IEA INTERNATIONAL ENERGY AGENCY

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

National Survey Report of PV Power Applications in Thailand
2013

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Prepared by

- *Bureau of Solar Energy Development, Department of Alternative Energy Development and Efficiency (DEDE),Ministry of Energy*
- *King Mongkut's University of Technology Thonburi (KMUTT)*

TABLE OF CONTENTS

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 23 member countries. The European Commission also participates in the work of the Agency.

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 24 participating countries are Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), China (CHN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia (MYS), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Thailand (THA), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). The European Commission, the European Photovoltaic Industry Association, the US Solar Electric Power Association, the US Solar Energy Industries Association and the Copper Alliance are also members.

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 2013. 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 2013 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2013, although commissioning may have taken place at a later date**.

1.1 Applications for Photovoltaics

Thailand has a long record of PV applications. In the first half of the 1990s, PV water pumping units and PV battery charging stations were introduced into rural areas. PV units were subsidized by two government agencies supporting rural area development, i.e. the Department of Energy Development and Promotion and the Public Works Department. In the mid-2000s, about 203,000 PV stand-alone solar home systems (SHS) were introduced by the Provincial Electricity Authority (PEA) to rural villagers.

Previous installations were mainly off-grid systems. In the past two decades (1990s and 2000s), PV cumulative installation was closed to 50 MW, 29.6 MW from stand-alone systems and 20 MW from grid-connected systems. Since the introduction of incentive program in 2009 the PV application has changed dramatically. In 2011 and 2012 the cumulative capacity was 242 MW and 387 MW, respectively. PV became main solar power plant installation in Thailand.

1.2 Total photovoltaic power installed

There are two groups of PV installation data. The first is stand-alone systems that its' installation capacity was reported. The second is grid-connected systems that the agreement of purchase to the utilities capacity was reported.

Table 1: PV power installed during calendar year 2013

			MW installed in 2013 - AC value	MW installed in 2013 - DC value
Grid-connected	BAPV	Residential		
		Commercial		
		Industrial		
		Total BAPV		
	BIPV	Residential		
		Commercial		
		Industrial		
		Total BIPV		
	Ground-mounted	cSi and TF	436.69 MW	
		CPV		
		Total Ground-mounted	436.69 MW	
Off-grid		Residential		
		Stand alone by DEDE		0.21 MW
		Hybrid systems*	0.15 MW	0.25 MW
		Total off-grid		
		Total	436.84 MW	0.46 MW

*Hybrid systems: Estimated from power rating of inverter provided by Leonics Co., Ltd

Table 2: Data collection process:

Are the installation data reported in AC or DC?	Both, there are AC of grid-connected system and DC of stand-alone system.
Is the collection process done by an official body or a private company/Association?	Public agencies which are The Energy Regulatory Commission (ERC)and The Department of Alternative energy Development and Efficiency(DEDE).
Link to official statistics (if this exists)	www.erc.or.th and www.dede.go.th (In Thai)
Additional comments on market and data collection, especially the estimated accuracy of data	This data is not include the grid connected PV for self consumption

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

MW-GW for capacities and GWh-TWh for energy	2013 numbers	2012 numbers
Total power generation capacities (all technologies)	33,379 MW	32,600 MW
Total power generation capacities (renewables including hydropower)	3,788 MW	2,786.27 MW
Total electricity demand (= consumption)	170,100 GWh	161,778 GWh
New power generation capacities installed during the year (all technologies)	n/a	n/a
New power generation capacities installed during the year (renewables including hydropower)	1,001.73 MW	n/a
Total PV electricity production in GWh-TWh	942.97 GWh	439.85 GWh
Total PV electricity production as a % of total electricity consumption	0.55 %	0.27 %

Table 4: Other informations

	2013 Numbers
Number of PV systems in operation in your country (a split per market segment is interesting)	794.07 MW (AC) of grid-connected systems (Mostly solar farm) 29.73 MW (DC) of stand-alone systems
Capacity of decommissioned PV systems during the year in MW	0.46 kW of stand-alone systems n/a of grid-connected systems
Total capacity connected to the low voltage distribution grid in MW	n/a

