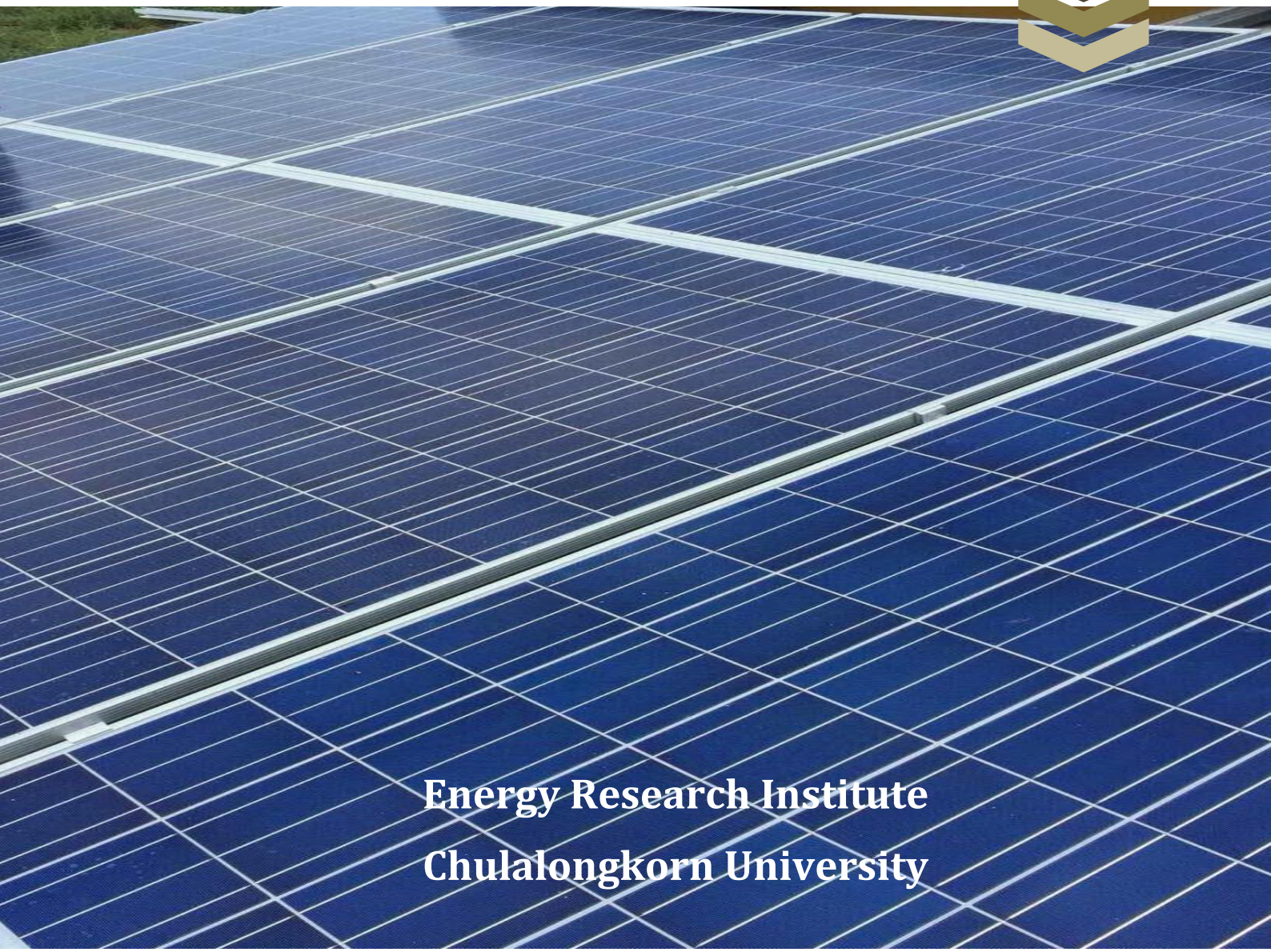
TSPR

Scaling Up Solar PV: A Roadmap for Thailand



Energy Research Institute

Chulalongkorn University

British Embassy Bangkok

Energy Research Institute

Department of Alternative Energy Development and Efficiency

MINISTRY OF ENERGY

Lead Author: **Dr. Sopitsuda Tongsopit**, Energy Research Institute, Chulalongkorn University

Authors: **Dr. Surachai Chaitusaney**, Faculty of Engineering, Chulalongkorn University

Dr. Amornrat Limmanee, National Electronics and Computer Technology Center (NECTEC)

Mr. Noah Kittner, University of California, Berkeley

Ms. Pimjai Hoontrakul, Environmental Resources Management

Special Acknowledgements:

Ministry of Energy Department of Alternative Energy Development and Efficiency

Ms. Kulwaree Buranasajjawaraporn

Ms. Thidarat Sawai

King Mongkut's University of Technology Thonburi

Dr. Dhirayut Chenvidhya

Energy Research Institute, Chulalongkorn University

Ms. Apinya Aksornkij

Ms. Morakot Tossabanyad

JULY 2015

Cover Picture: Grenzone

Executive Summary

The rapid decline in cost of solar photovoltaic technology during the past five years presents a new course for the role of solar electricity in Thailand's energy sector. Promoting energy security through decreased reliance on imported natural gas and decentralizing the electric grid, pose both challenges and opportunities for market growth. Solar PV is a critical technology to meet three objectives:

1) Utilizing Thailand's domestic energy resources,

2) Advancing the economy through sustainable development, and

3) Enabling consumer participation in energy production.

Thai public policy, including the Alternative Energy Development Plan (AEDP), mandates the share of renewable energy increase to 20% of the total installed capacity by 2036, and the economics increasingly tips the balance in favor of promoting solar electricity as a major way to meet this target.

In Thailand, the subsidy adder represented the most significant policy tool pushing for grid-connected solar electricity. The dramatic rise in installations warrants further planning and investigation for smaller, distributed rooftop generation, since the majority (>90%) of installations have been utility scale, to date. Today's transition to fixed feed-in tariffs for both rooftop and ground-mounted installations and associated regulations will continue to be improved to address the challenges of solar PV expansion and the arrival of grid parity. Future stability of manufacturing policies for BOS and modules within Thailand will aid the development of a solar PV industry that can utilize local materials and labor to promote job creation and economic development.

The following roadmap outlines three main scenario pathways for Thailand's solar power development to 2035 including 1) a Domestic Market boom, 2) ASEAN market leader, and 3) an open and innovative market. The roadmap resulted from a stakeholders' consultation process under the project entitled "Thailand Solar PV Roadmap Initiative", supported by the UK Southeast Asia's Prosperity Fund.

The projected development pathways recommend the creation of strategic industry development to capture the full value of solar PV along its supply chain, attract foreign investment in upstream manufacturing, and position Thailand as a regional R&D and testing hub for new solar developments. The findings of this report highlight the historic role of solar PV for Thailand to meet renewable energy policy targets and the future opportunities that could unlock the potential of solar for both economic development and a resilient distributed energy system that shifts the paradigm from large centralized producers to a consumer participation-based model.

Table of Contents

Chapter 1 4

1.1 About Thailand's Solar PV Roadmap Initiative (TSPR) 4

1.2 Vision for Thailand's Solar PV Industry 4

Chapter 2 6

2.1 Supporting Policies 6

2.2 Current Barriers 13

Chapter 3 17

3.1 Thailand's participation in the PV value chain 17

3.2 SWOT Analysis of Thailand's PV development and challenges 19

3.3 Summary 20

Chapter 4 21

4.1 Solar Targets by 2035 22

4.2 Benefits to Thailand: Carbon Emissions Reduction and Employment Creation 24

4.3 Elements of each scenario: Forces/Players 25

4.4 Scenario 1: Domestic Market Boom 28

4.5 Scenario 2: ASEAN Market Leader 31

4.6 Scenario 3: Open and Innovative Market 36

Chapter 5 40

5.1 Scenario 1 40

5.2 Scenario 2 42

5.3 Scenario 3 44

Chapter 6 47

6.1 Strategies for the Government and Energy Regulator 47

6.2 Strategies for the Private Sector 57

6.3 Strategies for End-Users and Communities 59

Conclusions 61

References 62

Chapter 1
Scaling up Solar PV for Thailand: An Overview

1.1 About Thailand's Solar PV Roadmap Initiative (TSPR)

Thailand's Solar PV Roadmap Initiative (TSPR) was funded by British Embassy's South East Asia Prosperity Fund. The Initiative was co-hosted by the Department of Alternative Energy and Energy Efficiency and the Energy Research Institute, Chulalongkorn University. This represented the first platform in Thailand in which key stakeholders in the solar industry-- government agencies, utilities, private companies, academia, and civil society – deliberated from the bottom up on the desirable future of Thailand's solar power development. The platform attracted stakeholders to help shape the agenda around which strategic partnerships could coalesce. In order to stimulate debates about current barriers and future visions, the Initiative organized a series of seminars and workshops between June 2013-April 2015**.** The seminars were designed for participants to express their ideas and comments on three key areas of development: policy/regulation, grid integration, and financing and business models. In addition, the two workshops enabled participants to deliberate on solar power targets to 2035 and aspirational future scenarios for Thailand's solar PV development.

The Solar PV Roadmap Initiative would like to express our gratitude to the host organizations (ERI and DEDE), our team members, and all the stakeholders who participated in the seminars and workshops and jointly developed a vision and action plans for Thailand's solar power development.

1.2 Vision for Thailand's Solar PV Industry

VISION: "***Solar PV enhances energy security through the decentralization toward green power sources and the reduction of dependence on fossil fuels."***

Thailand's increased reliance on natural gas now comprises more than 70% of its power generation, and Thailand will import more than 50% of its natural gas demand by 2020. Energy security remains a major concern, while serious environmental impacts of fossil fuel combustion are felt across economic sectors. Supplementing natural gas generation with coal-fired power plants will neither increase energy security nor ensure long-term sustainability. Solar PV is viewed not only as a clean energy option but also an empowering tool to reduce Thailand's reliance on fossil fuels and to enable more consumers' participation in electricity generation. Participants in the Solar PV Roadmap Initiative joined a collective effort to develop a vision for Thailand's solar

power development to 2035. Stakeholders envisioned **a green decentralization scenario in which households and businesses in Thailand can increase their energy self-reliance and security by choosing their power sources, either through self-generation or buying from greener third-party providers.**

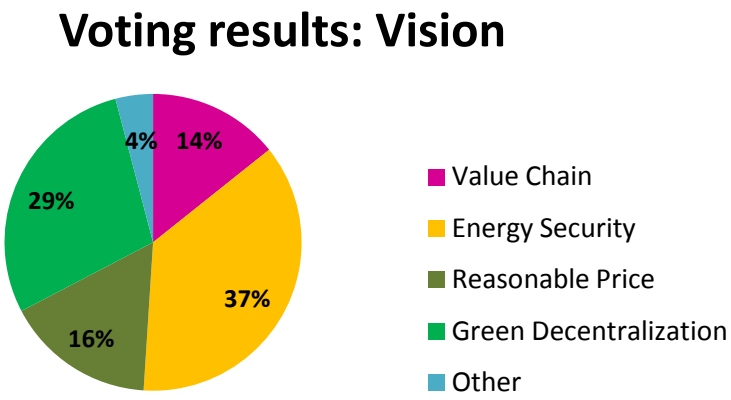


Figure 1.1: The Voting Results for Thailand's Vision of Solar Power Development to 2035

Chapter 2
Background and Current Status

2.1 Supporting Policies

2.1.1 AEDP

Thailand's Alternative Energy Development Plan (AEDP 2012-2021) set targets to increase the share of renewable energy to 25% of final energy consumption by 2021. The objectives of the AEDP are to substantially replace fossil fuels by renewable energy, reduce dependence on energy imports, promote green energy communities, support domestic renewable energy industries, and support R&D in Thailand to increase the competitiveness of Thai technologies in the global market (DEDE, 2012). Solar PV is a promising technology that can help Thailand achieve the AEDP's objectives. For the solar power sector, the major support mechanism so far has been the feed-in tariff program, locally called the Adder, whose results have been to drive an impressive growth of large-scale solar power installations, as shown in Figure 2.1. However, the objectives of solar power development under the AEDP also include the promotion of green energy communities, the support of domestic renewable energy industries and R&D – objectives whose fulfillment can distribute solar benefits to wider groups of population. The Thai government has therefore attempted to make solar benefits more accessible by introducing rooftop programs and community programs but progress has stalled due to many barriers especially permitting barriers and financial barriers.

Table 2.1: The Targets for Renewable Power in Thailand

Type of RE	AEDP targets (MW)
Solar	3,000
Wind	1,800
Hydro	324
Biomass	4,800
Biogas	3,600
MSW	400
Hydrogen	1
Geothermal	1
Tidal	1
Total	**13,927**

Notes: AEDP (2012-2021) was passed by NEPC in January 2009 and the targets were updated by NEPC on July 16, 2013

2.1.2 Adder and Its Results

The Adder Program was implemented in 2007 to incentivize the production of different types of renewable power. Adder is an additional payment paid on top of utilities' avoided cost of purchasing electricity. The adder given for solar power was set at 8 Thai Baht/kWh between 2007-2010 and was reduced to 6.50 Thai Baht/kWh. The Adder program for solar power closed in June 2010 and no new applications for the solar adder were accepted. The result of the solar adder program has been an exponential growth of solar power as shown in Figure 2 and its status as of May 2014 is shown in Table 2.2. Despite the

cessation of the adder, solar PV experienced remarkable growth. A backlog of applications coupled with rapidly declining manufacturing costs in China created a very attractive opportunity to invest in solar. Financial institutions became more willing to invest and participate in solar PV projects, which caused a surge in investment.

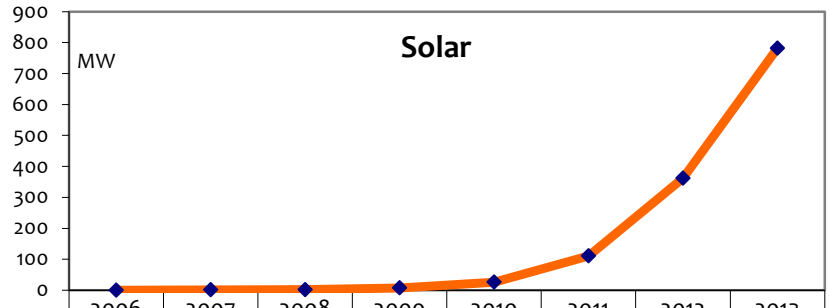
Lack of transparency and inconsistency in financial incentives undermined the initial feed-in tariff structure. Therefore, moving forward, open screening criteria and a consistent regulatory framework could make the feed-in tariff a more powerful policy mechanism to support solar PV for Thailand.

After a four-year pause in the solar adder program, the government reopened the support in the form of feed-in tariff in 2014 for a quota of about 500-600 MW of new solar farms[1]. The new solar farm capacity would receive a fixed feed-in tariff at the rate of 5.66 THB/kWh for 25 years after the commercial date of operation. The approved projects are expected to come online by December 2015.

Solar PV system, Credit: Grenzone

Solar PV system, Credit: Solventia Solar in Thailand

[1] NEPC. 2014.



	2006	2007	2008	2009	2010	2011	2012	2013
Solar	0.01	1.44	1.75	7.67	26.29	110.97	361.91	781.89

Figure 2.1: The Growth of the Installed Capacity of Grid-Connected Solar Power in Thailand between 2006-2013

10 kWp Solar PV System at Sri Thana Rice Mills, Credit: VE Solar

Table 2.2: The Current Status of Grid-Connected Solar Power Capacity and Solar Power Applications in the Pipeline

Status	Proposed			Accepted			PPA Signed			COD		
Type of Power producer	Number	Installed Capacity (MW)	Contracted Capacity (MW)	Number	Installed Capacity (MW)	Contracted Capacity (MW)	Number	Installed Capacity (MW)	Contracted Capacity (MW)	Number	Installed Capacity (MW)	Contracted Capacity (MW)
SPP (Solar)	1	45	41	0	0	0	3	221.44	220	3	184.92	175
VSPP (Solar)	182	1,011.8	991.6	2	4.4	4.25	60	253.17	236.87	241	760.09	707.91
Total	183	1056.8	1032.6	2	4.4	4.25	63	474.61	456.87	244	945.01	**882.91**

Source: ERC (2014); Notes: EGAT data is as of 14/03/2557, PEA data as of 07/05/2557, and MEA data as of 14/03/2557.

