THAILAND PV STATUS REPORT 2011

by The Solar Club, THAILAND

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DEFINITIONS

Adder
An additional energy purchasing price on top of the normal prices that power producers (under the VSPP and SPP scheme) will receive when selling electricity to the Power Utilities.

SPP
Small Power Producer supplying electricity to grid by using non-conventional energy including renewable energy but excluding natural gas, oil, coal and nuclear energy, waste energy, energy respecting to cogeneration principle as a primary energy source with generating capacity more than 10 MW but does not exceed 90 MW.

VSPP
Very Small Power Producer supplying electricity to grid by using waste renewable energy, biomass energy with back-up supply < 25%, waste energy as a primary energy source with generating capacity not exceeding 10 MW.

Off-grid domestic PV system
PV system installed to provide power mainly to a household or village, not connected to the utility grid.

Off-grid non-domestic PV system
PV 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.

Grid-connected distributed PV system
PV system installed on or integrated into consumers' premises usually on demand side of electricity meter, on public and commercial buildings to provide power to a grid-connected consumer or directly to the electricity grid.

Grid-connected centralized PV system
PV 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 consumer. The system is not located to perform specific functions on the electricity grid other than the supply of bulk power, typically large scale ground mounted system, i.e. solar farm.

ABBREVIATIONS

BOI	Board of Investment
BSC	Bangkok Solar Co., Ltd.
BSP	Bangkok Solar Power Co., Ltd.
CDM	Clean Development Mechanism
CES	Clean Energy System
CIGS	Copper Indium Gallium Selenide
COD	Commercial Operation Date
CSSC	CES Solar Cells Testing Center
DEDE	Department of Alternative Energy Development and Efficiency
EEI	Electrical and Electronics Institute
EGAT	Electricity Generating Authority of Thailand
EGCO	Electricity Generating Public Co., Ltd.
EIA	Environment Impact Assessment
EPPO	Energy Policy and Planning Office
ERC	Energy Regulatory Commission
ESCO	Energy Service Company
FiT	Feed-in-Tariff
KMUTT	King Mongkut's University of Technology Thonburi
kW	Kilowatt
kWh	Kilowatt-hour
kWp	Kilowatt-peak
MEA	Metropolitan Electricity Authority
MOCVD	Metal-organic Chemical Vapor Deposition
MSW	Municipal Solid Waste
NED	Natural Energy Development Co., Ltd.
NEPC	National Energy Policy Committee
NSTDA	National Science and Technology Development Agency
ONEP	Office of Natural Resources and Environmental Policy and Planning
PEA	Provincial Electricity Authority
PPA	Power Purchase Agreement
PTEC	Electrical and Electronic Products Testing Center
RE	Renewable Energy
REDP	Renewable Energy Development Plan
ROIC	Return on Investment of Capital
SHS	Solar Home System
SME	Small and Medium Enterprises
SPP	Small Power Producer
TCO	Transparent Conductive Oxide
TGO	Thailand Greenhouse Gas Management Organization
TISI	Thai Industrial Standards Institute
UEE	Universal Energy Engineering Co., Ltd.
VSPP	Very Small Power Producer
ZnO	Zinc Oxide

FORWARD

The enactment of a 15 year Renewable Energy Development Plan (REDP) in early 2009 with a target to increase the Renewable Energy (RE) share to 20% of the final energy consumption in 2022 serves as a stimulus for RE generation in Thailand. The RE generation target is set at 6% of the total power generation for the country, and is being promoted through the Very Small Power Producer scheme (VSPP; not exceeding 10 MW) and the Small Power Producer scheme (SPP; more than 10 MW but does not exceed 90 MW). The main mechanism is by means of the Board of Investment (BOI) tax incentives and the eligibility for adder for a period of 7-10 years.

The total solar energy generation target set under the 15 Year REDP is 500 MW by 2022. With the worldwide dramatic decrease in price of solar PV (since 2009) and the rather low risk aspects of the technology coupled with increased public acceptance have boosted investors' interest in solar energy generation projects more than other renewable energy options. About 100 MW of electricity from solar cells is now operational in Thailand. The total capacity of solar energy generation proposed to be installed and connected to the grid up until 2011 is 7 times the original target of 500 MW. Two thirds are solar PV while the rest is solar thermal. The latter may no longer be feasible considering the latest solar technology and the availability of local solar resources.

The adder price for the solar energy generation of 8 THB/kWh (26.67 US cents/kWh) is the highest among all renewable energies in Thailand. To prevent an adverse affect from an overwhelming number of the solar project proposals on the retail electricity price, the Thai Government decided to halt the acceptance of new solar energy generation proposals under the VSPP and SPP schemes, and reduced the adder to 6.5 THB/kWh (21.67 US cents/kWh) in June 2010. The next round for submitting solar energy generation projects is under consideration with the new Feed-in-Tariff (FiT) scheme. In addition, the Ministry of Energy is contemplating a new target of 2,000-3,000 MW for solar power generation, possibly by 2020.

However, two critical issues must be addressed. One is the low growth of the Thai PV industry, despite a fast utility scale PV power plant expansion. The other issue is that standards for the solar PV modules set by the Thai Industrial Standards Institute (TISI) are done only on a voluntary basis.

The current success of VSPP and SPP solar PV generation projects in Thailand has generated acceptance and confidence, not only among investors, but also among local and international financial institutions. In addition, the recent joint cooperation among three local banks - Kasikorn Bank, Bank of Ayudhya and Thanachart Bank with IFC, a member of the World Bank Group - in providing financial support for two VSPP projects of solar power companies announced in October 2011, is one notable example. Other examples include the loan approval by the Asian Development Bank (ADB) to the SPP power generation projects of the Bangchak Co., Ltd. and the Natural Energy Development Co., Ltd.

This report aims to provide an overview of the status of solar PV in Thailand in 2011 coupled with a recent update on related policies and incentives. The information presented here is to support all stakeholders involved in developing the solar energy generation market in Thailand. Contributors to this report are from various government agencies, the solar PV system manufacturers, the distributors, the integrators and the utilities that voluntarily joined the "Solar Club" under the support of the National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology. The Club hopes that this report provides a useful insight into the solar PV situation in Thailand. Any additional information is highly welcome and will be used in future updates of this report.

December 2011

NSTDA and The Solar Club

INTRODUCTION

Energy plays a critical role in the economic development of all nations. When coupled with an increasing demand, while facing global warming and climate change, the future energy policy and outlook of Thailand have been adapted to reflect this crucial combination and transformation. The production and consumption of energy from renewable sources, e.g. hydro, wind, biomass and solar energy, is now on the rise.

Fossil fuels are the major sources of energy in Thailand for electricity generation, transportation and industrial production and these are typically imported in the form of crude oil. Natural gas, on the other hand, is largely a domestic resource. Though Thailand possesses a diverse range of renewable sources of energy, they are modest in quantity compared to other countries. With issues of energy security and price stability looming large around the world, Thailand is inevitably affected. Good progress has been made towards the renewable energy policy and practice in Thailand.