Total capacity connected to the medium voltage distribution grid in MW	619.07 MW (AC) including low voltage distribution grid
Total capacity connected to the high voltage transmission grid in MW	175 MW (AC)

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

Sub-market	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Stand-alone domestic	-	-	-	-	-	-	-	-	-	-	-	-
Stand-alone non-domestic	2.57	3.13	9.07	22.11	28.66	28.90	29.34	29.49	29.65	29.88	30.19	29.73
Grid-connected distributed	-	-	-	-	-	-	-	-	-	-	-	-
Grid-connected centralized	0.32	1.10	1.76	1.77	1.86	3.61	4.06	13.67	19.57	212.80	357.38	794.07
TOTAL (MW)	2.89	4.22	10.83	23.88	30.52	32.51	33.39	43.17	49.22	242.68	387.57	823.80

2 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.

2.1 Direct support policies

Table 6: PV support measures (summary table)

	On-going measures	Measures that commenced during 2013
Feed-in tariffs (gross / net?)		**Feed-in tariffs (gross)** -The PV electricity will be sold to grid with the FiT prices in order to promote private, individual and SME to invest in solar power. -The first target is 200 MWp which comprises of; -100 MWp for private households -100 MWp for SME and factories.

		-The FiT price is classified into 3 installation size as below; -Household (0-10 kWp) = 23.2 USCent/kWh (6.96 Bath/kWh) -Small Enterprise (10 - 250 kWp) = 21.8 USCent/kWh (6.55 Bath/kWh) -Medium & Large Enterprise/Factory (250 – 1,000 kWp) = 20.5 US cent/kWh (6.16 Bath/kWh) The other FiT for PV generation by community not more than 1 MW was also set by decreasing stepwise prices: 9.75 THB/kWh for 1 – 3 years, 6.50 THB/kWh for 4 – 10 years, 4.50 THB/kWh for 11 – 25 years.
Capital subsidies for equipment or total cost	100% subsidy for stand-alone system in the rural area	
Green electricity schemes	none	none
PV-specific green electricity schemes	none	none
Renewable portfolio standards (RPS)	none	none
PV requirement in RPS	none	none
Investment funds for PV	none	none
Income tax credits	- 100% revenue tax exemption for first 8 years and 50% for next 5 years for BOI promotion scheme for all RE generation -no income tax credits for individual	
Prosumers' incentives (self-consumption, net-metering, net-billing…)	none	none
Commercial bank activities e.g. green mortgages promoting PV	RE financial consultant	Long term soft loan (~7 years)
Activities of electricity utility businesses	-Purchasing or RE electricity generated by adder incentives under VSPP and SPP programme	-Purchasing of electricity selling proposals under the FiT incentives for residential, small and medium commercial buildings and

		industrirs and large commercial building s and industries
Sustainable building requirements	none	none

2.2 Direct Support measures

2.2.1 Support measures exiting in 2013

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

Since 2007 Thailand has announced the adder (Feed in Premium) on top of the normal electricity tariff, 8 THB/kWh of both solar and solar thermal energy for 10 years. Then between 2011 and 2012 there were consideration on new PV stimulus schemes and PV rooftop with FiT was announced in September 2013.

2.2.1.2 Prosumers' development measures

The PV generation for self-consumption is allowed in Thailand. However, if your PV circuit is connected to grid, you must be applied to ERC and the electricity distributor. At this moment there exists feed in tariff scheme for solar PV rooftop for residential, small and medium commercial buildings and factories and large commercial buildings and factories. All the electricity generated are elegible for selling with the designed FiT. Under the FiT scheme, the grid costs (for meter and other expense) are varied from 10,000 baht

(313 $US) for low voltage to 20,000 baht (626 $US) for medium voltage.

2.2.1.3 BIPV development measures

-None-

2.2.1.4 Rural electrification measures

The government continuously provides the stand-alone PV system to the rural non-electrified areas to increase the quality of lives of the people . The PV systems are provided for schools, health clinics and water pumping for communities and for specific projects.