2.1.3 FiT (2013) and its results

After the discontinuation of the incentives for solar power in three years between 2010-2013, on July 16, 2013, the National Energy Policy Commission (NEPC) approved two FiT programs, which reopened the support of solar power in Thailand. The FiT programs include rooftop feed-in tariff and community ground-mounted solar feed-in tariffs with a combined total target of 1,000 Megawatts.

1) Rooftop Solar FiT Program

The first FiT program is for rooftop solar power with rates for three scales of installations (Table 2.3). The government set a total quota of 200 MW for rooftop solar FiT– with 100 MW allocated to residential-scale installations (0-10 kW) and another 100 MW allocated to commercial- and industrial-scale installations (10kW-1 MW). The NEPC resolutions initially stated a requirement of a Commercial Operation Date (COD) deadline by December 2013 as a pre-requisite for receiving FiT. However, an ERC resolution approved a deadline postponement to the end of January 2014[2] and an NEPC resolution later postponed the deadline to December 2014[3] due to the delays caused by the permitting process. Once grid-connected, the system owners will get paid for 25 years. The applications period was open

[2]ERC. 2014.
[3]NEPC. 2014.

during the 1.5 months between 23 September 2013 – 15 November 2013[4]. The 100 MW quota for commercial- and industrial-scale installations were completely subscribed in the year 2013. However, only 31.28 MW of residential-scale rooftop solar systems were subscribed. Therefore, in August 2014, the NEPC announced that approximately 70 MW of residential rooftop solar capacity will be opened up for applications with a slightly lower feed-in tariff rate of 6.85 Baht/kWh (Table 2.4).

[4] ERC. 2014.

Table 2.3: Feed-in Tariff Rates for Rooftop Solar Power Approved by the NEPC in 2013

Scale	FiT Rate (Baht/kWh)	Quota
0-10kW	6.96	100 MW (only about 30 MW was subscribed)
>10-250 kW	6.55	100 MW
>250 kW-1 MW	6.16	

Table 2.4: Feed-in Tariff Rate for Residential Rooftop Solar Power Approved by the NEPC in August 2014.

Scale	FiT Rate (Baht/kWh)	Quota
0-10kW	6.85	70 MW (to fill in the 100 MW quota)

2) Community Ground-Mounted FiT Program

The second FiT program includes feed-in tariff rates for community ground-mounted solar (1 Tambon, 1 Megawatt). This program has built-in degression in two steps, with the rate of 9.75 THB/kWh for year 1-3, 6.50 THB/kWh for year 4-10, and 4.50 THB/kWh for year 11-25 (Table 2.5). The government allocated a total quota of 800 MW for this community FiT program with the conditions that the systems be installed by December 2014. The project owner will be Thailand's Village Fund, and the project developer and O&M contractor will be the Provincial Electricity Authority of Thailand (PEA). The power produced is sold to the PEA (EPMC, 2013).

Table 2.5: Feed-in Tariff Rates for Community Ground-Mounted Solar Systems

Year	FiT Rate (Baht/kWh)
1-3	9.75
4-10	6.50
11-25	4.50

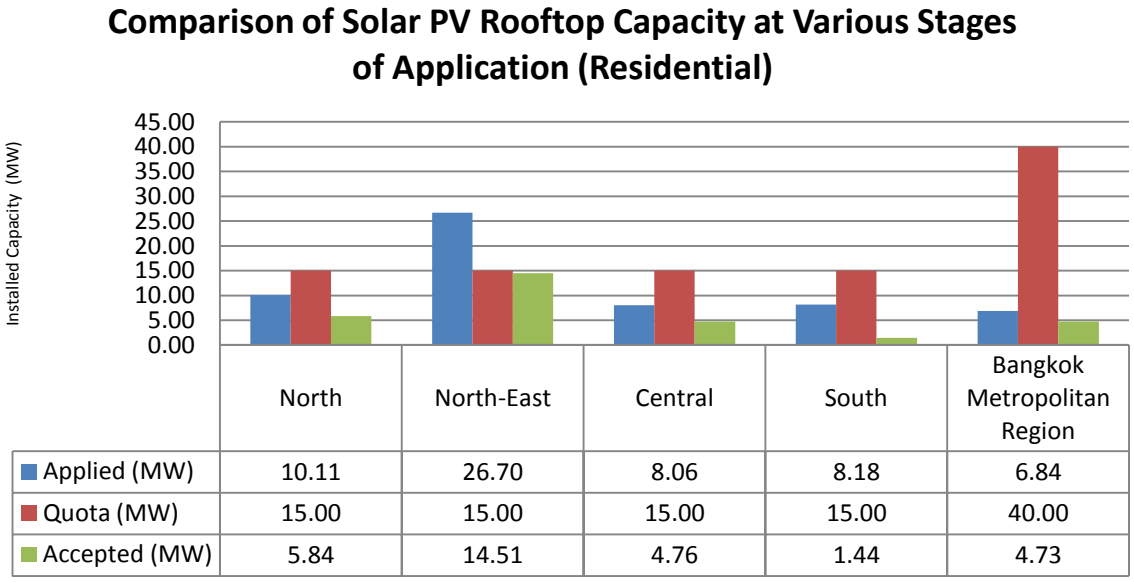
The introduction of both new FiT programs result in an additional solar target of 1,000 MW, increasing the total solar AEDP target to 3,000 MW.

Results of 2013 FiT Programs

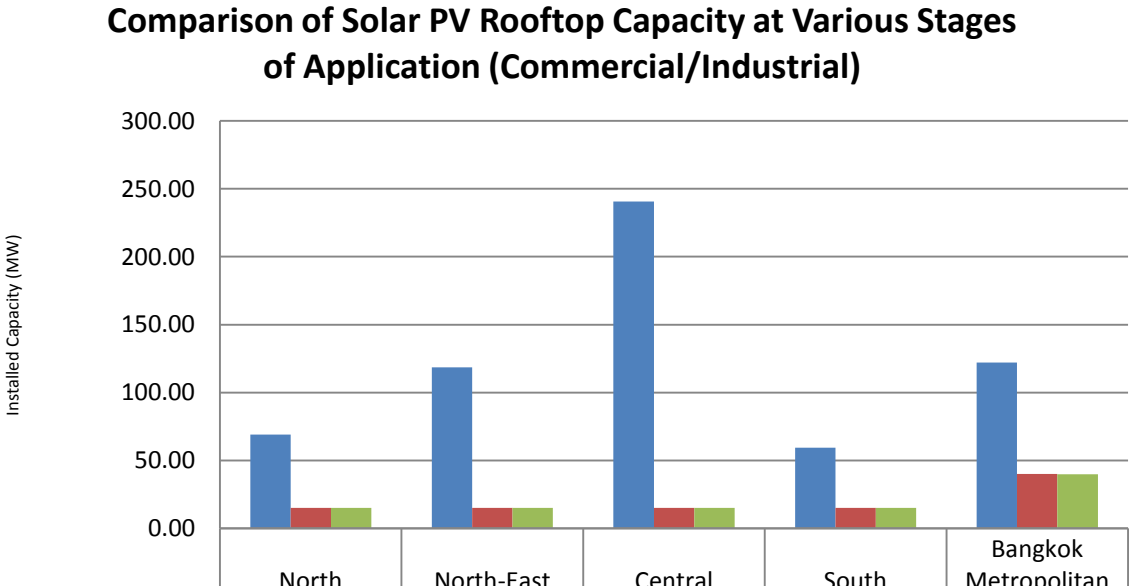
The launch of the rooftop FiT program in 2013 received positive responses from the private sector. Applications for rooftop solar FiT program exceeded the quota for the commercial and industrial scales while the applications for the residential solar FiT were lower than the quota as shown in **Figure2.2.**

As of May 2014, the community-scale incentives for solar PV development have stalled due to a lack of support from financial institutions to guarantee loans. Without the bank support, the Ministry of Energy has been unable to provide the funding for the initial communities who have applied for the 1 – MW systems. Despite community and private sector interest in developing the projects, the policy framework proposed by the Ministry of Energy will not support solar PV without good

program designs and the confidence of national banks. However, the National Council for Peace an Order, which came into power in May 2014, has transformed the 800-MW community programs into a program that would instead be sited on government properties and on the properties of agricultural co-operatives. The new program will involve Public Private Partnerships and a new set of rules, regulation, and promotional scheme is yet to be released as of July 2015.



	North	North-East	Central	South	Bangkok Metropolitan Region
Applied (MW)	10.11	26.70	8.06	8.18	6.84
Quota (MW)	15.00	15.00	15.00	15.00	40.00
Accepted (MW)	5.84	14.51	4.76	1.44	4.73



	North	North-East	Central	South	Bangkok Metropolitan Region
Applied (MW)	68.94	118.49	240.57	59.31	122.03
Quota (MW)	15.00	15.00	15.00	15.00	40.00
Accepted (MW)	15.00	15.00	15.00	15.00	39.85

Figure 2.2: A Comparison of Applied and Accepted Applications for Residential, Commercial, and Industrial Rooftop FiTs in Different Regions of Thailand
Source: PEA (2014); MEA (2014)

2.2 Current Barriers

In the TSPR workshop on December 12, 2013, a survey was conducted and allowed 42 participants to prioritize the types of barriers to solar PV development in Thailand. The results are shown in **Figure 2.3.** The description of these barriers reflects direct experiences of financiers, investors, developers, and government officials expressed in the seminars held by TSPR between 2013-2014.

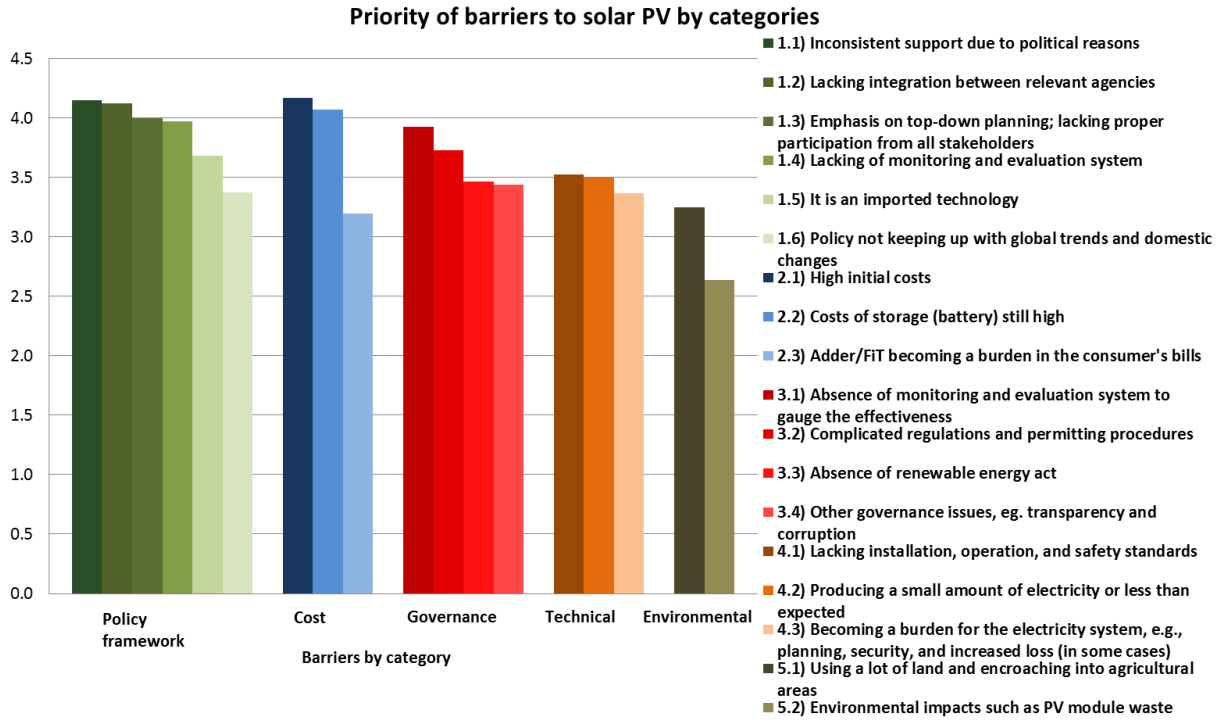


Figure 2.3: Stakeholders' Ranking of Solar PV Barriers in Thailand

The highest ranked barrier is the high initial cost of solar modules (4.17), followed by policy uncertainties (4.15), the lack of integration between different agencies (4.12), the high cost of energy storage (4.07), and the policy emphasis on top-down planning (4.00), which does not allow proper participation from stakeholders. These barriers are grouped into categories and discussed in more details below.

2.2.1 Policy and Politics

Policy uncertainties remain a key element of Thailand' solar power development. The Adder support for solar power that began in 2007 was interrupted in the three years between 2010-2013 and was followed by a brief opening of new support in the form of feed-in tariffs in the two months period between October-November 2013. Uncertainties and discontinuities in incentive scheme or financial support policies make project investment valuation difficult and severely limit investors' interest.

Political influence and the emphasis on top-down planning have resulted in limited opportunities to integrate important information from stakeholders and to coordinate well with relevant government agencies. For this reason, policy designs and permitting

procedures that appear workable in the beginning often run into obstacles during the implementation stage. A case in point is the requirement of Industrial Permits for residential-scale rooftop solar systems. While the recent rooftop solar regulation released by the Energy Regulatory Commission is effective and efficient, developers find that many other laws outside of the Ministry of Energy's and ERC's jurisdiction are blocking residential-scale projects from materializing. In addition to the Energy Industry Act 2007, solar projects sized greater than 3.7 kilowatts have to comply with the Factory Act 1992, the Building Control Act 1979, and the Energy Production and Development Act 1992, and the associated authorities.

Multiple institutions govern the integration of solar PV on the grid. When the Ministry of Energy sets targets for solar PV generation, the lack of clarity creates confusion for prospective investors in solar projects. For instance, without proper grid interconnection standards, it remains unclear whether certain projects will pass different stages of the permitting process. Additionally, it remains up to EGAT or the PEA/MEA to determine whether the project will be suitable for grid integration. The goal of EGAT and the PEA/MEA are to ensure reliable electricity generation and therefore they do not want to add expensive infrastructure to balance loads and maintain grid stability during periods of intermittency. Investment in smart grid infrastructure could help overcome these barriers, but the discrepancy still holds between the goals set forth by the Ministry of Energy and the practice implemented by electric utilities such as EGAT.

2.2.2 Governance

The support for solar power in Thailand can be characterized by weak governance overall. Despite the presence of the Alternative Energy Development Plan (AEDP) and its targets, there is no mechanism to ensure that the targets are met and that relevant agencies the public sector undertake their responsibilities in the most effective manner. Complicated permitting procedures remain a major barrier of solar power development of any scale. Furthermore, complicated permitting procedures coupled by low transparency make the process of securing the right to Adder and FiT vulnerable to "the influence of dominant and influential stakeholders." As revealed by the extensive interviews with stakeholders in Eclareon (2014)'s research and expressed by Solar PV Roadmap Initiative's stakeholders, there was a presence of "extra-administrative fees" in various steps of acquiring permits for solar PV rooftop.

2.2.3 Economics

The high upfront cost of solar power remains one of the highest ranked barriers. This is especially true for small-scale rooftop systems whose potential buyers may not be able to afford the upfront cost. But the economic equation is changing as average solar modules prices are projected to decline through the rest of 2014 (NREL, 2013a), and according to some studies, through 2035 (IEA, 2014). The International Energy Agency (IEA) has forecasted a declining trend of PV module cost as shown in Figure 2.4. It is expected to fall 50% in the next 20 years to $0.3-0.4 (real value) per watt-peak by 2035 (IEA, 2014). Utility-scale prices are expected to be in the range of 4.8-11.9 US cents/kWh by 2035; whereas rooftop-scale system prices are

expected to be in the range of 5.5-19.7 US cents/kWh by 2035 (IEA, 2014, p.p. 24). In general, PV module cost declines 20% (23-24% for thin films and 19-20% for c-Si) for every doubling in cumulative installed capacity (IRENA, 2012).