Thailand's energy policy goal is to effectively satisfy the energy needs of the country while achieving sustainable energy security. Focus has been placed on the energy development from domestic sources, both short and long term, to reduce dependency on imported energy. To alleviate trade deficit, the energy plan is to rely more on indigenous energy sources to reduce the risk of energy shortage and to improve the instability of energy prices.

Thailand's Renewable Energy Development Plan (REDP) has been introduced by the Ministry of Energy and is focused on encouraging all sectors to increase their share of renewable energy production and consumption including solar energy. The REDP is to be implemented over a fifteen year period from 2008 to 2022. The objective of REDP is to increase the portfolio of renewable energy to 20.3 % of the final energy consumption in 2022. Many measures from several organisations have been introduced in order to reach the target such as tax and non-tax incentives by BOI, and the adder measure and finance scheme under Ministry of Energy.

For research and development in solar energy in Thailand, the areas of focus are photovoltaic (PV) cell materials with higher conversion efficiency, PV reliability field test and life cycle assessment in a tropical climate, performance improvement of PV systems, recycling PV panels and the use of PV in energy efficient homes. Support given to these R&D projects will therefore develop researchers' skills and experiences. Collaboration and coordination are promoted among the public and the private sectors to further technology development and to sustainably increase energy efficiency and the utilization of renewable energy in Thailand.

1 Executive SUMMARY

This first report from Thailand offers a unique overview of the status of solar energy development in the country in 2011. It is in the context of rapid developments in renewable energy, investments, industries and policies in recent years and the rising demand for energy consumption that this report has been drafted. The report covers current policies, incentives, R&D status, implementation and the development of a solar industry as well as outlining future trends and areas of growth. Many of the trends reflect the increasing significance of solar energy being used conventionally and in rural areas.

- The 15 Year Renewable Energy Development Plan or REDP has set a target for all renewable energies of 20.3% by 2022. The electricity from solar energy is set at a modest level of 500 MW.
- In September 2011, the cumulative PV installation in Thailand was 100 MW. The ratio of off-grid to grid-connected system was approximately 30:70.
- Value chain of Thailand PV industries lacks upstream players, e.g. ingot/wafer and TCO glass manufacturers.
- There is a need for policies to create and drive sustainable Thai's PV industries.
- There is also a need for R&D concerning an entire life cycle of PV modules and a collaboration among different actors in the Thai PV community.
- Large scale solar farms have dominated the PV market in Thailand since 2009. The new policy will focus more on local community investment as well as rooftop PV for residential and commercial buildings using the FiT incentive scheme.

2 Framework for DEPLOYMENT

PV power generation technology is an effective means to improve the living standards in remote areas while reducing greenhouse gas emissions. The principal driver of today's rapid PV growth lies in the promotion policy. Like other countries, Thailand has established its incentive policies to promote the use of renewable energy. These policies have successfully propelled growth of PV in Thailand during 2008-2011. Investors continue to keep their eyes on modifications and enhancements to the incentive price that supports new PV projects.

2.1 Policies and Incentives

- **PV Capacity Target**
  The 15 Year Renewable Energy Development Plan or REDP, approved by the Cabinet in early 2009, has set the target for all renewable energies to be 20.3% of total energy consumption by 2022. The target for electricity generation from solar energy is set modestly at 500 MW (or 0.24% of REDP target).

- **Incentives for Renewable Energy Promotion**
  There are 6 main incentives for supporting RE use and production. Five of them are designed and administered by the Ministry of Energy and one by the Thailand's Board of Investment (BOI). The five measures from the Ministry of Energy include information dissemination services for investors and the public, the financial grant for initial investment, the Revolving Fund, the ESCO Capital Fund and the adder measures. The BOI provides an income tax privilege and other cost deduction. Another indirect measure to support renewable energy production is the Clean Development Mechanism (CDM). A summary of these incentives is shown in Fig 2.1.

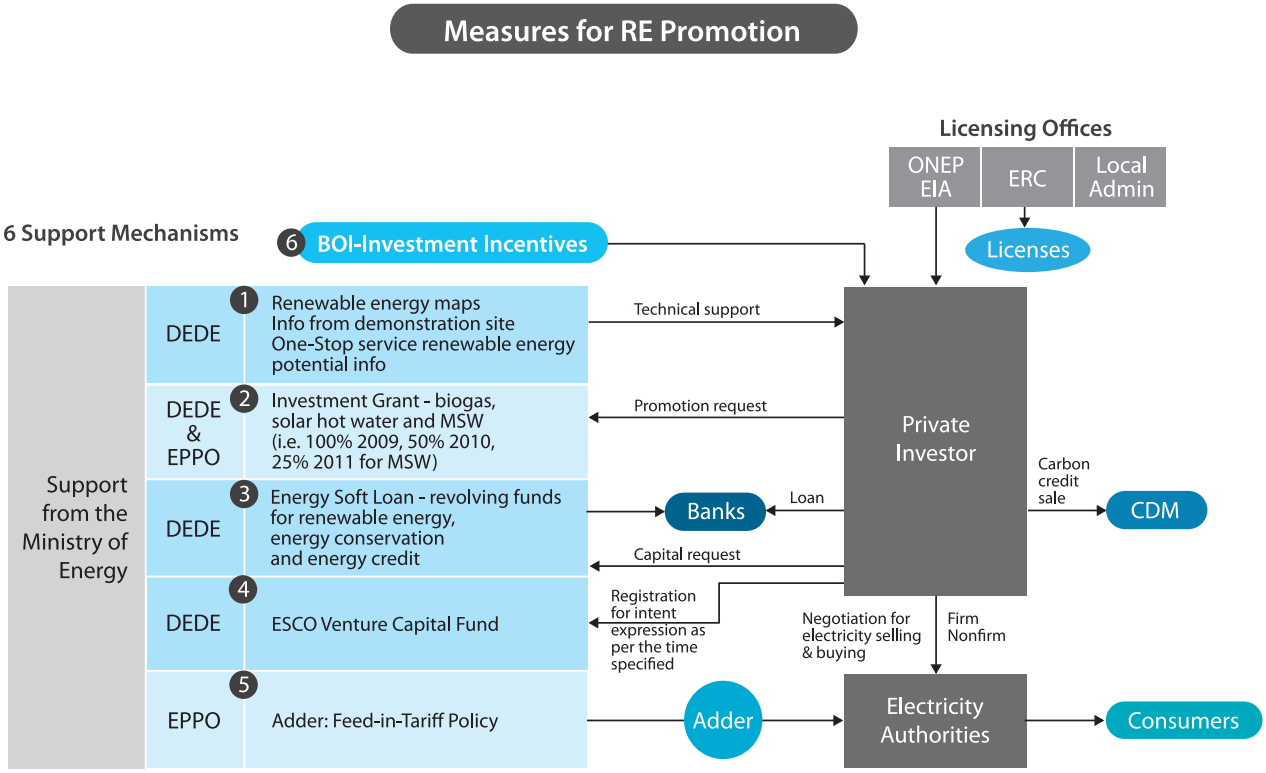


Fig. 2.1 Measures for renewable energy promotion

Description of 6 Support Mechanisms

1. Information Provider
The solar radiation maps are available for SMEs and the public.

2. Investment Grant
These grants are available for solar hot water system, biogas, etc.

3. Revolving Fund
This fund comprises one component from the Ministry of Energy (about 7,000 million THB) and another component of the same amount, from commercial banks. The total fund will be channeled through 13 banks to finance all renewable energy technologies. The loan has fixed interest rate at ≤4% for 7 years of the loan period.

