from the database of the Department of Industrial Works, there are 2,506 job creations for solar power business. Solar PV manufacturing and module assembly employ 696 jobs. The rest is employed in solar PV plant.

c) The 5 MWp ground-mounted PV under the governmental agency and agricultural cooperative program help created new companies set up specifically to join the program as project

supporting developers. This program had announced its first phase of 600 MWp this year, but final selection and SCOD will be in 2016

d) For R&D, mentioned in the previous section, the majority of the projects have been working on how to use PV efficiently in combination with the power from the grid. There was no vibrant information on job creation for R&D in manpower and time spending on PV related activities.

5.2 Business value

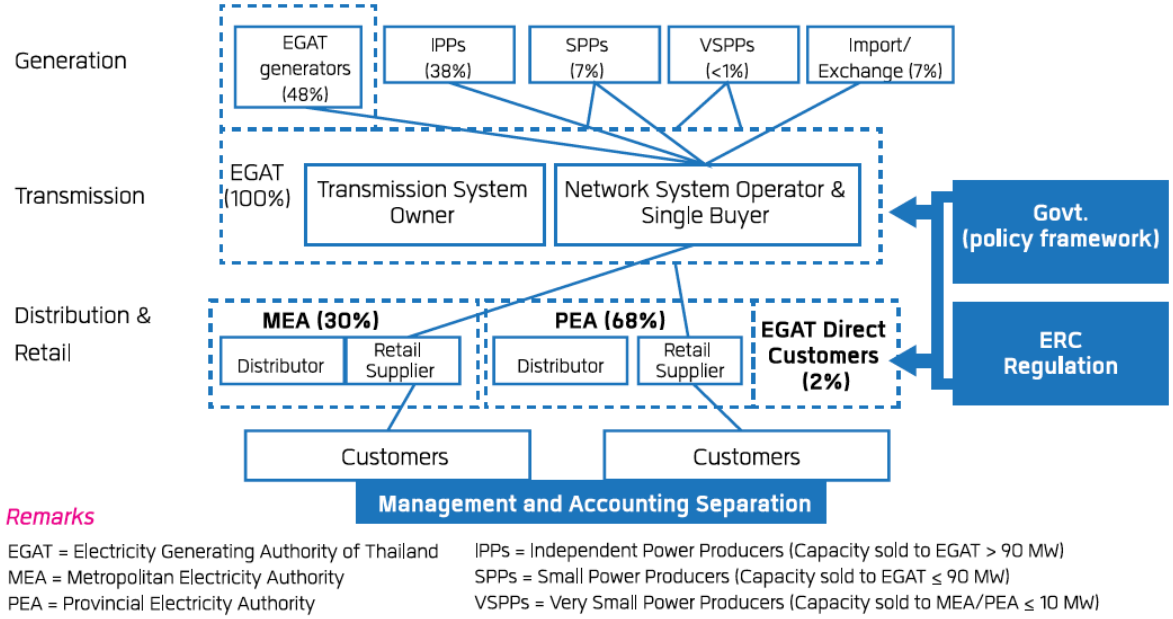
The PV ground-mounted power plant with FiT scheme program has contributed a tremendous business value especially for the project developers and project owners listed in Thailand's stock market. Moreover, the price of the land in the area where the grid is available has increased constantly. Even though, the detail of the property price is confidential for each developer. An estimate of the value of PV business in Thailand is shown in Table 17.

Table 17: Value of PV business

Sub-market	**Capacity installed *in 2015*(MW)**	**Price per W** *(from table 7)*	**Value**	**Totals**
Off-grid domestic				
Off-grid non-domestic	0.30	195-210	58.5-63.0 *Million*	
Grid-connected distributed	120	41-54	4,920-6,480 *Million*	
Grid-connected centralized	*N/A*	*N/A*	N/A	
				4,978.5-6,543*Million*
Export of PV products				*N/A*
Change in stocks held				*N/A*
Import of PV products				*N/A*
Value of PV business				4,978.5-6,543*Million*

6 INTEREST FROM ELECTRICITY STAKEHOLDERS

6.1 Structure of the electricity system



Thailand's electricity industry is a single buyer market and regulated by the government. There are three main states owned companies in the electricity sector. EGAT is responsible for generation, dispatching and transmission, while PEA and MEA are the two distributors in provincial and metropolitan areas respectively.