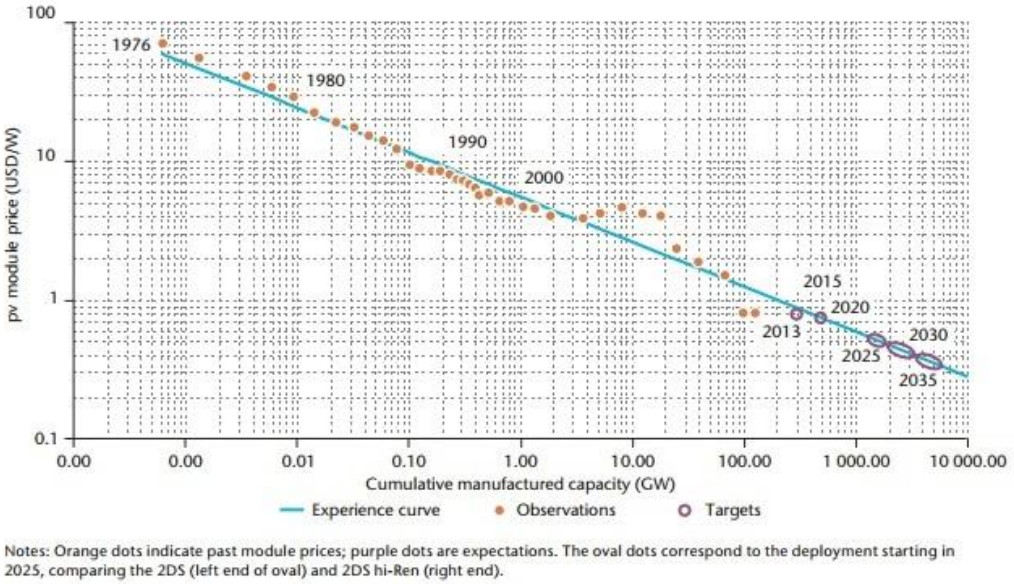


Figure 2.4: Solar PV Module Price Forecast
Source: IEA (2014)

Already in many countries, solar power has become competitive with grid electricity. Financial innovation and innovative business models are increasing the installed capacity of solar power despite upfront capital costs by deferring ownership to utilities or creating leasing arrangements. For Thailand, with the assumption of 7% retail price rise per year, residential rooftop solar electricity could become competitive by 2024.

Reducing soft costs of solar PV may play a critical role in making solar PV more financially viable in Thailand. Across the world, the largest barriers include the cost of permitting, balance-of-system components, and other policy-induced components that augment the price per Watt of solar PV.

Innovative financial arrangements including those by Solar City and Solar Mosaic provide leasing or crowdsourcing options to support solar PV projects. Currently in Thailand, the market does not exist for leasing or crowdsourcing financial investment, preventing investors with little upfront capital from being able to participate in solar development. Furthermore, since not all sites in urban areas are suitable for solar PV, the leasing and crowdsourcing methods both provide ways to make efficient use of rooftop spaces that receive more insolation. People who want solar PV power, but lack suitable sites for rooftop PV can also invest through crowdsourced funding schemes.

2.2.4 Technical

The Adder program drove the emergence of solar farms in many locations across the country, but there is an agglomeration of projects particularly

in areas of high solar irradiation in the Northeast of Thailand. This physical clustering of supply does not overlap well with the availability of electrical loads, and therefore sparking the debate on increasing losses and increasing costs of transmission investment. This experience with the solar farms should not be used as a basis for judging future usefulness of solar power in Thailand, however. Distributed solar at the residential and commercial-scale in the presence of loads offer great benefits in terms of peak demand reduction and the deferral of investment in generation, transmission, and distribution facilities.

Geographic and spatial diversity of rooftop PV aggregates to smooth the variable generation. During cloudy days, some roofs underneath the clouds will not be able to produce much electricity, but there is a higher chance that there may be grid-connected roofs that are not subjected to the same weather. Compared to a ground-mounted solar farm, this offers benefits during cloudy days to produce some power instead of completely shutting down generation.

2.2.5 Environmental

Though the life-cycle carbon emissions of solar power are small compared to fossil fuels (NREL, 2013b), other environmental impacts during the manufacturing stage remain of concern. Since there are few air emissions during the use-phase of the panels, they could be a great strategy to shift away from electricity sources that contain large amounts of SO2 and NOx. The expansion of utility-scale solar power systems (solar farms) sometimes displaces agricultural areas such as those used for rice, cassava, and sugarcane cultivation. In Thailand, there is currently no public framework to handle land use competition between the energy and agricultural sector. Examples of land use regulation that affect large-scale solar installations can be found in the FiT regulation of Ontario and the National Planning Policy Framework of the UK (Ontario Power Authority, 2014; BRE, 2013; Department for Communities and Local Government, 2013). Both legal frameworks express a preference for development to be directed to land outside prime agricultural lands.

In addition to land use concerns, the implications of end-of-life PV panel disposal remain largely unexplored in Thailand[5]. Currently, PV panels at the end of their life are regulated by the Industrial Act, 1992[6], but there is no guarantee that the PV panels are disposed properly with proper recovery of material and the minimization of the releases of toxins. Massive waste volumes will result at the end of the 25-year lifetime of the 1,300 Megawatts solar farms currently operational and in the pipeline to be developed in Thailand. Without forming proper policy for disposal, many of these solar panels will end up in landfills.

[5] Kittner et al. 2013.

[6] Department of Industrial Works. 2014.

Chapter 3
Thailand's Participation in the PV Value Chain and SWOT Analysis

Solar PV power has been rapidly growing in recent years due to supporting policies worldwide combined with decreasing investment cost. As a result, solar power became more competitive than ever before and is expected to be a significant part of the world's future energy mix. Thailand is predicted to outstrip other ASEAN markets for PV installation since Thailand's newly released adder scheme will drive 2.9 GW of installation by 2017. However, at present Thailand's position in photovoltaics value chain, as shown in **Figure 3.1**, is focused on downstream deployment and still relies heavily on imported part and components.

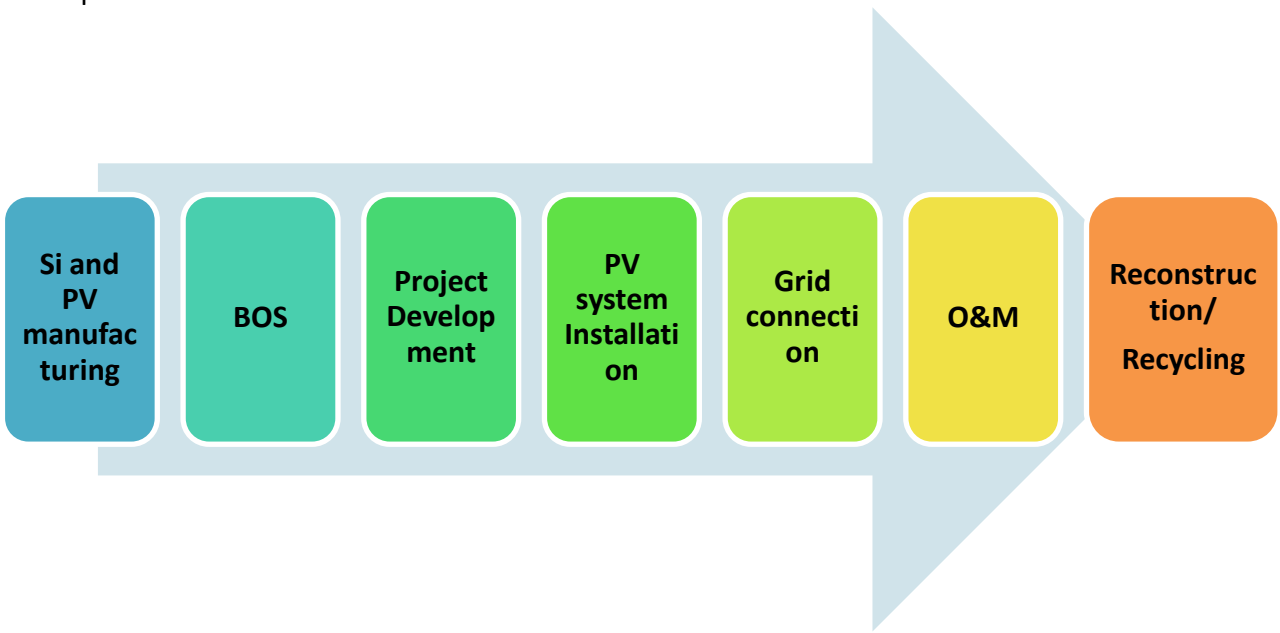


Figure 3.1: Thailand solar PV value chain

3.1 Thailand's participation in the PV value chain

Key players in Thailand's solar value chain include manufacturers of modules and BOS components, project developers, financiers, EPC contractors, and O&M contractors. As can be seen in Table 3.1, there are a few local module manufacturers with a total capacity smaller than 200 MW. Due to small-scale production, these domestic PV module manufacturers face difficulty in competing on price with foreign manufacturers. There is only one Thai manufacturer that produces inverters. As shown in Table 3.2, there exist Thai companies who provide cable, structure, combiner box and MV transformer. Note that the given lists of foreign companies are only examples.

PV service business has boomed, owing to the policy packages consisting of feed-in-tariff rates for rooftop and ground-mounted solar systems with a total target of 1000 MW. This 1 GW

installation is due to complete in the next few years. As can be seen in Table 3.3, there are many companies, both domestic and foreign companies, delivering engineering, procurement and construction services (EPC) together with the provision of operations and maintenance (O&M) services.

Table 3.1: Local Manufacturers of PV Modules and Related Materials

		Local manufacturer
PV module	Solar cell and module	Bangkok Solar (65 MW Thin film Si) Ekkarat (24 MW mono and multi c-Si) Solartron (70 MW mono and multi c-Si)
	Module (Imported cells)	Spot Solar, Sharp, Solartron
Related materials	Silicon wafer	None
	TCO glass	None
	Encapsulant sheet	None
	Terminal box	Bangkok Solar

Table 3.2: Manufacturers of Balance of System (BOS) and Components

BOS	Local manufacturer	Foreign company
Inverter	Leonics	SMA, Schneider,
Solar charging controller	Leonics	-
Cable	Bangkok Cable Jaroong Thai	Multi-Contact
Structure	Kemrex, Leonics Esco,	Versolsolar Hangzhou
Combiner box	Leonics, EIC	-
MV Transformer	Ekarat Engineering, Charoeanchai TF	-

Table 3.3: PV Service Companies

Service	Local company	Foreign company
Contractor	ItalThai, Toyothai, Leonics ESCO, SPCG	Solventia Solar
Engineering & Procurement and Construction	Ekarat Solar, Bangkok Solar Power, Leonics ESCO, Thai Solar Future, CH.Karnchang, Power Solution Technologies, Pro Solar	Annex Power, Conergy, Jardine Engineering, Sun Edison energy Engineering, REC Systems, Mctric,

Service	Local company	Foreign company
(EPC)	Group, Energy&Environmental Management, SPCG	Performed Line Products, Sonnedix Solar, Solventia Solar, Tsus Excellent Engineering
System monitoring	Leonics-MoC, SPCG	Conergy
Operation and Maintenance (O&M)	Leonics ESCO, Power Solution Technologies, Energy&Environmental Management, SPCG	-

3.2 SWOT Analysis of Thailand's PV development and challenges

Owing to the adder program, which was implemented from 2007 to 2010, Thailand's solar capacity has bounded from less than 2 MW in 2007 to 782 MW at the end of 2013. And newly released adder scheme for solar rooftop in 2013 is expected to continue the PV growth in Thailand. While the adder program has been noted to have some trouble with administrative inefficiencies which have slowed application approvals, it has been successful thus far in attracting foreign investment, and will likely continue to do so.

An analysis of the internal Strengths and Weaknesses of Thailand's PV and also the Opportunities and Threats (SWOT) is shown in **Table 3.4.**

Table 3.4: SWOT Analysis

Strengths	Weaknesses
⅄ Geographical location - Centre of ASEAN - No big disasters like earthquake, volcano eruption. ⅄ Longer experience on solar farms than other ASEAN countries ⅄ PV incentive policies	⅄ Unstable policies ⅄ Difficult to compete on price of products ⅄ No promotion for local content ⅄ Underestimation of problems that may arise from incentive policies
Opportunities	**Threats**
⅄ A leading country of ASEAN in solar energy utilization ⅄ Consulting, EPC and O&M services for neighboring countries ⅄ Hub of PV R&D and testing under tropical climate	⅄ Strong competitors like Singapore and Malaysia. These two ASEAN countries have high potential to increase their international competitiveness.

Clearly, Thailand can be a leading country of ASEAN in solar energy utilization because of its promoting policies and excellent geographical location. The experience of Thailand of mega-scale solar farms would be potentially fruitful source of information for other ASEAN countries. Furthermore, regarded as one of the top emerging markets, it is a good chance for Thailand to become a new hub of PV testing services. Even though the incentive policies have enhanced the PV installation capacity of Thailand dramatically, the majority of the solar farms' installations use imported modules and other supportive components. The ratio of local labor cost to total investment cost is found to be significantly small. Additionally, a rapid increased PV penetration also causes technical problems on the existing electricity grid.

Among ASEAN countries, Singapore and Malaysia have high potential to increase their international competitiveness in the PV field. Singapore has high-level science, technology and engineering skills, and also has strong international links. The Solar Energy Research Institute of Singapore (SERIS), Singapore's first major research centre in solar energy, had a technology transfer agreement with the Fraunhofer Institute and already established of the solar module testing and certification centre. However, air pollution which occasionally caused by neighbors' forest fire smoke makes its location unsuitable for the PV field test. Malaysia has emerged as one of the major hubs of the largest solar PV manufacturers in the world. Major solar PV companies in the country are considered as the makers of high quality solar products, making the industry as a main growth area for Malaysia's economy. Several solar companies in the country are: First Solar, Inc. (USA); Q-Cells SE (Germany); SUN POWER (USA); Panasonic Corporation (Japan).

To become the 'real' leader of ASEAN and a good role model in the solar PV utilization, Thailand needs to develop many frameworks for improving PV related skills, standards and technologies as will be outlined in Chapter 6.

3.3 Summary

- Thailand has opportunity to position itself as an expert on EPC and O&M services, a testing hub and a developer of specific PV technologies for high temperature regions.
- Frameworks for improving EPC skills and testing & certification and enhancing international cooperation in R&D are necessary for Thailand.
- Reuse/Recycling of a large amount of end-of-life modules in the next few decades is also a challenging task.

Chapter 4
Development of Three Scenarios of Thailand's Solar Power Development to 2035

Inspired by Shell Global Scenarios to 2025 (Shell, 2005), the three scenarios of Thailand's solar power were developed to enable the visualization of future paths for Thailand's solar PV development. Political and economic uncertainties provide a backdrop from which these paths may emerge. Stakeholders in the TSPR workshop on March 31, 2014 helped identify drivers, barriers, challenges to achieving the final outcomes of each scenario.

Description and summary of each scenario

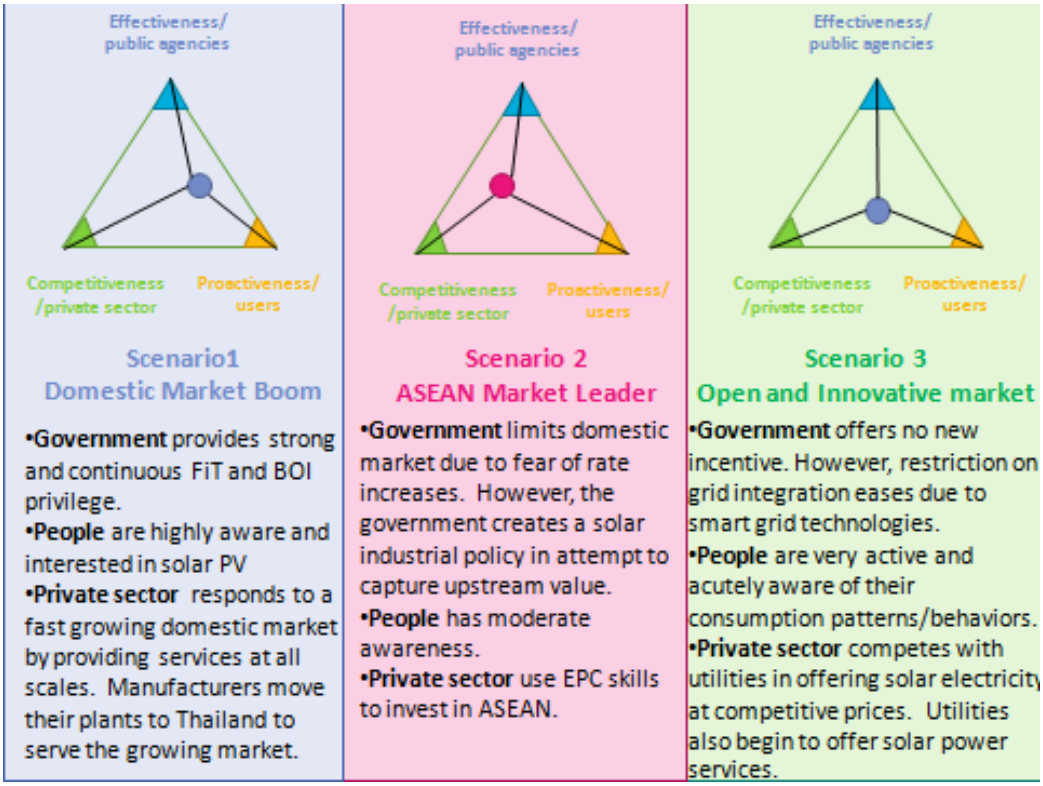


Figure 4.1: Comparison of 3 Scenarios under different influence of the main players

- **Domestic Market Boom:** Favorable political conditions and the government's commitment to reduce carbon emissions provide strong and continuous support for the solar market in the short- to medium-term. As a result, the solar power market in Thailand expands rapidly until it

achieves a significant share of the total installed capacity by 2035.