4. ESCO Capital Fund
The Energy Conservation Promotion Fund (ESCO Fund) is provided to two fund managers, one being the Energy for Environment Foundation and the other for the Foundation of Thailand Energy Conservation Center. These two fund managers will support the ESCO and the SME investors in various schemes, each not more than 50 million THB per project. The support provided ranges from a loan to ESCO at 4% interest rate, venture capital with the ESCO and the SME investment, as well as support for such activities as equipment leasing, technical support, CDM support, etc. The size of the ESCO capital fund is 1,000 million THB or 33 million USD.

5. Adder Measures
Thailand is among the first ASEAN countries to promote power generation from renewable energy, with the provision of adder as an incentive measure. Adder is an additional energy purchasing price on top of the normal prices that power producers will receive when selling electricity to the power utilities. The policy directive regarding the adder scheme was initiated in 2006, and the actual implementation commenced in early 2007, after the National Energy Policy Committee (NEPC), chaired by the Prime Minister, had approved adder rates.

The adder scheme has been reviewed from time to time to best suit each renewable energy technology, and to encourage more investments from the private sector. The latest revision, made in 2010 by the Energy Policy and Planning Office (EPPO), Ministry of Energy, reflects the changing trends of project costs, technologies and overall economic conditions. The amendments were also made to the criteria and terms of power purchase. It is to ensure that the promotion of the power generation from renewable energy complies with the stipulated policy, which can be summarised as follows.

Reduction of Adder for Solar-PV Projects

During 2007-2008, the growth rate of the proposed sale of electricity generated by solar energy (photovoltaic) to the national grid system was rather insignificant. A contributing factor was that solar-PV technology was relatively expensive, and the designated adder of 8 THB/kWh (about 23 US cents/kWh) at that time was not attractive enough to encourage investments. However, in the third quarter of 2008, the costs of the solar-PV systems and system components in the world market began to drop considerably. In addition, under the initial adder scheme, the deadline for submission of the capacity sale proposals was set at the end of 2008. A number of investors rushed to submit their proposals to meet that deadline in the fourth quarter of 2008. This has resulted in a noticeable increase in the proposed sale capacity from solar-PV projects. The sum of all solar PV projects operating or under development was 2,809.26 MW.

Later, in 2009 there was a dramatic increase in the number of solar-PV projects that supply power to the grid, ranging from 1.75 MW at the end of 2008 to 7.67 MW.

In 2010, a sharp increase in the electricity supplied to the grid from solar-PV was observed as were adverse impacts on power tariffs and power system security. All were much more than initially anticipated. An analysis was done by EPPO on of Return on Investment of Capital (ROIC) of all solar-PV projects and the impact of the adder provision on the power tariff burden of consumers. The findings have led the National Energy Policy Committee (NEPC) to pass a resolution to reduce the adder rate for the solar-PV projects from 8.00 THB/kWh to 6.50 THB/kWh on 28 June 2010. However, the support duration remained unchanged, i.e. 10 years from the commercial operation date (COD), while no new capacity sale proposals from more solar-PV projects were accepted. In addition, NEPC required that a recommendation be made on an alternative approach to support solar-PV projects in the future, i.e. the introduction of FiT for rooftop solar-PV systems.

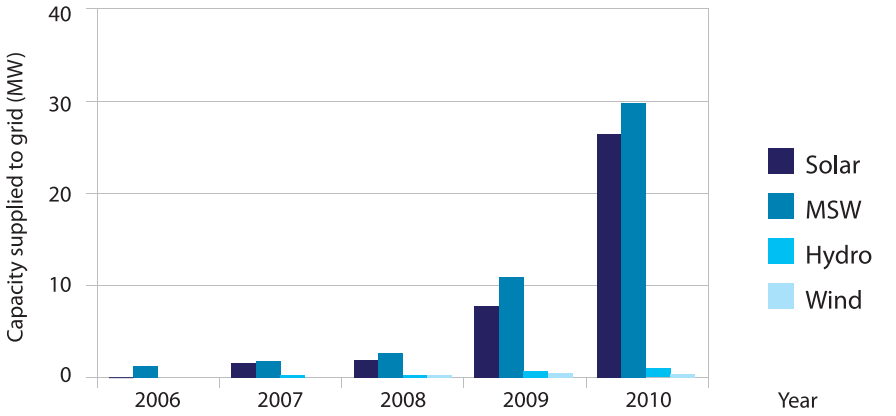
For the power generation using other RE technologies, the adder rates remained unchanged, as shown in Table 2.1.

Table 2.1 Summary of adder rates, classified by RE technology and fuel

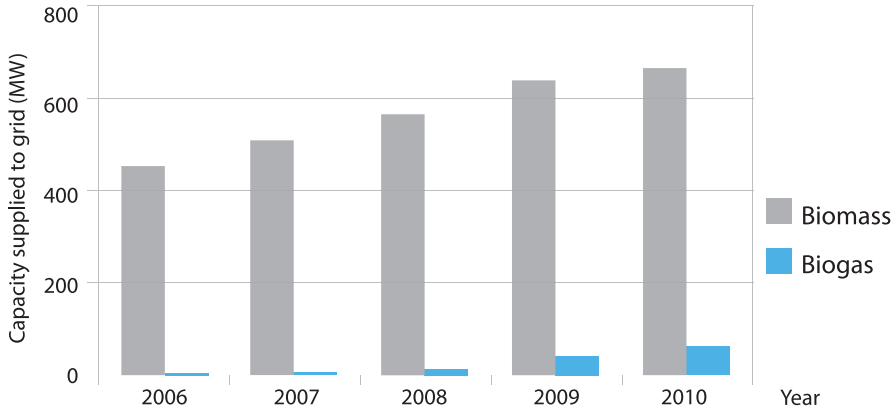
Thailand's Adder for RE Power Generation						
Renewable Energy Technology/Fuel	**2007-2008 Adder Rate** (THB/kWh)	**2009 Adder Rate** (THB/kWh)	**2010 Adder Rate** (THB/kWh)	**Special Adder for Diesel Replacement** (THB/kWh)	**Special Adder for Three Southernmost Provinces** (THB/kWh)	**Support Duration** (Years from COD)
1. Biomass						
- Installed Capacity ≤ 1 MW	0.30	0.50	0.50	1.00	1.00	7
- Installed Capacity > 1 MW	0.30	0.30	0.30	1.00	1.00	7
2. Biogas						
- Installed Capacity ≤ 1 MW	0.30	0.50	0.50	1.00	1.00	7
- Installed Capacity > 1 MW	0.30	0.30	0.30	1.00	1.00	7
3. Waste (MSW and Industrial Waste, excluding Hazardous Waste and Organic Waste)						
- Landfill or Digestion Process	2.50	2.50	2.50	1.00	1.00	7
- Thermal Process	2.50	3.50	3.50	1.00	1.00	7
4. Wind						
- Installed Capacity ≤ 50 kW	3.50	4.50	4.50	1.50	1.50	10
- Installed Capacity > 50 kW	3.50	3.50	3.50	1.50	1.50	10
5. Small/Microhydro						
- Installed Capacity 50 - ≤ 200 kW	0.40	0.80	0.80	1.00	1.00	7
- Installed Capacity < 50 kW	0.80	1.50	1.50	1.00	1.00	7
6. Solar	8.00	8.00	6.50	1.50	1.50	10