2.2.1.5 Other measures including decentralized storage and demand response measures

In Thailand, decentralized storage has not been implemented nationwide yet. However, Thailand electric utilities have started Smart Grid/Micro Grid pilot projects, which include small battery storage systems. In addition, a battery storage system of 1,200 AH 560 Vdc is constructed at a 500 kWSolar PV Farm (Pha Bong, Mae Hong Son province). Regarding demand response, Energy Regulatory Commission (ERC) of Thailand has been studying to save the electric energy consumption of 100 MW, and the final target would be 2,000 MW by Critical Peak Pricing (CPP).

2.2.2 Support measures phased out in 2013

Thailand has announced the adder (Feed in Premium) for all RE under VSPP and SPP programme since 2007. The National Energy Policy Committee stop taking PV proposal under the adder scheme since June 2010 until now. This was due to the proposal of the PV capacity was far more higher than the 3,000 MW target in the RE development plan.

2.2.3 New support measures implemented in 2013

In September 2013, the Feed in Tariff for PV rooftop was announced for VSPP not more than 1 MW, 6.16 to 6.96 THB/kWh of 25 years. The selling rates are depending on the size of the system. The voluntary registration of solar PV rooftop installers has been conducted by Ministry of Energy to support the program. The other FiT for PV generation by community not more than 1 MW was also set by decreasing stepwise prices: 9.75 THB/kWh for 1 – 3 years, 6.50 THB/kWh for 4 – 10 years, 4.50 THB/kWh for 11 – 25 years.

The selling rates of PV rooftop are 6.96 THB/W for a small system (≤ 10 kW), 6.55 THB/W for a medium system (10 – 25 kW) and 6.16 THB/W for a large system (25 kW – 1 MW).

2.2.4 Measures currently discussed but not implemented yet

-None-

2.3 Indirect policy issues

The PV system installation without FiT consists of the three PV projects. There are (1) 25 MW of PV rooftop in all Town halls buildings in 76 provinces of Thailand, excepting Bangkok, (2) PV rooftop for 450 systems of 20 kWp, totalling capacity is 9 MW and (3)Rooftop and ground mounted systems of 40 kWp of PV system for 350 Vocational colleagues, totalling capacity is 14 MW.

2.3.1 International policies affecting the use of PV Power Systems

- None -

2.3.2 The introduction of any favourable environmental regulations

- None -

2.3.3 Policies relating to externalities of conventional energy

- None -

2.3.4 Taxes on pollution (e.g. carbontax)

- None -

2.3.5 National policies and programmes to promote the use of PV in foreign non-IEA countrie

- None -

3 HIGHLIGHTS OF R&D

3.1 Highlights of R&D

Late of 1980s the research activities of cell and module production are carried out by the private sector to improve their module productivity whilst the research activities of universities and government research institutes work towards building a knowledge base.

The R&D activities are divided into 3 groups such as (1) solar cells and related materials, (2) PV components and (2) PV applications. Solar cells and related materials consist of the topics of silicon ingot, TOC glass, thin film Si, CIGS, organic and dye sensitized. PV applications consist of system evaluation and techno socio-economic management of PV systems in rural areas. In addition the research of inverters in grid and stand-alone hybrid systems is carried out.

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

- None -

Table 7: Public budgets for R&D, demonstration/field test programmes and market incentives.

	R & D	Demo/Field test
National/federal	-	-
State/regional	-	-
Total	-	

4 INDUSTRY

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

Table 8: Production information for the year for silicon feedstock, ingot and wafer producers

Manufacturers (or total national production)	Process & technology	Total Production	Product destination (if known)	Price (if known)
-	Silicon feedstock	tonnes	-	-
-	sc-Si ingots.	tonnes	-	-
-	mc-Si ingots	tonnes	-	-
-	sc-Si wafers	MW	-	-
-	mc-Si wafers	MW	-	-

Describe briefly the overseas activities of any key companies also operating in other countries.

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

Total PV cell and module manufacture together with production capacity information is summarised in Table 9 below.

Table 9: Production and production capacity information for 2013

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					
1Ekarat Solar	-	-	25	-	n/a
2Fullsolar	-	-	25	-	0.5
3 Solartron	-	-	70	-	n/a
4 Solar Power Technology	-	-	n/a	-	n/a
Total	-	-		-	
Thin film manufacturers					
1Bangkok Solar	-		60		n/a
2Sharp (Thailand)	-		7		1
Cells for concentration					
-	-	-	-	-	-
TOTALS			**> 192**		

The following additional information **may** also be provided in text:

a) Whether the manufacturer produces their own cells in-house or whether they are purchased on the international market, or both.