- **ASEAN Market Leader:** The solar market faces limited support from the government in the short term due to reservations among politicians and bureaucrats on the benefits of solar power and the selective focus on costs. However, seeing the higher upstream benefits, the government shift policy focus from domestic use toward domestic manufacturing. The government attracts global manufacturers to establish plants in Thailand while giving incentives for the sourcing of local materials and workforce. However, due to limited domestic market, experienced developers and EPC contractors in Thailand expand into other ASEAN markets and bring Thai expertise in project development, design, and engineering skills, while the domestic solar market remains stalled. Therefore, Thailand becomes a manufacturing hub of solar energy technologies and a training hub for ASEAN solar workforce.

- **Open and Innovative Market:** Consumers are highly aware of power production options and seek to minimize impacts of power production to the environment through energy efficiency improvement and self-generation from clean power sources. Fossil fuel prices are on a steep rise in the medium to long term, making solar power competitive and inducing a broader base of consumers to install solar power systems. Utilities' deployment of smart grid technologies enables a smooth transition from centralized toward decentralized grid system. Small enterprises thrive, offering diverse, innovative power management solutions that meet consumers' needs and eventually compete with the utilities in providing clean power to end-use customers.

4.1 Solar Targets by 2035

In order to quantify the solar targets under each scenario, a set of assumptions called scenario logics, shown in Table 4.1, 4.2 and 4.3, were used together with assumptions under the PDP up to 2030, and a linear projection of the country's total installed capacity assumption up to 2035. The growth rate of solar power under each scenario is then derived, as shown in Figure 4.2.

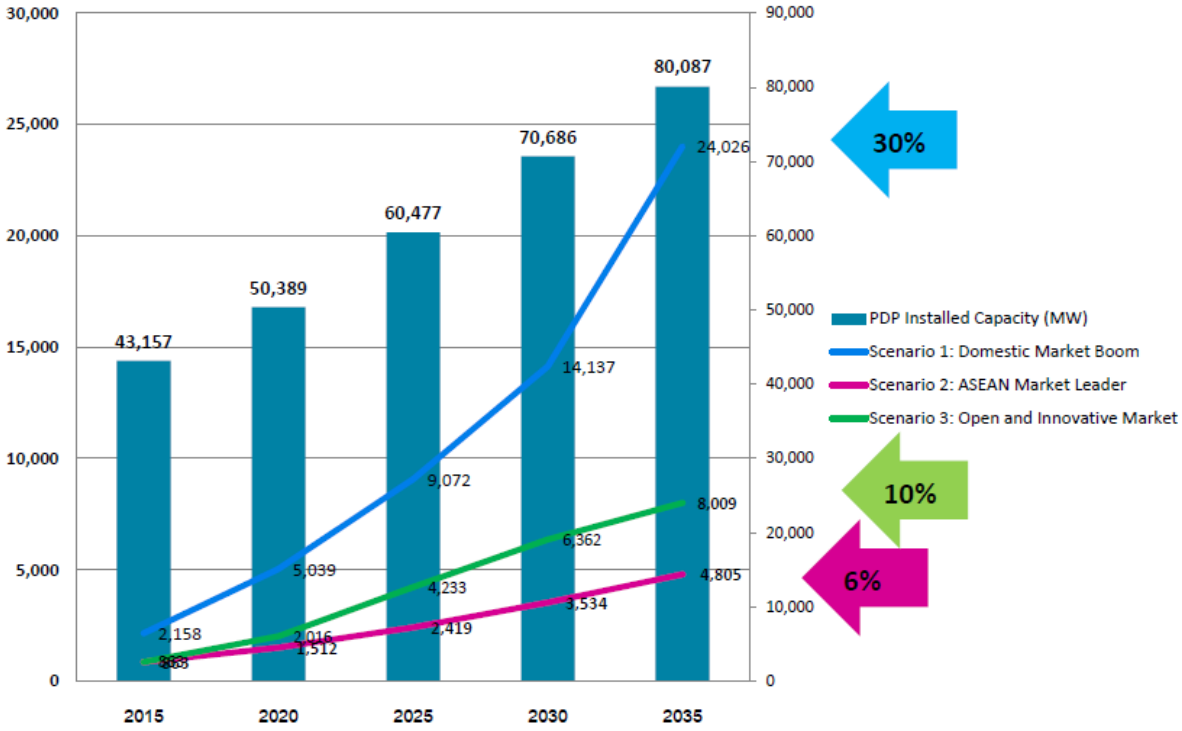


Figure 4.2: Comparison of 3 Scenarios and Forecasted installed Capacity (MW)

The growth rate assumptions of solar installed capacity between 2015-2035 could be categorized into:

- **High Case (Domestic Market Boom):** The High Case has a share of solar installed capacity to the total country's capacity at 30% in the year 2035. This share of 30% represents stakeholders' preference, which was derived from the result of a survey conducted in a TSPR seminar and the maximum voting result from the participatory workshop on 12 December 2013[7] (Figure 4.3).

- **Low Case (ASEAN Market Leader):** The share of solar power in the country's total installed capacity is 6% in the year 2035. This assumption was developed based on the current situation in which the Thai government has not yet provided a strong support for solar energy. As a result, Thai developers and EPC contractors build up their marketability in the international market instead.

[7] June 21, 2013 Seminar: "The Integration between Solar PV and the Grid: Key Issues for Thailand" and December 12, 2013 Seminar: "Seminar on Removing Barriers for PV Rooftop System", co-hosted by GIZ and ERI.

- Thus, the solar installed capacity growth in 2035 is set at 6% which corresponds to business-as-usual projection. According to the current AEDP, the solar target is 2021 is set at 3,000 MW, which is approximately 5.9% of the total installed capacity in 2021.

- **Medium Case (Open and Innovative Market):** The share of solar power to the country's total installed capacity is 10% in the year 2035. It was set to fall between the two scenarios mentioned above.

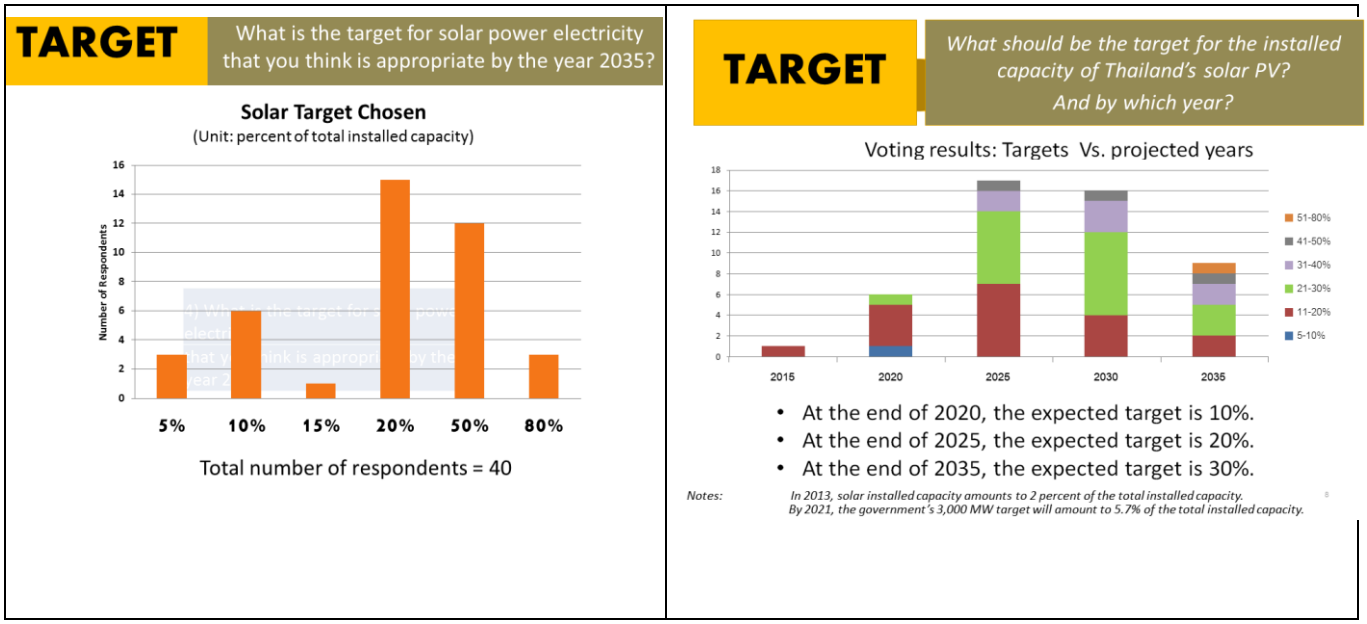


Figure 4.3: Voted Targets of Solar PV as a Share of Thailand's Total Installed Capacity

4.2 Benefits to Thailand: Carbon Emissions Reduction and Employment Creation

Three types of benefits were calculated based on the development under the three scenarios. These numbers represent conservative estimates of benefits since other types of benefits have not yet been taken into account, including GDP growth, deferral of generation, transmission, and distribution investment, and the hedging against fossil fuel prices fluctuation.

Table 4.1: Benefits of solar PV installation in Thailand

Benefits	Domestic Market Boom (High Case)	ASEAN Market Leader (Low Case)	Open and Innovative Market (Moderate Case)
CO_2 emission reduction (tCO2)	18,703,163.89	3,740,632.78	6,234,387.96
Fossil Fuels Reduction (ktoe)	2,895.54	579.11	965.18
Jobs Creation (Jobs)	70,052.65	15,523.84	17,975.51

4.3 Elements of each scenario: Forces/Players

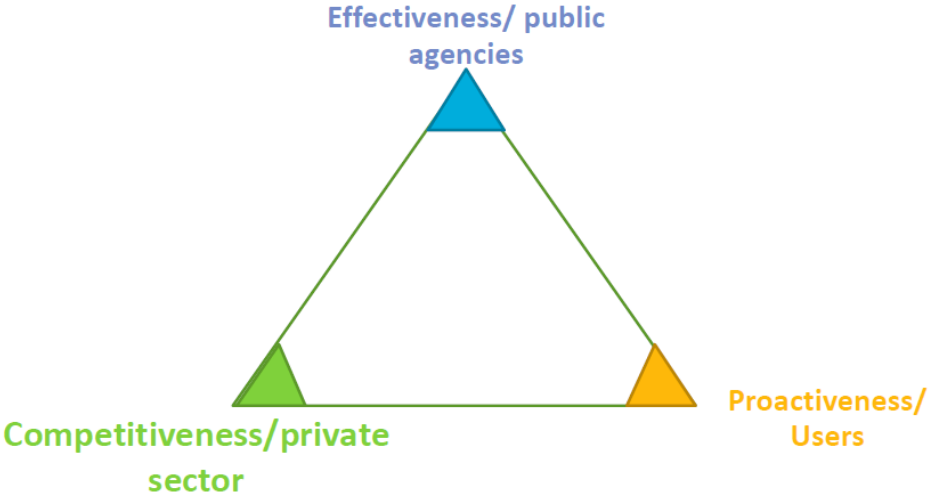


Figure 4.4: The three main players

Thailand's solar power development is shaped by the balance of three driving forces, namely public agencies, the private sector, and consumers. Each driving force, placed on each corner of the triangle in Figure 4.3, exhibits a certain element that is ideal for solar power support. While the three driving forces may simultaneously happen in the ideal world, the scenarios in this roadmap were developed based on the overlapping of two strong driving forces.

4.3.1 Effectiveness/ public agencies

• Policy-making agencies including the Energy Policy and Planning Office (EPPO) and the National Energy Policy Council (NEPC), and implementing agencies, including the Energy Regulatory Commission (ERC) and the three utilities (EGAT, PEA and MEA), are the key public agencies involved in solar PV deployment.

• These public agencies could build up a supportive environment or discourage the

solar PV development with policy uncertainties.

• Well-designed and well-implemented market incentives, could help PV reach its target, drive down the cost, and encourage people participation.

• On the other hand, ineffective policy and regulatory frameworks could cause confusion among stakeholders, increase investment risk, and create a bad image of the PV development.

Current Status:

Policy uncertainties have historically been a key characteristic of Thailand's solar power policy with the frequent rule changing between 2008-2010 and on-again, off-again feed-in tariff support. While utility-scale solar power capacity continues to increase due to the long backlog of contracts in the pipeline, no new application for feed-in tariffs is currently accepted**.** At the same time, 2013's launch of feed-in tariff support for rooftop solar power set a relatively low target of 200 MW. There was no clear prospect of policy continuation until the 2014's announcement by the National Council for Peace and Order (NPCO) on August 15, 2014.

4.3.2 Competitiveness/private sector

• Private businesses in the PV value chain include module manufacturers, panel distributors, equipment sellers, consulting companies, independent power producers, and EPC contractors.

• The private sector can be a driving force in terms of contributing to policymaking, building skilled workforce, and increasing public awareness and demand for additional solar PV capacity.

•More ASEAN economic integration in the near future may mean opportunities for early movers that specialize in the green power industry to tap into larger markets.

•The degree of competition in the domestic market is strongly influenced by the policy and regulatory landscape. Even though solar power market expansion is strongly driven by global modules prices, domestic market conditions and government intervention can cause system price differentials as evidenced in the comparison between U.S. and German system prices (LBNL, 2013).

• A highly competitive environment characterized by guaranteed grid access, low barriers to entry, low transaction costs of permitting, and no subsidies for fossil fuels, can lower the price differentials between countries. Therefore, whether pricing conditions are competitive can be an important driving force that shapes future PV market scenarios. A competitive market can stimulate entry and induces new business models for increasing access.

Current Status: The current market for solar power in Thailand is non-competitive and can limit the role of the private sector due to three main reasons. First, grid access is not guaranteed due to technical concerns and the lack of standardized grid access protocol. Second, the permitting process remains complex and involves many agencies and delays. And third, the emphasis on top-down planning allows disproportionate influence by large market players in policy and regulatory design at the expense of proper participation and feedback from all stakeholders.

The lack of competition in Thailand's solar market has meant a high risk environment for investors and a lack of incentives for new entrepreneurs to initiate new business models for broader access. Given the limited size of the domestic market, big players in the Thai PV market are already looking abroad for investment opportunities.

In regard to Thai people's roles in the solar industry, more skilled workforces are being built in solar farm businesses and many companies already have plans to expand the solar farm business into neighboring countries. However, the government does not have strategies on the upstream, midstream, and downstream section of the solar industry – thereby foregoing opportunities to systematically build value and build important human skills in the solar industry.

4.3.3 Proactiveness/Users

• Across the globe, a green mindset is driving the adoption of eco-friendly products or services than ever before. Electricity consumers today are becoming more aware of the sources of their power and many have expressed a preference for green self-generation.

• Proactive users of the future, especially owners of rooftops, will likely participate in the investment in solar systems provided that new business models allow for more widespread investment by individual or groups of customers.

Current Status: Many surveys' results have shown Thai consumers' preferences toward green power, especially solar power . The Solar PV Roadmap Initiative policy deliberation process revealed stakeholders' aim to achieve a target of solar power as high as 30% of the country's installed capacity by 2035. However, proactive people are still limited in their ability to invest in solar power due to the relatively high cost, limited business models & financing options, and complex permitting processes.

4.4 Scenario 1: Domestic Market Boom

Scenario 1 is driven by the joint forces of effective public agencies and proactive consumers. The government is committed to diversifying fuel sources for power generation and reducing carbon intensity of the power sector. Continuous support is given in the short to medium term until grid parity happens for residential rooftop solar power. After this point, solar power becomes competitive with grid electricity. Highly aware consumers show a strong demand for on-site solar power generation to offset the need for conventional grid electricity. Investment in solar becomes a norm for households and businesses, resulting in an average growth rate of 85% per year between 2015-2035, as shown in Figure 4.5. The total installed capacity of solar power reaches 24,026 MW (24 GW), or about 30% of the country's installed capacity, rendering Thailand to become the largest solar power market in ASEAN.