The overall promotion of the power generation from RE through of the adder incentive mechanism during the past 4 years has resulted in a significant increase in interest in investment by the private sector in renewable energies.

Figure 2.2 presents a comparison of the RE capacity supplied to the grid and the fuel types (both SPPs and VSPPs) at the end of 2006 (before the adder program was implemented) and at the end of 2010 (after the implementation of the adder program).



(a) Trends of Solar, MSW, Hydro and Wind Energies



(b) Trends of Biomass and Biogas

Fig. 2.2 Amount of RE capacity supplied to the grid before and after the adder scheme was introduced (2006-2010)

6. BOI Investment Incentives

BOI has agreed to promote Alternative Energy and Energy Efficiency as key technologies. Solar power plants and manufacturers of solar cells are eligible sectors.

The advantages offered are

- Import duty exemption for machinery (all zones)
- 8 year corporate income tax exemption with no cap (all zones)
- Additional incentives for zone 3
- Additional 50% reduction in corporate income tax for 5 years (year 9th - year 13th)
- Deduction of infrastructure construction costs
- Double deduction of public utility costs

Note:
Zone 1: Bangkok, Samut Prakan, Samut Sakhon, Nakhon Pathom, Nonthaburi and Pathum Thani (Bangkok and 5 provinces)
Zone 2: Angthong, Ayutthaya, Chachoengsao, Chonburi, Kanchanaburi, Nakhon Nayok, Phuket, Ratchaburi, Rayong, Samut Songkhram, Saraburi and Suphanburi (12 provinces)
Zone 3: Remaining 58 provinces

- **Indirect Policy**

Clean Development Mechanism (CDM)

CDM is a cooperative mechanism established under the Kyoto Protocol. It was designed to assist the industrialized countries in meeting their mandatory greenhouse gas emissions reduction targets, while promoting sustainable development in developing countries. Having ratified the Protocol in 2002, Thailand is classified as a non-Annex I Party and it is not obliged to any emission reduction targets. The Thailand Greenhouse Gas Management Organization (TGO) is the country's Designated National Authority (DNA) for its voluntary acts on the emission reduction.

There is no carbon market for selling or buying carbon credits in Thailand. However, there exist over the counter (OTC) trades (trade in the voluntary markets) where developers of CDM projects and countries within the Annex I can trade credit through delegates, financial funds, and brokers. 291 letters of intent (LoI) have been submitted to TGO. TGO has issued a Letter of Approval (LoA) for 154 projects. Among the approved projects, there are only 4 solar energy projects (updated on 24 Nov 2011).
* Information from http://www.tgo.or.th

2.2 Standards, Codes and Testing Services

- **Standards and Codes**

The Thai Industrial Standards Institute (TISI), under the Ministry of Industry, is the national standards authority of Thailand who establishes the TIS standard for the country including PV systems. The Thai Technical committee (TTC) was formed by the Ministry at the end of 2006.
Most standards for the PV systems (the IEC standards) were adopted into the TIS family of standards. Examples include the TIS 1843-2542 (IEC 1215:1993), TIS 1844-2542 (IEC 1277:1995) and TIS 2210-2548 (IEC 1646:1996).
The Thai version of IEC 61215:2005 or TIS 1843-2553 has been announced in the Government Gazette in 2011.
Other standards released by IEC/TC 82 have been reviewed and will be proposed by the technical committee in the near future.

The Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA) are the two distribution network utilities in the country. MEA and PEA regularly review and issue regulations concerning grid interaction for Small Power Producers (SPP) and Very Small Power Producers (VSPP). The latest announcement was done by PEA in 2011.
The Power Purchase Agreements (PPAs) for generation size smaller than 10 MW (or VSPP), must be co-signed with the MEA or PEA. For those larger than 10 MW (or SPP), the Electricity Generating Authority of Thailand (EGAT) is the co-signer of the PPAs. The key condition is that the grid-inverters must be certified in compliance with the utility codes and one combination of the IEC 61727:2004 and IEC 62116:2008 or IEEE 1547 and UL 1741 or others accepted by the utility.

In the government procurement process, each of the government agencies, e.g. the Department of Alternative Energy Development and Efficiency (DEDE), the Electricity Generating Authority of Thailand (EGAT), the Defense Industry and Energy Center, etc., must specify its own technical specifications and the IEC standards of the PV modules. Most of them request that the main equipment be tested by the government testing bodies. For those in the group of households located in remote and restricted areas, another set of standards for solar home systems (SHS) is used. The SHS standards were jointly developed by the Department of Local Administration, under the Ministry of Interior and the Engineering Institute of Thailand, under H.M. The King's Patronage (EIT).

As we are approaching the single market ASEAN Economic Community in 2015 (AEC 2015), all stakeholders in Thailand are preparing themselves for the ASEAN Electrical and Electronic Mutual Recognition Arrangement (ASEAN EE MRA). The essential requirements would be aligned to IEC standards.

- **Testing Services**

The testing facilities are located in universities and government agencies (e.g. PTEC at NSTDA (Ministry of Science and Technology) and EEI (Ministry of Industry)). These facilities provide testing services for the specifications and compliance requested in the procurement's terms of reference.