Power generation composes of 5 different types: power plants owned by EGAT, IPP-independent power producer with capacity more than 90 MW, SPP-small power producer with capacity more than 10 MW but less than MW, VSPP-very small power producer with a capacity less than 10 MW, and the power imported from neighbouring country.

The utilities' policies are regulated by ERC and are under supervision of NEPC including power quality monitoring.

6.2 Interest from electricity utility businesses

PEA is a distributor for the provincial areas, has shown several interests on PV development through the PEA ENCOM International, its first subsidiary company with focuses business in renewable and energy saving activities. PEA ENCOM has 5-year Renewable Energy Investment Plan (2011-2015) for solar power specifically around 204 MW. MEA is also interested in PV as part of its energy efficiency activities and has the plan for EV development.

EGAT as a generating utility has the plan to install PV Power plant of total 162.25 MW from 2015-2036, which includes ground-mounted solar PV plants and floating PV power plant in their dams.

6.3 Interest from municipalities and local governments

In Thailand, municipalities and local governments have less participation for PV market except for energy efficiency. A few local administrative organisations have shown interest in PV power

generations since they are unable to do the power service business to local customers as the primary duty to generate and sell electricity to customers are contained within the utilities only.

7 HIGHLIGHTS AND PROSPECTS

In 2015, the latest AEDP2015 was to support the alternative energy development which had been approved by The National Energy Policy Committee (NEPC). The 30% share of renewable energy in the total final energy consumption, for power generation, heat and biofuel production, had been set for the next 20 years or by 2036. The target set for solar energy was also raised to 6,000 MWp at the end of the plan in 2036. Under AEDP2015, power generated by renewable energy will base on power grid capacity and the merit order policy. The RE merit order will be (1) municipal and industrial solid waste, (2) biomass and biogas, (3) small hydropower, and (4) solar and wind. Solar PV power generation will be promoted once its LCOE price is competitive with electricity generated by imported LNG.

For PV market growth, its expansion especially for large scale PV power plant is continued thank to supporting policy. This year, new supporting policies for PV installations have been announced. One is 800 MWp the PV ground mounting of governmental agencies and Agricultural Cooperatives program separated to two phases; 300 MWp and 500 MWp. Another is the 2nd phase of household PV rooftop to reach the target of 100 MWp. In addition, the continuing policy of last year, the PV ground-mounted power plant with FiT scheme program which applied for application before 2010 under Adder scheme changed to FiT scheme play very important role to stimulate the PV installation as the SCOD was set for the end of the year.

For PV rooftop, at the beginning of the year, National Reform Committee has approved the policy to support the widespread installation of PV rooftop (or so called “Quick Win Solar”) with a very ambitious target in 20 years (2035) around 10,000 MWp for households, commercial buildings and factories. The proper implementation plan for the PV rooftop promotion is under consideration.

PV off-grid market has expanded its application from providing electricity for lighting and various activities for non-electrified rural communities to providing water pumping for the agriculture. The PV system for ground-water pumping together with the water management system was introduced for drought relief. In 2016, the widespread implementation of solar PV for water pumping for agricultural purpose will be done by the Government budget.

For next coming year, the 2nd phase of Solar PV for Government Agency and Agricultural cooperative has been planned to be implemented while the 1st phase will be started selling electricity to the grid by the end of 2016. For PV rooftop, the pilot project for liberalisation of PV rooftop was programmed to launch in mid of 2016. ERC is developing new regulation related to the grid-connected inverter for low voltage connection for the area of MEA. The regulation will consist of product standard, testing and certification. This regulation is an updated version of the actual grid code for a better support and increases in renewable energy connection to the grid, especially for solar PV.

Moreover, due to the Prime Minister intention to promote and support the efficient use of energy as well as the renewable energy for all governmental agencies together with the approval of smart grid master plan, more interest on the governmental agencies, universities, and research institutes for PV installations as part of the energy efficiency and energy management will be more observed in the future.

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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 some 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 is 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 functioned 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	allow customers to purchase green electricity based on renewable energy from the electricity utility business, usually at a premium price
PV-specific green electricity schemes	allow 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 is 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	allow 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	include 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	include '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	include 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