Key Targets and Milestones under Scenario 1

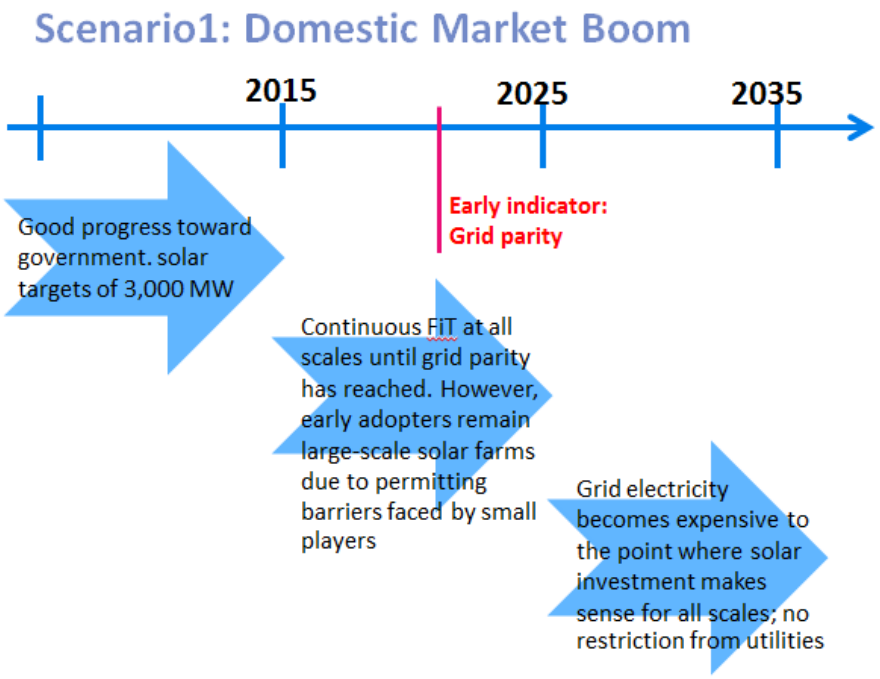


Figure 4.5: Milestones under domestic market boom scenario (scenario 1)

4.4.1 Scenario Detailed Descriptions

2015: Unrestrained Growth

- Strong FiT incentives to breed market growth at all scales; however, continued permitting barriers prevent small-scale installations.
- Utility-scale solar installations reach 2,000 MW in 2015.

Residential and commercial-scale solar installation reaches 158 MW in 2015, bringing the cumulative installed capacity in Thailand to 2,158 MW (2.2 GW).

•The majority of utility-scale expansion comes from solar farm PPAs in the backlog and community solar farms.

2025: Large-Scale Solar Farm Continues to Dominate

•FiT incentives continue at all scales until grid parity is reached in 2024.

•Increasing growth from residential and commercial rooftop solar, but large-scale installations (solar farms) continue to dominate until 2030. High awareness and high interests exist among wealthy consumers and solar farm developers.

•Conventional power supply becomes more expensive due to rising fossil fuel prices and rising cost of grid reinforcement.

2035: Decentralization of power supply

•Self-sustaining market for solar power. No subsidies from the government. Rooftop segment begins to gain traction.

•Every home, business, and community combines solar power and energy efficiency to help reduce energy costs.

• Smart grid technologies enable seamless integration of solar PV to the grid. Utilities can utilize the benefits of solar PV in peak load reduction.

•The total installed capacity of solar power reaches 24,026 MW (24 GW), or about 30% of the country's installed capacity.

998 kW System at the CRC Wharf, Credit: Photon Power

4.4.2 Expected installed capacity by 2035

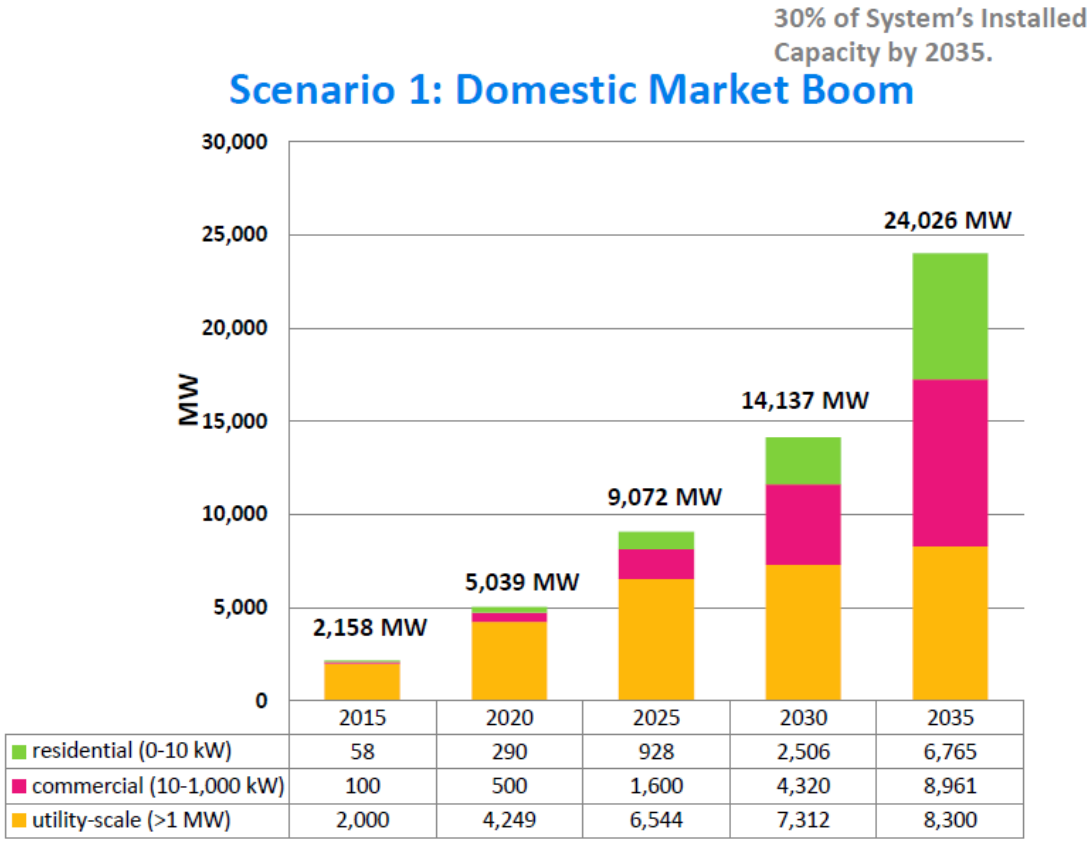


Figure 4.6: Expected install capacity of domestic market boom scenario

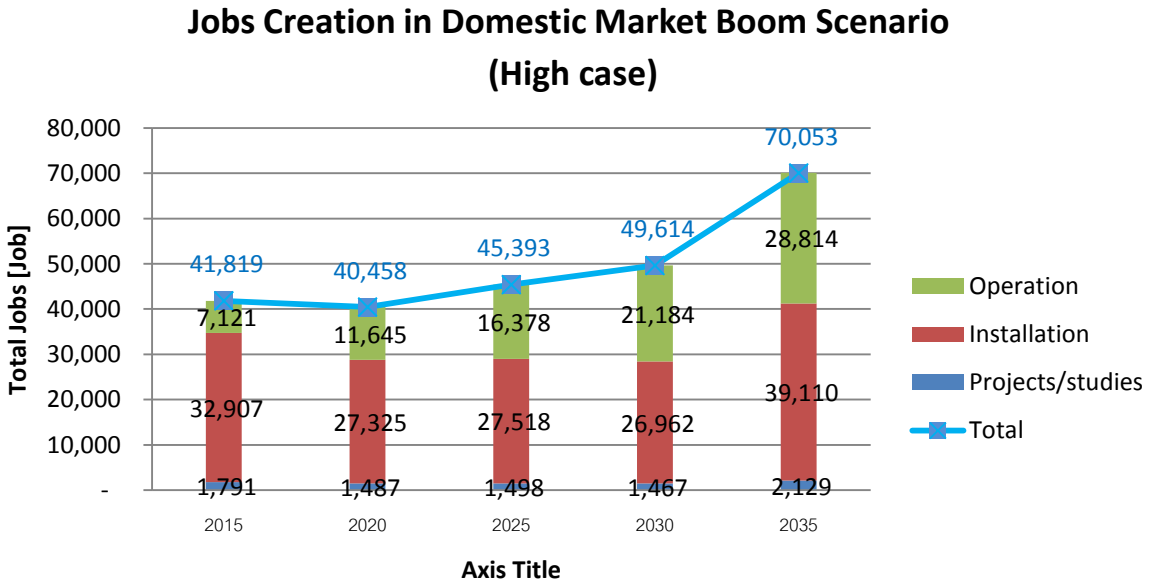


Figure 4.7: Expected jobs creation of domestic market boom scenario

4.4.3 Scenario Logics

Table 4.2: Logics of Domestic Market Boom Scenario

Type of logic	Scenario Logic	Assumption
Economics	• Modules Price	-global module prices continue to decline until 2035. The 2035 Module price is expected to be $0.6 per Watt peak (real value) according to the IEA.
	• System Price	-corresponds to global module prices but varying by country due to soft costs.
	• Grid Electricity Price	-rises along with prices of natural gas -conservative estimate is 3.5% per year
	• Privatization	-Increasing private participation in generation business (70% installed capacity comes from IPPs, SPPs, VSPPs)
Technology	• Technology	c-Si still dominates the market through 2035
Policy and Politics	• Policy to support PV (e.g., FiT, subsidy)	-continuous FiT until grid parity -continued BOI privilege (import duty+income tax exemption)
	• Administrative Barrier	-Government eases restriction on permits
	• Value chain	-No clear policy on the value chain but domestic market expansion attracts global manufacturer to invest in Thailand.
People	• Green Consumer Awareness	-High awareness and high interest especially wealthy and solar farm developer.
	• Inequality	-Inequality between small vs. large power producers/access to BOI privilege
Environment	• Climate change	- Extreme weather events are causing more frequent power outages. - Strong green policy mechanism

4.5 Scenario 2: ASEAN Market Leader

Scenario 2 is driven by an effective repositioning of the government's policy on Thailand's industrial competitiveness. Solar PV manufacturing is viewed as an important addition to the existing high-tech equipment manufacturing. Thailand successfully attracts manufacturers of solar PV modules to invest in Thailand despite limited domestic use. Related industries, such as glass, copper, mounting structures, and green building materials, thrive as they can expand local markets to serve the module industries.

The private sector builds their own capacity through the strengthening of capable human workforce to serve the growing market outside of Thailand. Thailand hence establishes itself as a manufacturing hub and centers for solar training in Southeast Asia.

Key Targets and Milestones under scenario 2

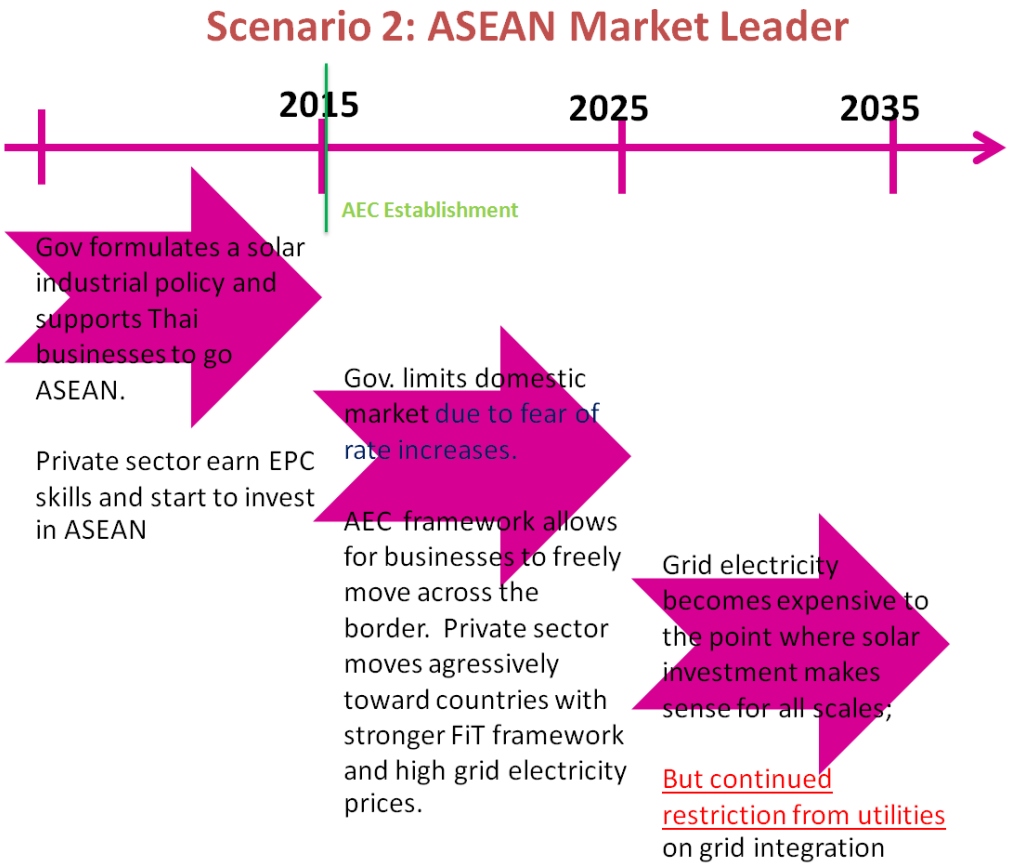


Figure 4.8: Milestones under the ASEAN Market Leader Scenario (Scenario 2)

4.5.1 Scenario detailed descriptions

2015: Strategic Industrial Policy with Limited Domestic Market Policies and Persisting Admin Barriers

- The government drafts and implements a Solar Industrial Plan designed to draw global manufacturers to invest in Thailand and to stimulate local economic activities of Thai suppliers.
- The government also provides incentives for Thai solar businesses to expand into ASEAN markets.
- However, with regard to domestic market expansion, the government offers no additional incentives since 2013 due to fear of impact on tariff rates
- Continued growth comes from projects in the pipeline which reach commercial operation with difficulties due to complex and lengthy permitting processes

- Low consumers awareness of the technology
- Utility-scale installations expect installed capacity of 850 MW in 2015. Residential and commercial sectors add 13 MW, bringing the cumulative installed capacity in Thailand to 2,158 MW (2.2 GW).
- With the help of the Thai government, Thai businesses begin to expand their investment in ASEAN countries.

2025: Rooftop solar market taking off; Businesses go ASEAN

- Residential and commercial rooftop markets begin to expand on their own due to declining module costs and the arrival of grid parity.
- Consumer groups and business groups successfully exert their influences through lobbying to overcome of administrative barriers.
- AEC framework and growing power demand abroad attract businesses to move across border. The government supports the solar sector to go abroad through tax incentives.
- Thai businesses aggressively move across borders toward countries with stronger FiT frameworks and high grid electricity prices, bringing their expertise in design, engineering, procurement, and installation.