1. The CES Solar Cells Testing Center (CSSC) located at the King Mongkut's University of Technology Thonburi (KMUTT) was established in 2005 with financial support from the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, and the Energy Conservation Fund. The CSSC facility can provide services for PV modules up to a 2 m x 2 m size, according to the IEC 61215:2005 and IEC 61646:2008, inverters up to 30 kW according to the IEC 61727:2004 and IEC 62116:2008 and batteries up to 3000 Ah at 100 hours rate according to IEC 61427:1999 and IEC 60896-11:2002. For more information, please visit: http://www.ces.kmutt.ac.th/

2. The Electrical and Electronic Products Testing Center (PTEC) was founded in 1998, through a cooperation agreement between NSTDA and King Mongkut's Institute of Technology Lardkrabang (KMITL). PTEC provides services in electrical and electronic products testing, calibration and consultancy to local manufacturers, especially for exporters seeking to upgrade their products to meet the demands of the international market.
PTEC also provides PV standard testing (IEC 61646 and IEC 61245) and PV on site testing in addition to the maintenance services. For more information, please visit: http://www.ptec.or.th/english/

3. The Electrical and Electronics Institute (EEI) was founded in 1998. It is an industry focused institute under the supervision of the Ministry of Industry.
EEI provides testing services of the balance of systems (BOS), such as charge controller and inverter according to the TIS 1293-2538 and PEA's requirement. For more information, please visit:http://www.thaieei.com

3 IMPLEMENTATION of PV Systems

Being situated near the equator, Thailand receives an annual average of solar irradiation of 18.2 MJ/m^2-day which is relatively high compared to other tropical and mid-latitude countries. This gives Thailand an advantage for PV systems implementation which began in the 1980s, largely for rural electrification. Owing to a reduction of PV prices coupled with the introduction of government incentives, a rapid growth in PV has been seen since 2007. By September 2011, the total accumulated PV installation reached 100.39 MW with many more projects in the pipeline. The total capacity of 500 MW from all PV systems is expected by 2016.

3.1 Applications of PV

- **Off-grid**
  The off-grid PV system was the first PV application in Thailand. Most of the off-grid system were installed in rural and un-electrified remote areas to improve the quality of the rural inhabitants' lives. The earlier applications were for lighting and telecommunications. Later, PV was used for water pumping, for providing electricity to schools/learning centers and healthcare clinics. Other examples include the use of PV in the military and police bases along the border areas and in the Royal agricultural projects. Most of the off-grid system capacity was less than 10 kW. These PV installations were financed by the government budget and implemented mainly by the Ministry of Energy. A boom in off-grid electrification was seen during 2004-2005 when the "Solar Home Program" was introduced. During that period, 203,000 units of the solar home systems (SHS) were installed by PEA throughout the country. However, the high investment cost of PV system and the high electrification rate for remote areas have slowed down the growth of the off-grid installation. For 2011, the cumulative installation capacity of the off-grid PV systems is 29.652 MW, 28.190 MW for electrical supply for school, health-care clinics and households, 1.142 MW for telecommunication and the rest 0.320 MW for rural water pumping.

- **On-grid**

  For on-grid applications, a rapid growth in solar farms has been seen since 2007 following the adoption of adder or FiT schemes. Before 2007, there were only a few installations of grid-connected PV systems. In 2004, without any financial incentive scheme being introduced, EGAT installed the first large grid-connected PV power plant of 500 kW at Mae Hong Soen Province, in the north of Thailand. In the same year, the first large PV rooftop of 460 kW was introduced at the Tesco Lotus Department Store located in downtown Bangkok. The adder measure has provided incentives for power generation from all renewable energies by paying higher electricity rate under the VSPP and SPP scheme. Table 3.1 shows a list of solar farms in Thailand, including those under-construction and scheduled to begin operations in 2012. The two solar farm mega projects - Bangchak of 38 MW in Ayutthaya and Natural Energy Development (NED) of 73 MW in Lupburi - are expected to operate and sell electricity by the end of 2011, but due to the flood crisis in Thailand their schedules have been postponed. When these power plants operate at their full capacity, they will dominate the grid-connected generation of the total PV installation in Thailand.

Table 3.1 Solar Farms in Thailand

No.	Location	Company	Module/Installation type	Capacity (MWp)	Electricity Generation (kWh/Year)	COD
1	Mae Hong Son	EGAT	Poly c-Si/ Fixed	0.504	618,000	9 Apr 2004
2	Chachoengsao	BSP	Thin film a-Si/ Fixed	1.495	2,168,000	5 Oct 2007
3	Udonthani	BSP	Thin film a-Si/ Fixed	0.282	443,000	1 Jul 2008
4	Petchaburi	BSP	Thin film a-Si/ Fixed	2.144	3,268,000	10 Feb 2009
5	Angthong	BSP	Thin film a-Si/ Fixed	1.136	1,799,000	11 Feb 2009
6	Udonthani	BSP	Thin film a-Si/ Fixed	1.563	2,451,000	2 Apr 2009
7	Nakhon Sawan	BSP	Thin film a-Si/ Fixed	0.547	865,000	1 Nov 2009
8	Nakhon Ratchasima	Solar Power	Poly c-Si/Fixed	5.940	-	30 Apr 2010
9	Lopburi	BSP	Thin film a-Si/ Fixed	2.225	3,525,000	25 May 2010
10	Ubonrachathani	EGAT	Poly c-Si/Tracking and Fixed	0.891	1,760,000	30 Dec 2010
			Thin film a-Si/Tracking and Fixed	0.121		
11	Nakhon Ratchasima	BSP	Thin film a-Si/ Fixed	1.114	1,741,000	1 Jan 2011
12	Prajuabkirikan	BSP	Thin film a-Si/ Fixed	1.949	2,972,000	1 Feb 2011
13	Sakonnakhon	Solar Power	Poly c-Si/Fixed	5.94	-	1 Feb 2011
14	Nakhon Phanom	Solar Power	Poly c-Si/Fixed	5.94	-	22 Apr 2011
15*	Ayutthaya	Bangchak	Poly c-Si/Fixed	30+8	51,831,000 + 14,408,000	Jun 2012 Mar 2012
16*	Lopburi	NED	Thin film a-Si/Fixed	73 (7 phases)	120,000,000	Phase I 22 Dec 2011