-In 2013 all manufacturers purchased all the cells from the international market.

b) An indication of the amount of production (cells, modules, other components, systems) exported from the country.

-n/a

c) Availability of specially designed products (large size modules, modules with thermal benefits, facade and roof top modules, home system kits etc.).

-n/a

d) New developments and new products that arrived on the market during 2013.

-n/a

4.3 Manufacturers and suppliers of other components

The only local manufacture of inverter is Leonics Co., Ltd. The CDM registered 8% of PV power plant installed in 2012 used the local inverters. The imported grid-connected inverters for PV power plants are from United States (53%), Germany (26%) and Japan (10%).

5 COMPETITIVENESS OF PV ELECTRICITY

5.1 Module prices

In 2011 and 2012, most PV systems installed in Thailand were mainly PV power plants, the average p-Si module price was 50 – 80 THB/W. The prices are established on a case by case based on the applications.

Table 10: Typical module prices for a number of years

Year	2013
Standard module price(s): Typical	80 THB/W
Best price	50-60 THB/W
PV module price for concentration (if relevant)	n/a

5.2 System prices

In 2011 and 2012, most PV systems in Thailand were PV power plants, the average system price was 60 – 100 THB/W. The prices are established on a case by case based on the applications.In 2013 residential solar rooftop price survey report the range of system prices is 60-100 THB/W and the average of residential solar rooftop price is 79 THB/W.

Table 11: **Turnkey Prices of Typical Applications**

Category/Size	Typical applications and brief details	Current prices per W
OFF-GRID Up to 1 kW	n/a	n/a
OFF-GRID >1 kW	5 kW of stand-alone systems in rural area	162.82 THB/W (Including Battery and other BOS)
Grid-connected Rooftop up to 10 kW (residential)	n/a	60-100THB/W Average of system price: ~79 THB/W
Grid-connected Rooftop from 10 to 250 kW (commercial)	n/a	~60 THB/W
Grid-connected Rooftop above 250kW (industrial)	n/a	~55 THB/W
Grid-connected Ground-mounted above 1 MW	n/a	60 – 100 THB/W
Other category existing in your country (hybrid diesel-PV, hybrid with battery…)	n/a	n/a

Table 12: National trends in system prices (current) for different applications

Price/Wp	2013
Residential PV systems < 10 KW	~79 THB/W
Commercial and industrial	~55 -60 THB/W
Ground-mounted	60 – 100 THB/W

5.3 Financial Parameters and programs (leasing)

n/a

Table 13: PV financing scheme

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

5.4 Additional Country information

Table 14: Country information

Retail Electricity Prices for an household (range)	3.73 -3.94 TB/kWh
Retail Electricity Prices for a commercial company (range)	3.73-3.93 TB/kWh Small commercial /Industrial 2.69 -2.72 TB/kWh Medum commercial/industrial
Retail Electricity Prices for an industrial company (range)	2.69 – 2.72 TB/kWh Large commercial/industrial
Population at the end of 2013 (or latest known)	64,623,000
Country size (km^2)	513,120 km^2
Average PV yield (according to the current PV development in the country) in kWh/kWp	1,371 kWh/kWp
Name and market share of major electric utilities.	1. Generators 1.1 Electricity Generation Authority of Thailand (EGAT)-42% 1.2 Independent Power Producers (IPP) >90 MW -35% 1.3 Small Power Producers (SPP) >10MW-<90 MW-12% 1.4 Very Small Power Producers (VSPP) <10 MW-4% 1.5 Imports -7%

	2. Distributors 2.1 Provincial Electricity Authority (Distributor for Provincial cities)-70% 2.2 .Metropolitan Electricity Authority (Distributor for Bangkok and its vicinity)-30%

6 PV IN THE ECONOMY

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

6.1 LABOUR PLACES

-n/a-

Table 15: Estimated PV-related labour places in 2013

Research and development (not including companies)	-n/a-
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	
Distributors of PV products	
System and installation companies	-n/a-
Electricity utility businesses and government	-n/a-
Other	
Total	