2035: Saturated domestic market due to grid limits

- The domestic solar farm market has not expanded due to (the unwillingness to lift) grid constraints. Solar farm capacity in 2035 is 1.4 GW
- The rooftop solar market expands rapidly and focused on self-consumption. Total rooftop capacity is 2.9 GW in 2035
- Solar capacity in 2035 makes up 6% of the country's total installed capacity

4.5.2 Expected install capacity by 2035

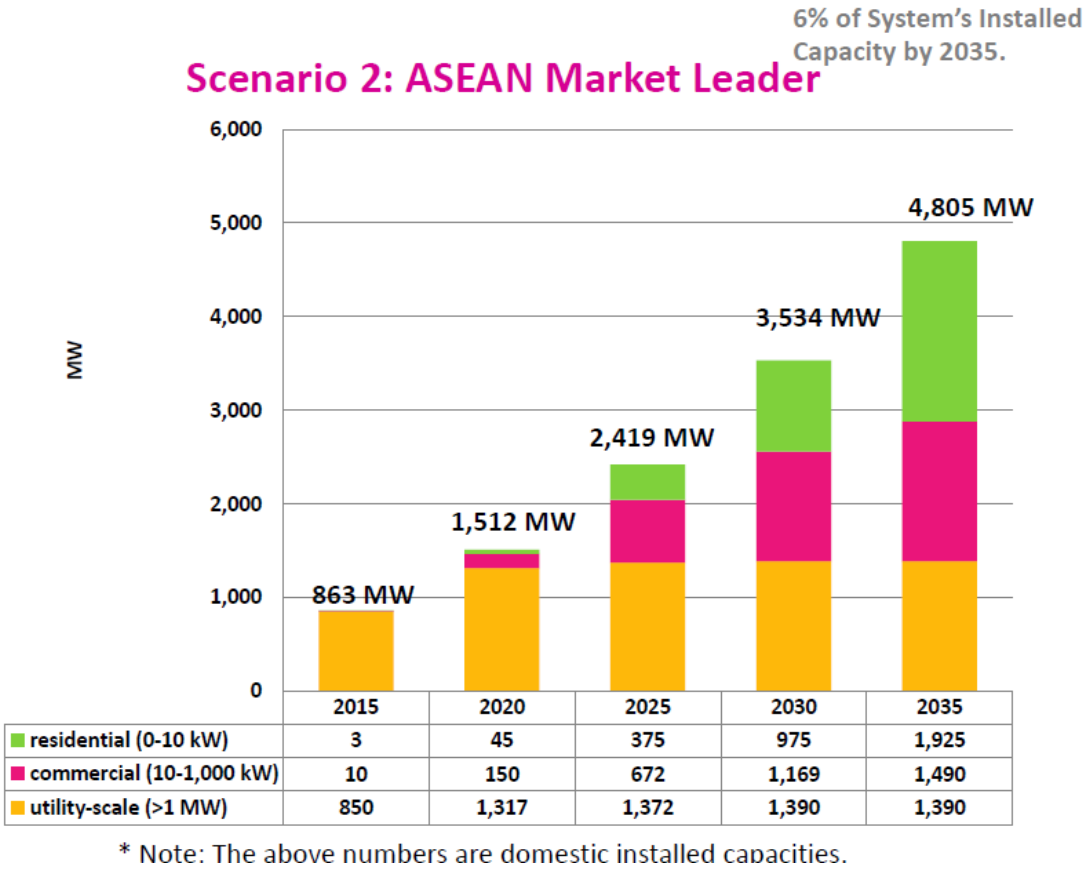


Figure 4.9: Expected install capacity of ASEAN Market Leader scenario

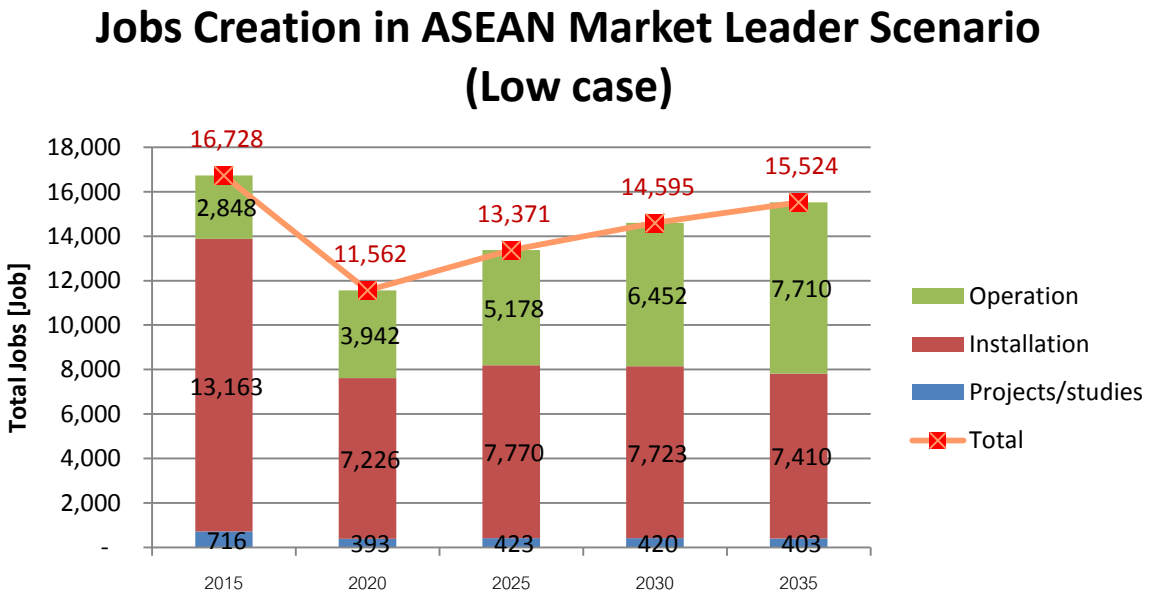


Figure 4.10: Expected jobs creation of ASEAN Market Leader Scenario

4.5.3 Scenario Logics

Table 4. 3: Logics of ASEAN Market Leader Scenario

Type of logic	Scenario Logic	Assumption
Economic	• Modules Price	-global module prices continue to decline until 2035. The 2035 Module price is expected to be $0.6 per Watt peak (real value) according to the IEA.
	• System Price	Varying prices due to off-grid, remote applications and country-specific context
	• Storage Price	
	• Grid Electricity Price	3.5% increases per year
	• Restructuring of electricity market in ASEAN countries	More private sector participation in generation sector across ASEAN countries
Technology		
	• Technology	c-Si continues to dominate the market through 2035
Policy and Politics	• Policy to support PV (e.g., FiT, subsidy)	-Limited FiT in short term; no FiT in medium & long term -Government encourages solar businesses to invest in ASEAN by ***
	• Tax regulation	
	• Administrative Barrier	• No significant overcoming of Admin barriers
	• Value Chain policy	• Industrial policy moving upstream of the PV value chain and technology transfer program
People	• Green Consumer Awareness	• Moderate consumer awareness
	• Inequality	• Off-grid and remote application in Indonesia, Laos and ,Myanmar becomes attractive market
Environment	• Climate change (environment)	• Regional climate change makes solar power attractive in niche applications such as emergency backup and rural microgrids. • Climate refugee • Flooded substation

4.6 Scenario 3: Open and Innovative Market

The government increases the targets for rooftop solar power while placing a limit on utility-scale solar expansion. In the short term, attractive incentives are provided for rooftop solar power, including direct subsidies and low interest loans. Obstacles to solar power investment are lifted, thereby lowering barriers to entry for small businesses. For example, the government amends existing laws to simplify and streamline the permitting process, enforce competition laws, and orchestrate widespread campaigns to engage consumers in distributed solar power production. The private sector responds with diverse and innovative business models for solar power system investment.

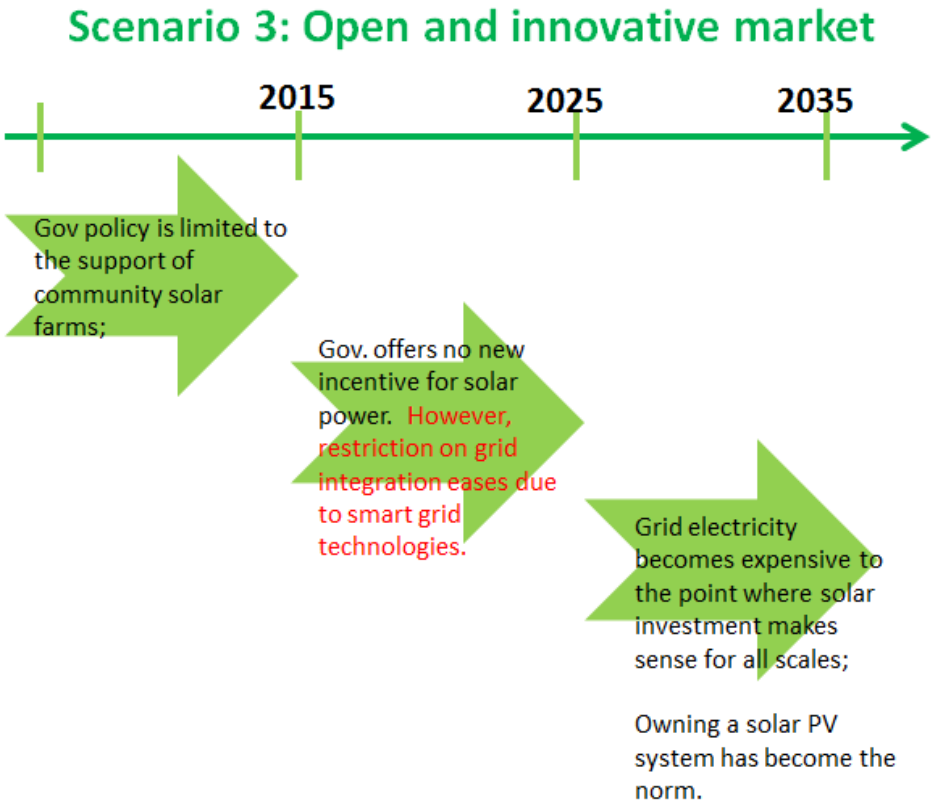


Figure 4.11: Milestones under Open and Innovative Market Scenario (Scenario 3)

4.6.1 Scenario Detailed Descriptions

2015: Market Expansion

- Utility-scale solar systems expect installed capacity of 833 MW in 2015 bringing the cumulative installed capacity in Thailand to 863 MW (GW). Residential and commercial sectors is 30 MW in 2015.
- SMEs are entering the residential and commercial sectors by offering services at competitive prices.

2025: Smart Grid Integration

- Thailand's solar installed capacity has reached 4.2 GW where 3 GW of which comes from commercial and residential systems.
- EGAT, MEA, and PEA have been rolling out smart grid technologies across the country. As a result, consumers' awareness of their electricity usage and price have increased and facilitate the increase in small solar PV systems being integrated into the grid resulting in an even more decentralized electrical generation.

2035: Dynamic and Interactive Market

- Owning a solar PV system has become the norm. Consumers are very active in the electricity market and are acutely aware of their consumption patterns/behaviors.
- Public, private, and community participation in electricity market is at all-time high.
- Thailand has become a vibrant hub for innovative products and services in solar PV systems and complementary technologies and services due to strong domestic market.
- The cumulative installed capacity for solar PV in Thailand has reached 8 GW or about 10% of the country's installed capacity.

4.6.2 Expected install capacity by 2035

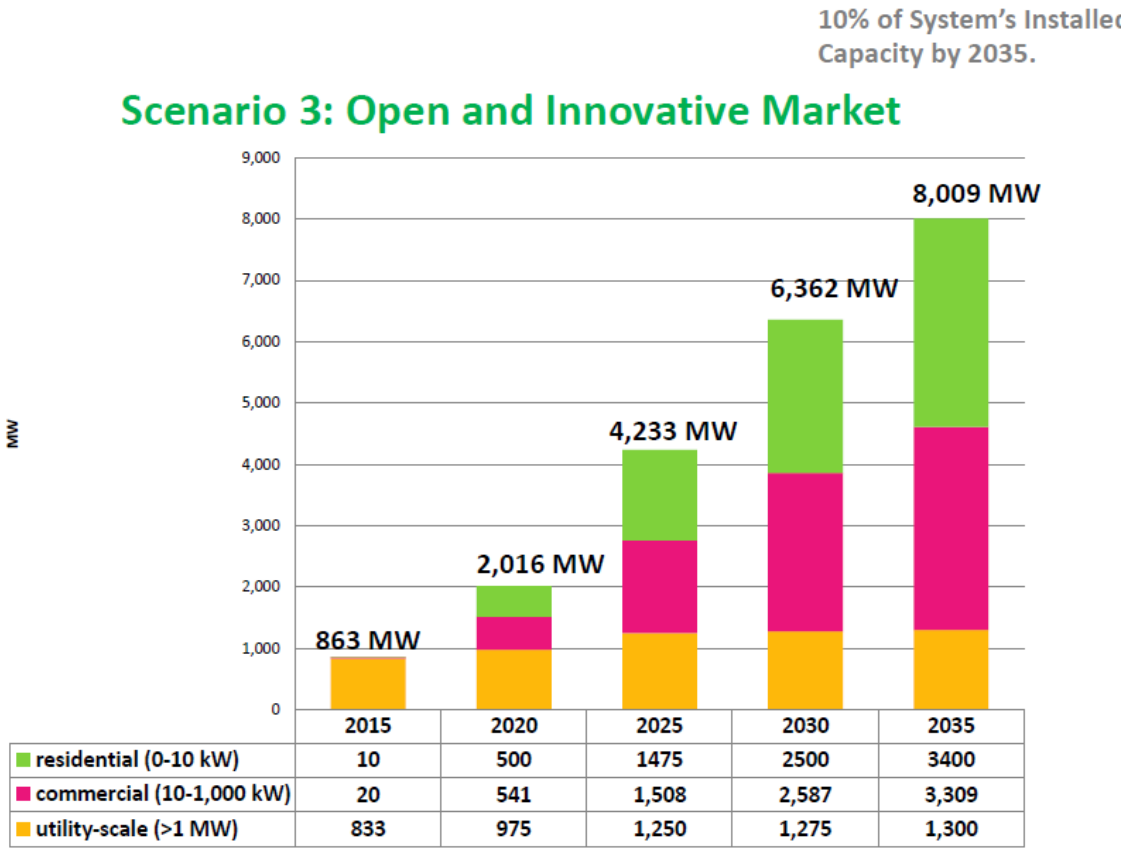


Figure 4. 12: Expected installed capacity of under Open and Innovative Market Scenario

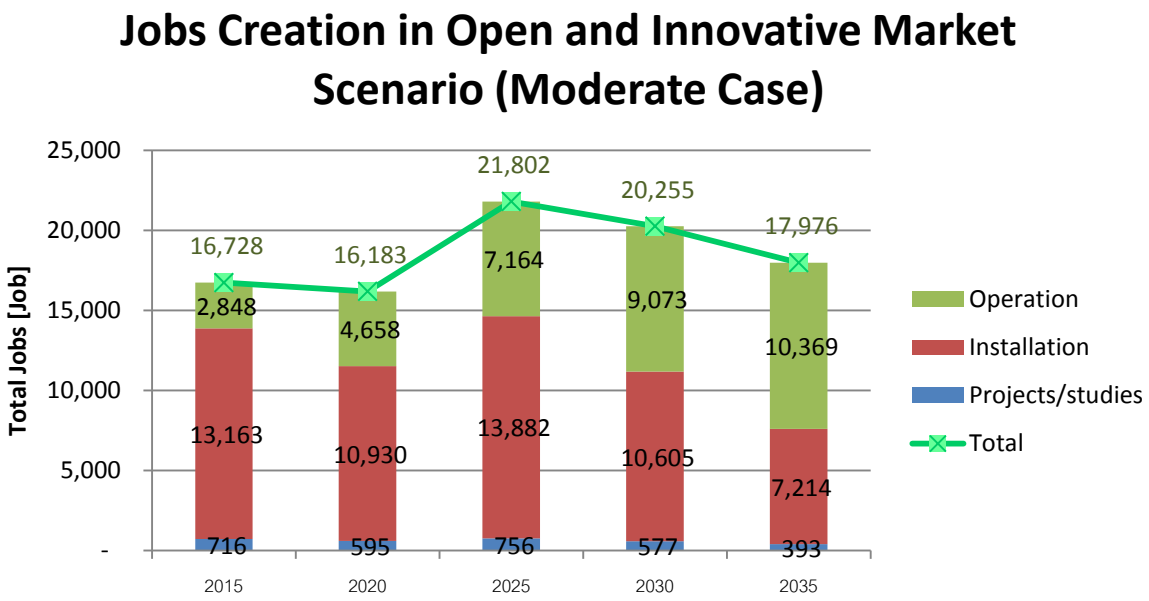


Figure 4.13: Expected jobs creation of Open and Innovative Market Scenario

4.6.3 Scenario Logics

Table 4.4: Logics of Open and Innovative Market Scenario

Type of logic	Scenario Logic	Assumptions
Economic	• Fossil fuels prices • Module Costs • System Costs	-global module prices continue to decline until 2035. The 2035 Module price is expected to be $0.6 per Watt peak (real value) according to the IEA. -lowered due to competition in the market
Technology	• Smart grid and other auxiliary or complementary technologies (e.g. storage)	• Diverse applications of solar systems subject to consumers' needs. For example, solar PV is combined with hydro storage in rural applications. Solar apps are developed for urban users to monitor their systems' performance.
Policy	• National renewable energy target • Financial incentives for solar PV development (e.g. tax breaks, FiT, adders, subsidies, loan guarantees)	• Long-term, credible, and well-designed policies to support solar PV : the amount of FiT decreases as cumulative installed capacity increase. • Low administrative barrier: Time required to issue permit for residential solar PV system < 15 days
Market	• Demand for solar power • Small and medium size players • Human capital to support growth	• Low barrier to enter market • Increase adoption of residential solar PV systems
Environment	• Pollution concerns from traditional fossil fuels • Climate change concerns	• Environmental impacts lead to shift in consumers' sentiment and increase awareness

Chapter 5
Drivers, Barriers, and Action Plans under Each Scenario

The Solar PV Roadmap Workshop on March 31, 2013 enabled participants to sharpen the three future scenarios. Participants looked 20 years into the future and identified drivers, barriers, and the action plans for the shaping of each scenario.