** Projects under construction*

3.2 Total Photovoltaic Power Installed

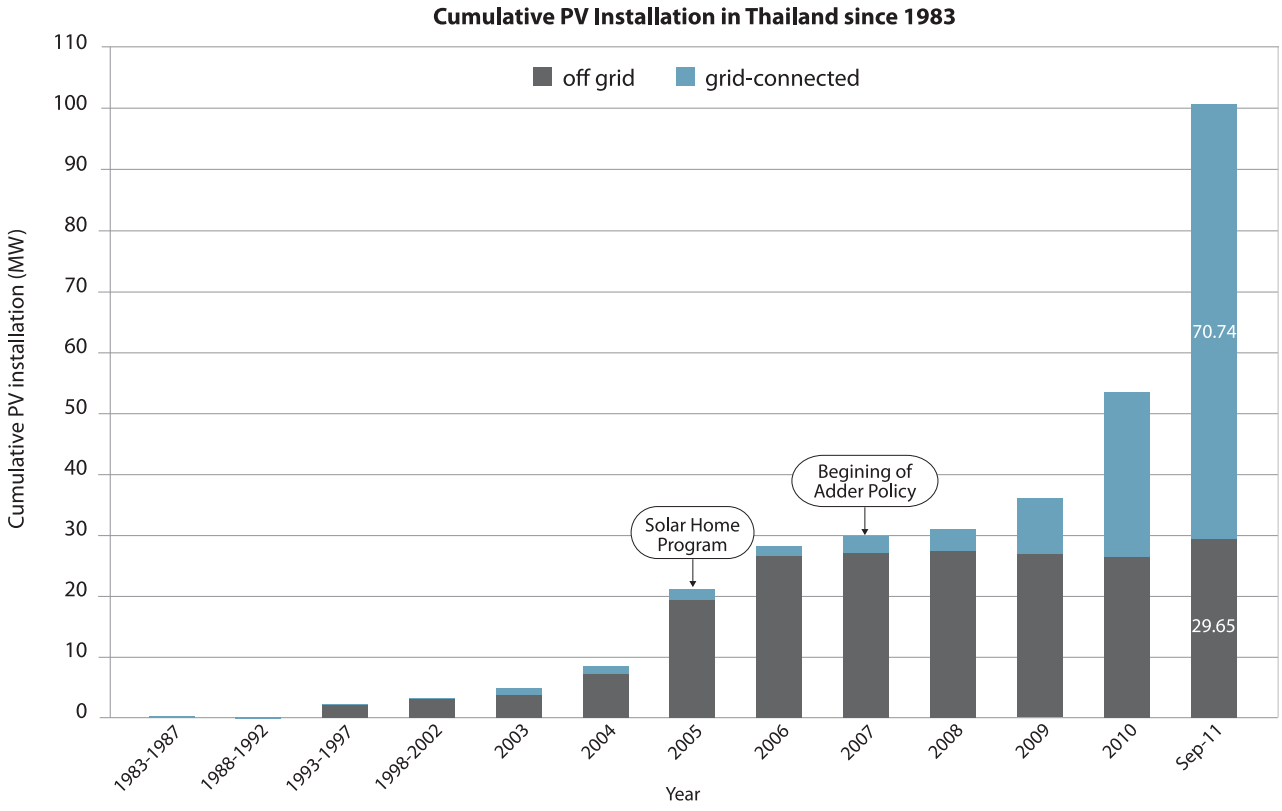


Fig. 3.1 Cumulative PV installation in Thailand since 1983 (updated September 2011)

The PV application in Thailand began in 1983 with off-grid installation in remote non-electrified areas. Slow growth was observed during 1983-2003. The system investment was rather costly and all PV installations were done using government budget. During 2004-2006, a large PV solar home project (SHS) for rural areas was launched by PEA which boosted the total PV installation capacity from 6 MW to more than 30 MW, the majority of which were off-grid systems. At the same time, this period marked the beginning of the establishment of the local PV manufacturers. It was in 2007 when the grid-connected PV systems were promoted by the government through the adder or FiT policies for all renewable energy generations under the VSPP and SPP plans. The global decline in the PV module pricing from 2009 onwards, coupled with the adder incentive, underpined a stepping up of the grid-connected PV installations in the country. In September 2011, the total accumulated PV systems installation in Thailand reached 100.39 MW, 70% of which were grid-connected. Grid-connected PV system will play an increasingly important role in Thailand, and are expected to achieve a total installed capacity 500 MW by 2016. However, the total capacity proposed for selling the electricity to grid is 3,553.91 MW (from both solar PV and solar thermal projects). The capacity of proposals in the pipeline is almost 7 times higher than the target set at 500 MW.

3.3 Total Electricity Generated from Grid-Connected PV

In 2010, the total electricity (domestically generated and imported) consumption in Thailand was 161,350,044,570 kWh. The PV generated electricity was 21,653,237 kWh (or 0.0134% of the total electrical demand). However, this number does not include those from the standalone PV systems. The breakdown of the electricity generated from PV are as follows:

Electricity Generating Authority of Thailand (EGAT)	2,202,107	kWh
Small Power Producer (SPP)	-	kWh
Very Small Power Producer (VSPP)	19,451,130	kWh
Total	**21,653,237**	**kWh**

At the end of November 2011, EGAT has signed 4 PPAs with 4 SPPs whose total installed capacity is 271.853 MW (declared net capacity of 265 MW) which will supply to grid by 2014. Seven more SPPs with the total installed capacity of 341.72 MW (declared net capacity of 336 MW) are under consideration by EGAT.

3.4 PV Mega Projects

There are two PV mega projects in Thailand whose capacity is greater than 30 MW each.

1. NED Power Plant (world's largest thin film solar farm)
The Natural Energy Development Co., Ltd. (NED), a joint venture of CLP Renewables Ltd. (CLP), Diamond Generating Asia Ltd. (a wholly owned subsidiary of Mitsubishi Corporation) and Electricity Generating Public Company Limited (EGCO), is constructing a solar power plant in Lopburi province. The project capacity is 55 MW net (73 MW gross). When completed, it will be the largest solar PV power plant in the world (www.pvresources.com). The project will install over 540,000 amorphous silicon thin film panels to meet the project capacity. It is also expected to connect with the 115 kV PEA substation. The COD for its first phase was December 2011. The plant is expected to reach its full capacity by first half of 2012.

2. Bangchak Solar Farm
The Bangchak solar farm is located in Bang pra-in, Ayutthaya province. The plant covers 500 rai (80 hectares) for the installed capacity of 38 MW. The project comprises two adjacent solar power plants, operating as a single complex. One has a net alternating current (AC) output of 8 MW, the other 30 MW. The two plants will sell their 30 MW output to EGAT and 8 MW to PEA under the SPP and VSPP arrangements. The solar cells used for the project are poly-crystalline silicon type.
Due to recent flood situation, the date for commercial operation of the power plant has been postponed until June 2012.

3.5 Highlights of R&D

Solar research and development (R&D) activities are being actively pursued by universities and government research institutes as well as by the private sector. The R&D activities range from solar cell materials to different PV applications. The basic research activities concerning the solar cell efficiency development are mostly done at a laboratory scale. However, R&D performed in the private sector, for examples at BSC and Leonics, is more focused on the product improvement and production cost reduction. The PV R&D activities in Thailand are summarized in Table 3.2.

Table 3.2 R&D Activities on PV in Thailand

	Topic	Organization	Remark
Solar cells and related materials	Silicon ingot	UEE	Physical/metallurgical-hybrid with purified solar grade (SoG) silicon
	TCO glass	NSTDA	High haze ZnO coated glass by MOCVD and sputtering techniques
		BSC	ZnO coated glass by sputtering technique
	Thin film Si	NSTDA	On glass and flexible substrates Multi-junction solar cells with low temperature coefficient
		BSC	Double junction a-Si module by batch process
	CIGS	Chulalongkorn University	High quality CIGS by molecular beam epitaxial technique
	Organic and dye sensitized	NSTDA and universities (Chulalongkorn Univ, Khonkaen Univ and Ubonratchthani Univ)	Low cost natural dye High efficiency D-D-π-A dye
PV components	Inverter	Leonics	On-grid and standalone hybrids
PV applications	System evaluation	Naresuan University	Mini grid, Tracking system Environmental effects
		KMUTT	Impact of PV penetration
		EGAT	PV tracking by water weighted Environmental effects on PV floating plant
		NSTDA	Environmental effects Loss analysis
	Techno socio-economic management	KMUTT	PV system in rural areas

4 Industry and GROWTH

2008-2011 was an exciting time for investors in the solar PV industry in Thailand. It was also a period of uncertainty. Both government and investors collaborated to restructure the policy and the regulations. The output that we see today includes the roof top installation's FiT, the adder for VSPP and SPP, and the future plan for the PV industry among other renewable energy sources. Yet a number of challenges remain; financing being one. The others identified include building regulations, power plants operation guidelines and infrastructure.