6.2 Business value

Table 16: Value of PV business

Sub-market	Capacity installed *in 2013*(MW)	Price per W *(from table 7)*	Value	Totals
Off-grid domestic	-	-	-	-
Off-grid non-domestic	0.21	162.82	$0.034x10^9$	$0.034x10^9$
Grid-connected distributed	-	-	-	-
Grid-connected centralized	436.69	60-100	$26.201x10^9$-$43.669x10^9$	$34.935\ x10^9$ *(average)*
Export of PV products				*N/A*
Change in stocks held				*N/A*
Import of PV products				*N/A*
Value of PV business				$34.969\ x10^9$

If possible, please provide some brief comment on the industry value chain in your country or provide references to articles, reports dealing with this topic.

In 2013, most of PV manufactures produced PV module by importing the PV cell from international market since there was no PV cell production plant locally.However, at the end of 2013, Solartron established a PV cell production line with 70 MW capacity and will use by itself and sell to other local mudule manufacturers. The company is expected to increase their production capacity to 190 MW by beginning of 2015.

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

Short description of the electricity industry landscape	-Structure: Separate to –generation and distribution and distribution -There are only two distributors or retailers– MEA for Bangkok and vicinity and PEA for Provincial cities-who are selling electricity to normal customers. -Ownership: All of them are public-state enterprise -Electricity Regulation Commission-an agency to regulate the energy industry operation

7.2 Interest from electricity utility businesses

Key dirvers: Clear government policy and plan on renewable energy generation with incentive measures

Barriers: Contraint on power grid capacity to cope with the distributed and unstable from RE generation.

- Built –Own-and Operate Model- EGAT a main power generator used this model to build its PV power plant and operated as grid support plant-1.56 MW
- Giving out power purchasing agreement to private investor –by EGAT and PEA-a provincial distributor for solar power plans -794 MW
- Giving out power purchasing agreement for PV rooftopn to individual , commercial and industry –by PEA and MEA (2 main distributors)-126 MW

7.3 Interest from municipalities and local governments

-n/a-

8 STANDARDS AND CODES

Certification is important to investors as it ensures performance and reliability of PV systems that have attracted their investment. The minimum certification requirements are IEC61215 for crystalline silicon modules and IEC61646 for thin film modules.

In 2011 the Thai Industrial Standards Institute (TISI) announced in the Government Gazette the TIS1843-2553 being the Thai version of IEC61215:2005 for crystalline silicon modules. In early 2013 TIS 2210-2555, the Thai version of IEC61646:2008, for thin film modules was announced.

PV module safety standard was announced in the Government Gazette. There are requirements for construction and requirements for testing, according to IEC standards IEC61730-1 and IEC61730-2, respectively.

BOS standard in Thailand concerns the safety for distribution lines and networks of the utility, the applied BOS standards are IEC61727 and IEC62116.

In addition, inverters for 200 MW of solar rooftop have to comply with the regulatory measures for grid connected inverters that was announced by the two Thai electricity distributing utilities, i.e. the Provincial Electricity Authority – PEA for rural areas and the Metropolitan Electricity Authority – MEA for Bangkok.

9 HIGHLIGHTS AND PROSPECTS

PV power plant installation has become dominant between 2009 and 2013 due to the renewable energy policy in the 15-Year Renewable Energy Development Plan -REDP(2007-2022) which had been updated to be the 10-Year Alternatiove Energy Development Plan –AEDP(2012-2021). This 10-Year AEDP has a target to share the renewable energy by 25% of the final energy consumption by 2021. The updated target for solar energy installation capacity is 3,000 MW.

The new FiT incentive for the first 200 MW PV rooftop project was announced in September 2013 and operation was scheduled by the end of 2013. The FiT for PV rooftop provide difference rate of 6.19-6.96 TB/kWh depending of the size of installation. The rate was fixed for 25 years.

The PV project of community rooftop was also approved by the NEPC in 2013.. The system capacity is not larger than 1 MW per community in the regional provinces under the services of Provincial Electricity Authority (PEA). The FiT program will be applied with dynamic rate base on the year of system operation.

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^{o}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 kW 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 kW of installed PV power.

Currency: The currency unit used throughout this report is the Baht from Thailand

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