5.1 Scenario 1

5.1.1 Drivers under Scenario 1

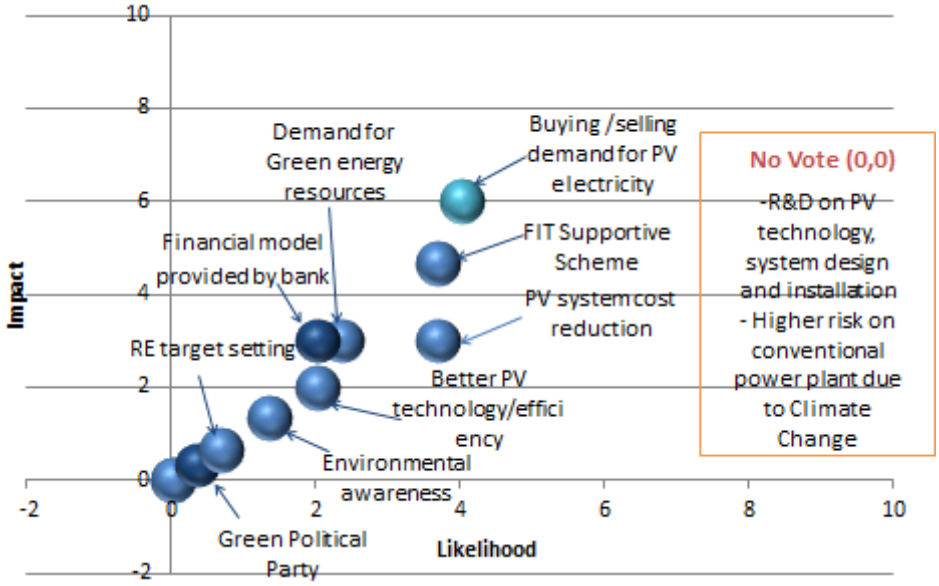


Figure 5.1: Drivers for solar PV development under Scenario 1

In order for solar PV to achieve a 30% share of power generation in Thailand by 2035, both the government and end-users have important roles to drive the market forward. End-users need to exert a strong demand for PV electricity, while the government needs to provide policies and mechanisms to incentivize the expansion of the solar PV market (Fig. 5.1). Participants saw that another strong driver is an effective and continuous FiT support scheme, which would help expand the market. Such strong drivers may arise from heightened environmental awareness and the Thai government's increasing commitment to climate change mitigation. The government sees the benefits of expansion of PV uses as outweighing the costs of fossil fuel uses and the cost of climate change vulnerabilities.

5.1.2 Barriers to Scenario 1

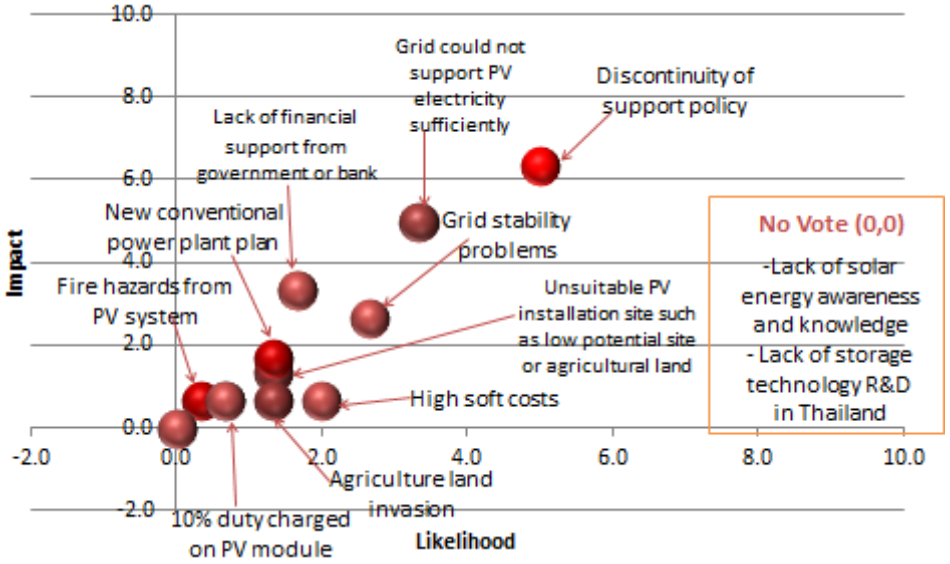


Figure 5.2: Barriers to Solar PV Development under Scenario 1

Major barriers remain if Thailand were to experience a domestic solar market boom. Discontinuity of support policy is the top identified barrier. Participants, especially from the utilities, are concerned about the ability of the grid to accept increasing solar electricity. These two strong barriers interact in a sense that grid bottleneck would provide a major justification for policymakers to block further solar expansion.

5.1.3 Action Plans for Scenario 1

Scenario 1 paints a picture of a highly virtuous government and consumers that are acutely aware of their environmental impacts. Therefore, every sector of the economy moves together as shown in the Action Plans below.

Table 5.1: Action Plans for Scenario 1

Player/ Term	Short term	Medium term	Long term
Public	EPPO and ERC receive inputs from all relevant agencies, and then formulate a plan that synchronizes their responsibilities. Energy and green environmental plans are integrated.		
	Design FiT measures to have continuity, and a clear and fixed revision timeline including annual degression rate. Utilities use smart grid technologies to limit the construction of conventional power plants		
			Coordinate RE plans and transmission upgrade/reinforcement plans
		Campaign for a solid understanding about the benefits of solar energy	
	A reward-penalty system is effectively implement to ensure public sector's high		

Player/ Term	Short term	Medium term	Long term
	performance		
	ERC implements policies effectively with the purpose of maintaining a balance of power among electricity producers, users, and utilities		
Private	Design innovative products for easier assembling, installation, and maintenance (Do It Yourself) while providing both pre-sale and after sales service of the PV systems as well as campaigning for a solid		
	understanding about the benefits of solar energy		
	Financial institutions formulate new financial models especially to support the investment in solar PV		
End-User	Consumers push the government for modules and inverter standards and third-party testing agencies so that consumers can have more confidence on the products.		
	Consumers mobilize the banking sector to create a socially responsible lending policy such as green lending standards		
	End-users try to educate themselves on energy issues and because of the high awareness on energy option and environmental impacts. They seeks out supports from the government and innovative products in the market to reduce household energy cost		

5.2 Scenario 2

5.2.1 Drivers for Scenario 2

Under Scenario 2, the government establishes an outward-looking economic policy in order to reap the benefits of more ASEAN economic integration, giving a priority to the solar sector. Seeing higher value in the upstream part of the value chain, the government positions Thailand as a regional hub for technology transfer by attracting global modules manufacturing plants and playing an active role in building domestic innovation systems for solar power. At the same time, existing Thai EPC services expand into the ASEAN solar markets with the assistance of the Thai government. This happens at the same time that other ASEAN economies, especially Thailand's neighboring countries are seeing a continuous economic growth and high energy demand. Therefore,

the key drivers identified under this scenario includes a business-friendly environment in ASEAN countries as well as an active role played by the Thai government in building an innovation hub and sending out skilled workforces to do businesses in ASEAN countries.

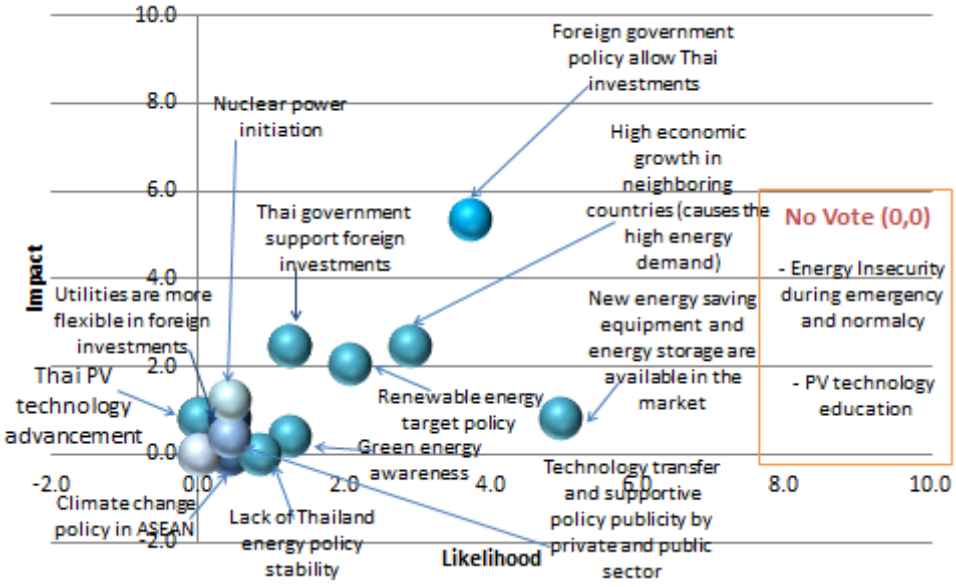


Figure 5.3: Drivers for Solar PV Development under Scenario 2

5.2.2 Barriers for Scenario 2

Many key barriers remain in achieving the outcomes of Scenario 2. First, there is a lack of effective R&D policies in Thailand and a lack of skilled human resources in ASEAN countries. ASEAN countries as a whole have the risk of weak compliance to the AEC framework in 2015.

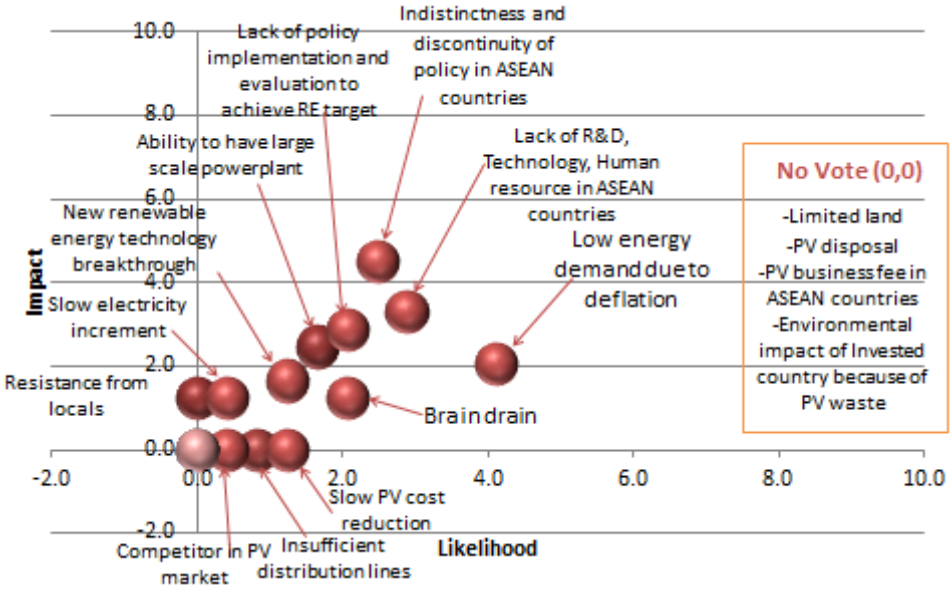


Figure 5.4: Barriers to solar PV development under Scenario 2

5.2.3 Action Plans for Scenario 2

Action plans under scenario 2 involve2 major highlights. First, the government passes and implements a solar industrial policy, designed to support domestic players to enhance their skills and integrate further upstream into the global solar PV value chain. Second, the government also helps Thai businesses to build a stronghold in solar PV services in the ASEAN market through national-level negotiations.

Table 5.2: Action Plans for Scenario 2

<table>
<tr><th>Player/ Term</th><th>Short term</th><th>Medium term</th><th>Long term</th></tr>
<tr><td rowspan="6">Public</td><td>Draft and Pass a Solar Industrial Policy</td><td>Integrate local suppliers into the upstream part of the solar supply chain.</td><td></td></tr>
<tr><td colspan="3">Push for R&D activities and training focusing on ASEAN applications</td></tr>
<tr><td>Formulate a Master Plan for ASEAN solar energy investment which contain action plans for governments as the key enabler</td><td colspan="2"></td></tr>
<tr><td colspan="3">Build strategic partnerships among private and public players to build a stronghold in ASEAN market.</td></tr>
<tr><td rowspan="2">-Public-Private- Collaboration in the capacity building of the solar workforce to serve the growing market outside of Thailand.</td><td>Research output targets are set and solar PV syllabi are developed</td><td></td></tr>
<tr><td rowspan="2">Private</td><td rowspan="2">Expand the negotiation to the ASEAN level</td><td rowspan="2">-Public-Private- Encourage the employment of local people to allow technology transfer</td></tr>
<tr><td>Build capacity of local suppliers to match with global solar supply chain requirement</td></tr>
<tr><td></td><td>Study and analyze business models abroad Solar PV project investment</td><td>Develop business models suitable for the investment areas</td><td>Scale up the project in new investment areas</td></tr>
</table>

5.3 Scenario 3

5.3.1 Drivers for Scenario 3

In order for small- and medium-sized businesses to thrive under scenario 3, two major drivers stand out from the discussion. First, the business environment has to be competitive, which means that the government has to design solar policy and implementation schemes to level the playing field for all players. Furthermore, the financing landscape encourages entrepreneurs to take risks, and hence small and innovative

businesses begin to thrive. At the same time, developers, banks, and other financial institutions engage in green initiatives designed to make solar power more popular and widespread. And since consumers are highly aware of solar power options, they also help with the spread of knowledge on solar power, making the market grow.

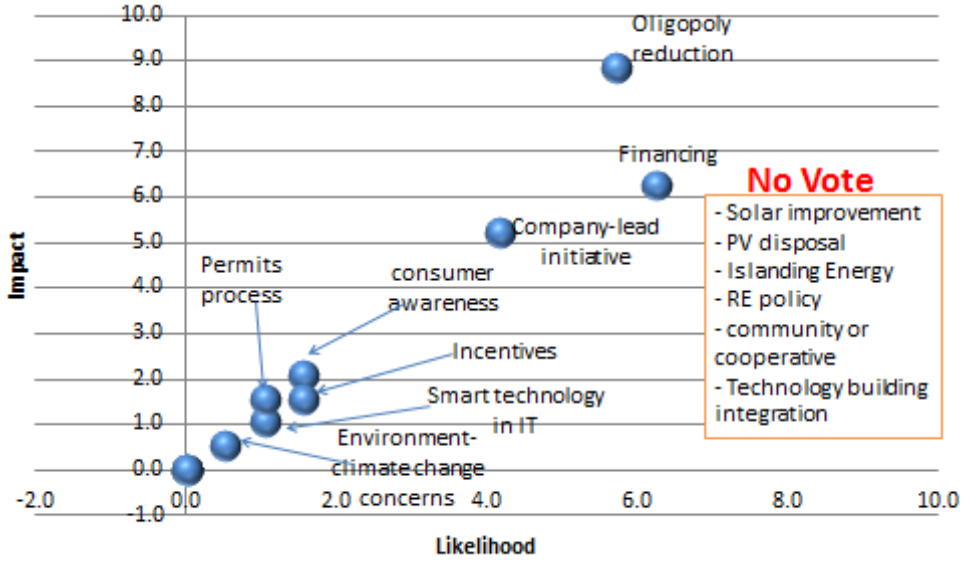


Figure 5.5: Drivers for solar PV development under Scenario 1

5.3.2 Barriers to Scenario 3

The barriers to Scenario 3 appear to be the business-as-usual factors that are currently stalling the Thai PV market. Government's solar policy is not accompanied by effective implementation of action plans along with long-term, stable incentives. More effective implementation is prevented by the lack of co-operation among government agencies and complicated permitting process.