At present the Thai solar PV industry still relies heavily on imported parts and components. The majority of the solar farms' installations use imported modules and other supportive components. The value of these imported modules and parts are estimated 70-80% of the total investment, quite a high value.

4.1 Production of Ingots and Wafers

There was no wafer production in Thailand in 2011. However, Thailand has a rich industrial cluster in silica mining located along western border with Burma in Kanchanaburi and Rajaburi provinces, where the SiO_2 content is 99-99.25%. This suggests that Thailand could rely on its own upstream feed of raw material for a local wafer production. A smelting plant of arc furnaces for producing metal grade silicon (Mg-Si) has been built with a capacity of 42,000 TPA for the export markets. In parallel there is the development of a suitable solar grade (SoG) refining technology for ingot.

The current status of the value chain of the crystalline silicon type PV industry in Thailand is shown in Fig. 4.1. At present, the wafers used for the solar cells and modules fabrication are all imported.

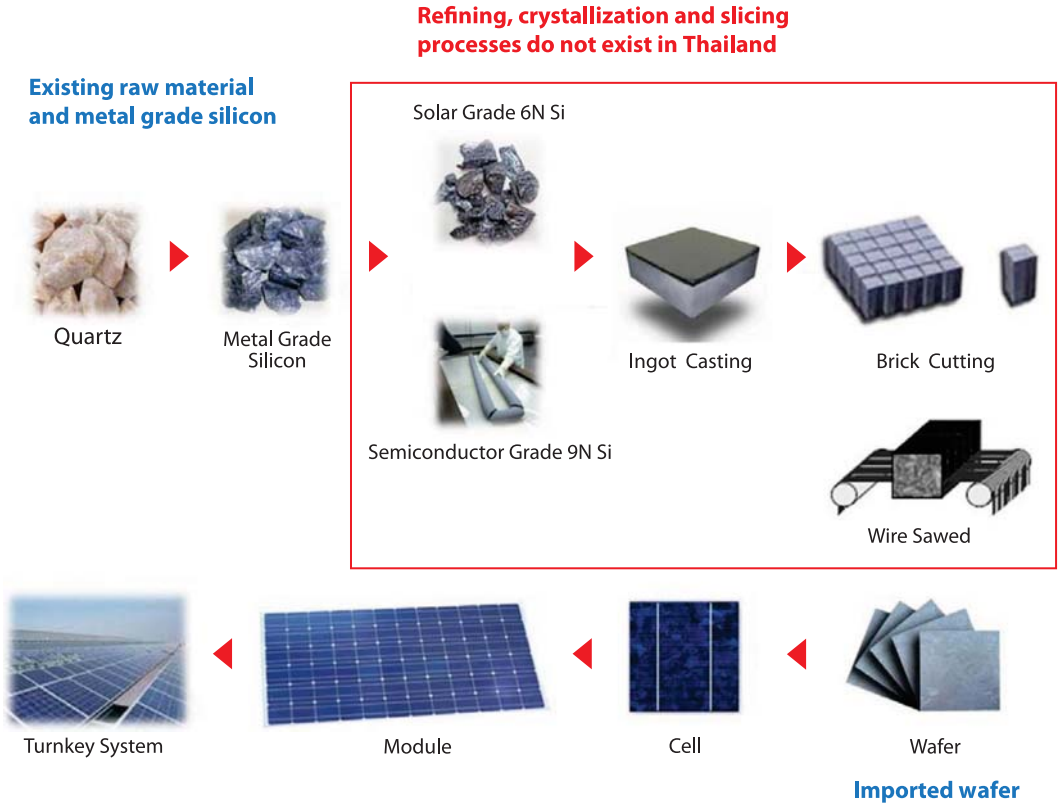


Fig. 4.1 Current status of Thailand PV industry value chain

4.2 Production of PV Cells and Modules

Table 4.1 Local Manufacturers of PV Modules and Related Materials

Type	Component	Local Manufacturer
PV module	Solar cell and module	Bangkok Solar (65 MW thin film Si) Ekkarat (24 MW mono and multi c-Si) Solartron (mono and multi c-Si)
	Module (imported cells)	Spot Solar, Sharp and Solartron
Related materials	Silicon wafer	None
	TCO glass	None
	Encapsulant sheet	None
	Junction box	Bangkok Cable

Currently, three companies make solar cells using imported TCO glasses, encapsulant sheets and wafers. The others make PV modules using imported solar cells.

4.3 Manufacturers and Suppliers of BOS and Components

There is only one Thai manufacturer that produces the power conditioning unit (PCU) for solar electrification for both off-grid and on-grid PV systems. These components contain an inverter, a charge controller and a monitoring system. The capacity of its PCU ranges from 150 W to 5 kW for the off-grid solar home system, up to 1,200 kW for the standalone hybrid off-grid system, and 2.5 kW to 1,250 kW for the grid-connected type. The solar charging controller is Maximum Power Point Tracking (MPPT) type with high voltage and current (480 V, 200 Amp). In addition, there exists a Thai company who provides the tele-monitoring and O&M service for both types of the PV installations. Tables 4.2 and 4.3 show a list of local manufacturers of BOS and PV services companies in Thailand.

Table 4.2 Local Manufacturers of Balance of System (BOS) and Components

BOS	Local Manufacturer
Inverter	Leonics
Solar charging controller	Leonics
Cable	Bangkok Cable (PV cable, XLPE cable) Jaroong Thai (CV cable, XLPE cable)
Structure	Kemrek, Leonics Esco and other local suppliers
Combiner box	Leonics (Surge protector and String power monitoring) EIC (Diode)
MV Transformer	Ekarat Engineering, Charoeanchai TF and Tusco Trafo

Table 4.3 PV Service Companies

Service	Local Company
Contractor	Italian-Thai, Toyo-Thai, Ritta-TGE, Leonics ESCO, Thai Solar Future and Demco
Engineering & Procurement and Construction (EPC)	Ekarat Solar, Bangkok Solar Power, Leonics ESCO and Thai Solar Future
System Monitoring	Leonics-MoC
Operation and Maintenance (O&M)	Bangkok Solar Power, Leonics ESCO and Thai Solar Future

4.4 System Prices

The PV system prices are established on a case by case basis based on their applications. The price also depends on the installation size. Based on available data during 2010-2011, the cost for large scale grid-connected systems with the capacity over 30 MW is estimated at 110 THB/W.

5 Highlights and PROSPECTS

In recent years, we have witnessed more dissemination and expansion of PV systems across the globe, especially with the shift towards reducing the greenhouse gas emissions. Considering all factors, Thailand is one of the most attractive places for PV investments because of its high solar energy potential and enticing government incentive policies. Although the adder price was recently reduced and the promotion policies are being modified, PV projects still receive significant attention from foreign and domestic investors.

5.1 Recent Investments

In addition to the two solar energy mega projects described in section 3.4, an additional 300 MW of the PV installations are in the pipeline. The announced projects are as shown in Table 5.1.

Table 5.1 Announced PV Power Plant Projects

Investor	Capacity (MW)	Location
Yanhee Solar and Ratchaburi Electricity	12.4	Nakhon Pathom
Solar Power Co., Ltd.	34 x 6 sites = 204	Northeastern
Solarta Co., Ltd.	9.7 + 6.2 = 15.9	Central region
Astronergy and Solar Park Co., Ltd.	5.5	Saraburi
PTT and IRPC	90 (total)	Songkla and Rayong

One among these projects is foreign investment. One of the Thai own projects belongs to the Petroleum Authority of Thailand (PTT), Thailand's largest enterprise. PTT has decided on a solar energy initiative with its first 50 MW power plant and a plan to launch another solar farm to achieve the total capacity of 90 MW in the near future.

5.2 Future Trends

In November 2011, the National Energy Policy Committee (NEPC) approved the revised REDP plan by increasing the share of renewable energy used in the total final energy consumption from the earlier 20% to 25% by 2021. The new target for each renewable energy technology is revised accordingly. For the solar power generation, the new target may reach 2000 MW by 2021. The new subsidy scheme under the FiT system will be introduced for all renewable energy generations.

Today, the PV market in Thailand is dominated by solar farms. This trend towards large scale installations is expected to grow. The revised REDP will consider the promotion of PV market for communities and rooftops as well with an increasing local content. An increase in the number of smaller distributed systems is forecasted. In addition, growth in the number of off-grid applications such solar water pumping and solar home systems for the remote non-electrified areas is expected.

Annex A:
Country Information

1) Thailand's electricity generation mainly depends on natural gas (68.6%).
(Source: Electric Power in Thailand 2010, DEDE's annual report)

2) Retail electricity prices (Year 2010)
Average electricity price: 3.11~3.35 THB/kWh
(Source: Electric Power in Thailand 2010, DEDE's annual report)

3) Electric consumption by residential sector (Year 2010)
33,337 GWh (22.3% of the total electric consumption)
(Source: Electric Power in Thailand 2010, DEDE's annual report)

4) Voltage
Household: 220 V 50 Hz

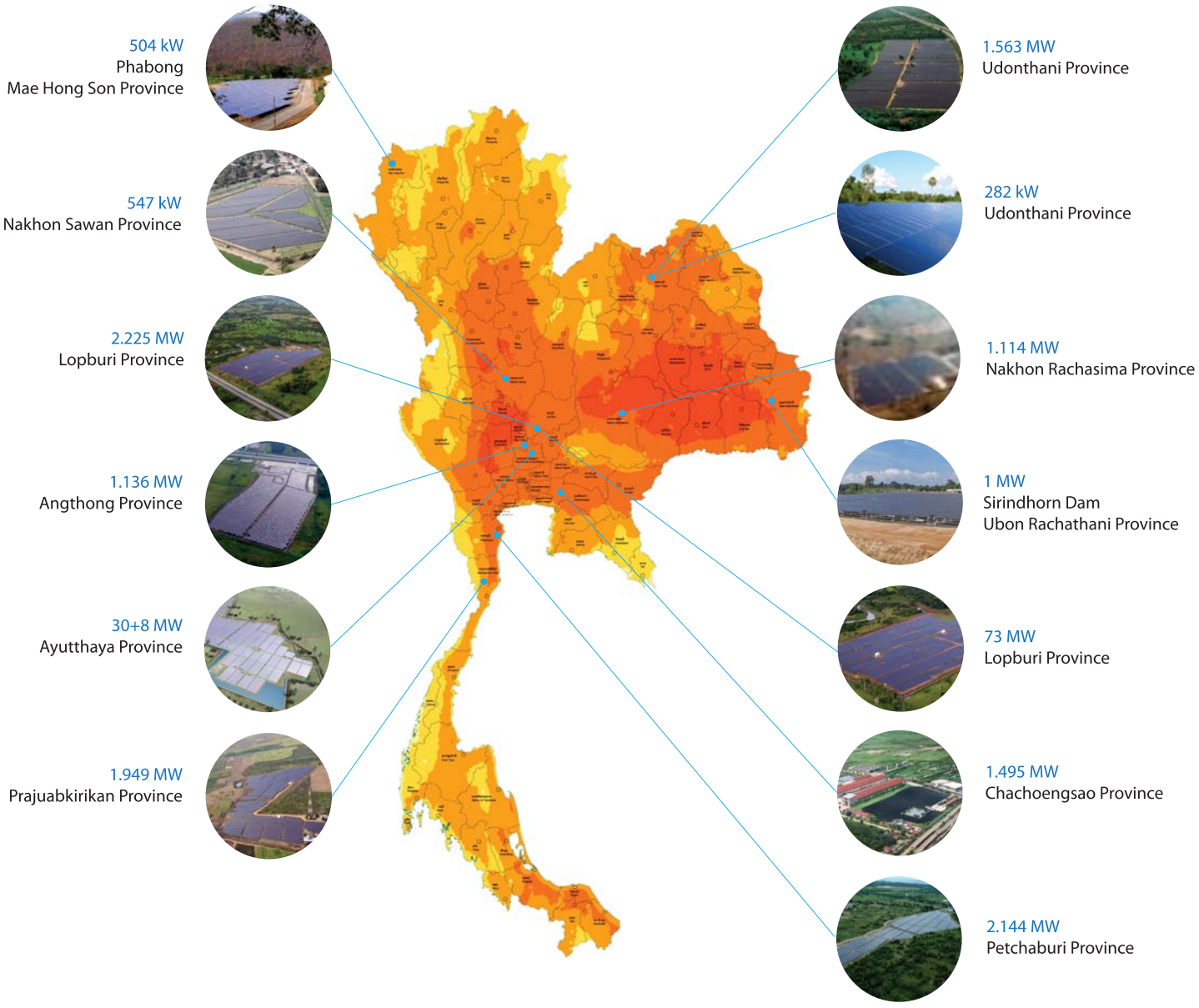
5) Retail price of diesel fuel (Year 2010)
Regular gasoline: 36.10~41.26 THB/litter
Gasohol: 30.85~32.35 THB/litter
Diesel oil: 27.55~28.69 THB/litter
(Source: EPPO)

6) Average solar radiation intensity (Year 2010)
6,500 MJ/m^2/year or 1,805 kWh/m^2/year
(Source: DEDE)

7) Typical values of kWh/kW for PV systems
1,000~1,500 kWh/kW/year
(Source: Naresuan University)

8) Climate
Tropical monsoon climate with a high degree of humidity
Annual average temperature: 22.5°C~32.3°C

Solar Farms in Thailand



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