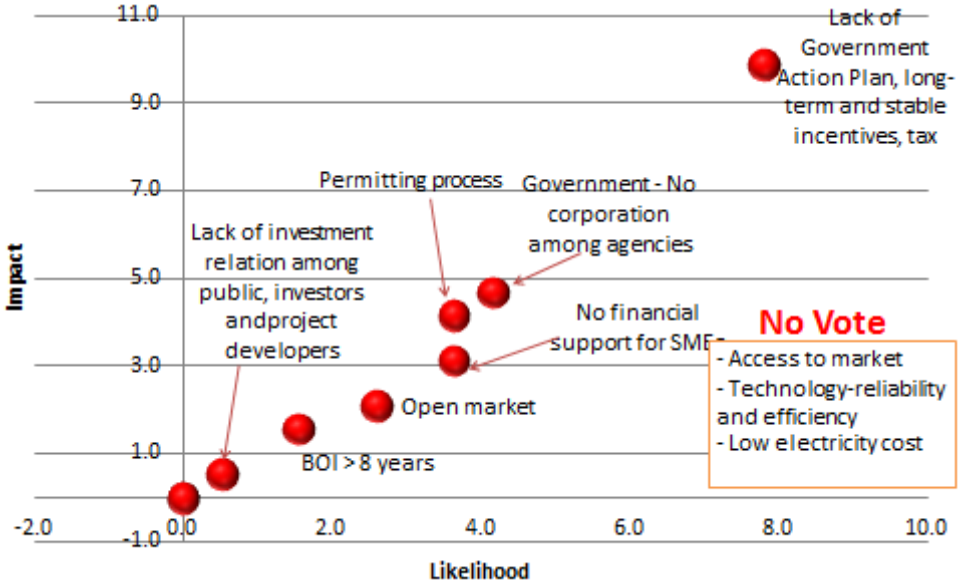


Figure 5.6: Barriers to solar PV development under Scenario 3

5.3.3 Action Plans for Scenario 3

The action plans from the government under Scenario 3 involves the creation of good governance from the policy-making process and implementation of policy. The private sector plays an effective lobbying role through a strong PV industry association and becomes engaged in every step of the government's process. Consumers are active players in helping to distribute solar PV information to enhance awareness and adoption.

Table 5.3: Action Plans for Scenario 3

Player/ Term	Short term	Medium term	Long term
Public	Lobby to include more stakeholders in NEPC structure		
	Establish Thai Photovoltaic Industries Association for lobbying	Incorporate public opinion in every step (Public hearing) (S-M-L)	Increase public awareness through education
	Create a clear simple, and transparent permitting process		Enforce government accountability
Private		Lobby Utilities to create fund or governance bank (Residential)	
	Build demand to create economies of scale		
End-User	Update and modify information website to be more user-friendly (DEDE)		
	Distribute information related to solar PV to public (How to)		
	ERI to start initiative to increase awareness in solar PV in school through projects		

10 kW System on a Residential Property Thanakorn-Saisiri Hoontrakul ,
Credit: InterSol Consulting

Chapter 6
Strategies

6.1 Strategies for the Government and Energy Regulator

The government and energy regulator has a large role to play in creating national policies, laws, rules, and regulation that provide an enabling environment for solar businesses and industries to thrive, keeping in mind public benefits.

1) Develop a strategic industry development framework

The potential to capture the value of solar PV to the Thai economy throughout its value chain should be analyzed along with strategic measures to achieve the value. Among ASEAN countries, Thailand is already the leader in solar power adoption. However, as long as solar electricity remains the most expensive type of electricity, solar support has continued to backfire since the costs of subsidies are not justified by the emergence of tangible benefits. Thailand stands to gain from more strategic industrial strategies with the aim of moving up the value chain in solar industries and being an ASEAN hub in solar power services:

1.1 Attract foreign direct investment in upstream manufacturing and form a solar industrial cluster.

The government can catalyze stronger linkages between global manufacturers and local related industries. Thailand already has local BOS industries, including makers of inverters, solar charging controllers, cables, structures, combiner boxes, and transformers. Upstream and downstream products can be packaged together to provide diverse solutions for ASEAN markets.

1.2 Position Thailand as a regional hub in R&D, EPC services, and testing.

Thailand can build an effective platform for increasing the skills of local workforce in the three areas in which the Thai workforce already has high potential:

- **Regional R&D hub for PV operating in high temperature regions**

Even though it is difficult for Thailand to make a breakthrough technology to develop super high-efficient solar cells or to produce products at the lowest cost and compete primarily on price, the technologies that can enhance energy yield/efficiency and stability of the PV systems, especially in high temperature regions, possibly help the local PV industries to expand their existing business/service or to start a new one.

The PV technologies that should be especially developed and promoted are:

- ✓ Technologies to reduce temperature loss of PV modules/systems

- ✓ Hybrid system, which combines PV with other form of generation
- ✓ Technologies to support PV diffusion such as forecasting system, demand response management and smart grids

- **Expert on EPC and O&M services**

Although it is almost impossible for local PV industries to compete on price of goods with China, local PV service businesses including EPC and O&M services tend to have a bright future. Since solar PV farms and rooftop PV systems will exist all over the country, high-quality skills and PV services of a wide range of scales will be needed throughout the country. Furthermore, the PV system integration services as well as the skilled engineer/labor can be exported to neighbor countries.

- **Testing hub for PV products and services**

Not only testing for PV module, inverter, or other component consisted in the system, but also tests of PV installation and complete PV system are significantly important. Since there is high volume of PV installations, it is not possible to rely on complex audits of each individual installation. The adoption of the IEC standards is beneficial; however, announcement of Thai version standards should be up-to-date, ensuring a timely response to released PV incentive policies. Since Thailand is regarded as one of the PV emerging markets in the world, it is a big chance for the PV testing facilities in Thailand to provide services, especially outdoor testing under real operating conditions (Tropical climate). At present a specific certification for PV systems installed under typical Southeast Asian climate - hot, humid and high irradiance (+/- 20o latitude) - is one of the most important issues needed attention. Data obtained from the test sites in Thailand can be a fruitful source of information for improving standardization of performance, safety and reliability of the PV modules as well as the PV system. Accordingly, Thailand also has potential to be a testing hub for PV.

2) Design solar power support policy to have certainty and continuity

Thailand's intermittent support for solar power in the past became a major obstacle for achieving the benefits that solar power promises. Residential and commercial-scale rooftop solar markets have not achieved economies of scale required for the system costs to come down and market competition to happen to enable choices for consumer. To avoid the trap of boom-and-bust cycle, Thailand needs to build a continuous domestic solar market driven by effective market formation strategies.

2.1 Getting the economics of solar power right: Combining incentives in the early market formation stage

Thailand needs to allow the solar market to grow continuously from a market formation stage to the mature stage. In the market formation stage, the

government needs to combine a number of incentives to stimulate the rooftop market. Feed-in tariffs alone is not adequate, especially for the residential market, since it does not address the high upfront capital cost that prevents solar PV from becoming mainstream. Countries with successful FiT programs such as Germany and Italy gave a generous mix of incentives in the formation stage of the residential market. The German government-funded 100,000-roof program pre-dated the feed-in tariffs. Implemented between 1999 and 2003, the program provided no-interest loans to PV installation sized 1 kW or greater[8]. In addition to the federally funded program, rooftop solar PV in Germany also receives support from other sources, including tax credits from local fiscal authorities and low-interest loans from state-owned banks and private banks (Spertino et al., 2013).

2.2 Establish a strong FiT framework with cost-containment mechanism

Feed-in tariffs should be given with continuity to the point of grid parity. But as the solar market grows, so is the subsidy for solar power and hence the concern on the impact on the pass-through cost to ratepayers. The burden of continued support can be moderated by a cost-containment mechanism based on the volume of solar power that comes online in each quarter or each year.

8 Details on the 100,000-Roof Solar Programme can be found from Erge et al. (2001)

Box 1: Key Elements for Future Feed-in Tariff Programs for Thailand's Rooftop Solar Support

No capacity cap: While it makes sense to set a target for solar power, the target should not serve as a ceiling. Additional PV capacity that exceeds the target can be moderated using a target corridor system similar to Germany's. The degression is tied to the actual amount of solar installed in the preceding year. If installations of solar electricity exceed targets then tariffs fall faster for new projects.

No deadline for application period:

As shown in Thailand's experience with FiT application deadline in 2008, deadlines can give rise to an overheating market that involves the secure of contracts for resale with actual Megawatts coming online very slowly.

Use volume-based FiT adjustment mechanism:

Two outstanding degression models exist: the corridor degression model (Germany) and cap & floor (Spain).

Corridor Degression: Since 2009, Germany implemented an automatic adjustment mechanism of FiT rates in response to increasing deployment volumes of solar power. Germany's amended Renewable Energy Sources Act (EEG, 2012) defined an annual target corridor between 2.5 GW and 3.5 GW for new PV installations. The degression rate will depend on whether the additional PV capacity is within the corridor. If the deployment in the period of 12 months prior to August 2013 exceeds the target volume, a higher degression rate would be applied[9]. Table 6.1 shows this volume-based, monthly degression schedule, determined by the capacity installed during the previous 12 months.

Ceiling and Floor Mechanism: The ceiling and floor FiT adjustment mechanism is used in Spain, where FiT rates are set based no market prices, and in Tanzania and Sri Lanka, where FiT rates are set based on utilities' avoided cost of purchasing power (See, e.g., Schallenberg-Rodriguez and Hass (2012) and Tenenbaum, Greacen et al. (2014). Adjustment of FiT rates cannot go below the floor and above the ceiling. The floor level provides assurance to investors and bankers that the project's income streams would be enough to pay back the returns or loans. The ceiling level provides assurance to investors and bankers that the costs of FiT would not skyrocket and hurt ratepayers.

[9] For more details on the history of Germany's degression mechanism, see Fulton (2012) and Grau (2014).

Table 6.1: Example of the Corridor Degression Mechanism in Germany

Installed Capacity During Prior 12-month Period	Monthly Degression
7,500 MW	2.8%
6,500 MW	2.5%
5,500 MW	2.2%
4,500 MW	1.8%
3,500 MW	1.4%
2,500-3,500 MW (target corridor)	**1%**
Less than 2,500 MW	0.75%
Less than 2,000 MW	0.5%
Less than 1,500 MW	0%
Less than 1,000 MW	-0.5%

3) Design solar policy and regulation that is transparent, accountable, and encourages competition

Regardless of what form solar subsidy may take, be it feed-in tariff, subsidy, or bidding, a regulatory system that is effective and ensures a level playing field among players should be put in place. Table 6.2 identifies key elements of policy and regulation that can lead to a vibrant, competitive market for solar.

Table 6.2: Key Elements of Good Governance of Solar Power Support

Policy	Regulation
▪ **Policy Consultation** -Formalize the process of policy consultation to include stakeholders early in the planning stage and provide effective channels to disseminate information and receive feedbacks. -The net benefits to policy options should be calculated and communicated with stakeholders as a basis to inform decision-making.	▪ **Eligibility Criteria** -Eligible criteria for the support of solar power should allow enough flexibility to enable diverse business models and financing options to thrive. For example, third-party ownership of rooftop solar systems can more easily organized if the income streams can be assigned to a third party and not just the meter owner. Furthermore, the 2013 rooftop regulation allowed installation on the roof of the house only. Future regulation should allow for installations on more diverse structures, such as on the building façade and on garage roofs.
▪ **Policy Announcement** -Provide certainty on the future timeframe of policy revision and application tender rounds of FiT.	▪ **Related Laws and Regulation:** -Ensure that related laws and regulations are amended to reduce barriers to the support of solar power prior to the launch of the support. -Coordinate the responsibilities of local, regional, and national agencies in administering solar power support measures.
▪ **Policy Objectives** The objectives for solar power development should have corresponding national commitment or plans. The focal points under the AEDP	▪ **Application Approval Procedures** -Use an online application process for project qualification screening rather than requiring applicants to apply in person. Following international best practices, the online

2012-2021 are already good strategies for supporting solar power, but corresponding measures should be stepped up to support the implementation of these focal points: 1. Promoting community to collaborate in broaden production and consumption of renewable energy 2. Adjusting incentive measures for investment from private sector appropriated with the situation 3. Amending laws and regulations which do not benefit to renewable energy development, especially the the amendment of laws and Industrial Act, 1992 (B.E. 2535). 4. Improving the utility infrastructure system to support increasing renewable energy, includes preparing a development towards Smart Grid system. 5. Public Relations and building up comprehensive knowledge about various solar applications. 6. Promoting research work as mechanism in development of integrated renewable energy industry	application process would provide: ✓ An electronic time stamp based on the first-come, first-serve principle ✓ Public information on capacity in the pipeline, approved capacity, cancelled capacity, and COD capacity ✓ A clear procedure for handling applications in the waiting list. • Simplified and streamlined process for small-scale residential systems less than 10 kW.
▪ **Policy Support Mechanisms** -Implement adequate measures to achieve solar policy objectives. The FiT measure alone, for example, is not enough to promote research work on solar power in Thailand. Nor does it have any specific design to encourage community participation in solar power	▪ **Contract details:** ▪ Contract Term: Current Standardized PPAs under the rooftop schemes lasts 25 years, which is the period of FiT payments. Future Standardized PPAs for solar farms and community solar should last as long as the payment (and not revert back to the original SPP and VSPP's SPPAs).

production.	▪ Solar Power as "Must-Take" Capacity: There is an absence of a "must-take" clause in the PPAs or SPPs, VSPPs regulations and the 2013 Solar Rooftop PPAs. A "Must-Take" clause would ensure that solar electricity that is injected successfully into the grid will be paid for. Many countries, including Japan and Germany passed renewable energy laws to ensure that electricity from renewable resources are prioritized.

4) Expand community solar opportunities

In addition to rooftop solar support, the previous and current governments have shown interests in providing solar benefits to rural communities. The national FiT scheme could be modified in such a way as to enhance rural capacity and share benefits to a wider group of population. **Box 3** summarizes potential community solar models that may be appropriate for Thailand, given current regulations and structures of the agencies involved.

Box 3: Potential Models for Solar Communities in Thailand

Model 1: Saving Co-operative Model **Scale: residential, commercial, or utility-scale**
1.1 Ownership Structure
Existing Thai saving co-operatives that are strong on the measure of portfolio quality, financial sustainability, and efficiency[10] have great potential to be investors or financiers of

[10] See Rosenberg (2009) for the indicators of microfinance institutions' performance.

solar projects while offering great opportunities for local community participation in solar power production. In this model, the co-op would be the majority shareholder of the project.

1.2 Sources of Capital

Co-investment Model: The co-operative provides a share of capital in the solar project, which can be rooftop or ground-mounted systems. Private investors make up the rest of capital requirement. The amount of the investment by the co-op would depend on their working capital.

Low-cost Financing Model: The co-operative provides a low-interest loan (as low as 1%) to the members for the installations of rooftop solar systems. The rest of the capital requirement comes from a private investor or EPC contractor who would co-own the system through its lifetime to ensure high system performance.

1.3 Benefit Sharing Structure

Co-investment Model: The FiT income is split according to the shareholding structure between the co-operative and the private investor.

Low-cost Financing Model: The FiT income is split between the co-op members, who use FiT income to pay back the loans, and the private investor according to its ownership share.

1.4 Approval Procedure

The government recruits high-performing co-operatives to participate in an educational seminar on solar power investment. Interested co-ops then participate in the government's information sessions and workshops on solar power investment. The final list of interested co-ops and microfinance institutions are then selected based upon technical potential and success indicators such as loan repayment, profitability, and efficiency of the fund.

1.5 Advantages	**1.6 Challenges**

-Co-operative members exert the demand for solar power themselves and hence are willing to learn about the technical and economic aspects of solar power. -If the systems are installed on houses, households that do not have appropriate orientation or tilt requirements may still be able to participate by jointly invest with the eligible households and help pay for the loans back to the co-op.	-The selection of the qualified co-operatives must be based on sound performance assessment criteria and not subject to political maneuvering.
1.7 Examples: The Community Organizations Development Institute's pilot residential rooftop solar projects include 3-kilowatt systems on 46 houses, which belong to saving co-operatives. The projects are among the few community-scale projects that win FiT approval by the distribution utilities in 2013. By combining low-cost financing of a saving co-op with bulk purchasing power and partnership with an investor, the project becomes affordable to low-income households. With a 1% interest rate from the saving co-operatives and a term of 15 years, the projects achieve an IRR of 8.47% and a payback period at year 10. In addition, the community-scale projects is unique in utilizing existing social capital characterized by strong community involvement from the project design stage and the training program implemented by the installers. This allows the communities to understand tangible benefits of solar power – not just how it helps reduce electricity demand from the grid but also how it can potentially enhance local income through the creation of skilled jobs.	
Model 2: Bidding for Benefit Sharing **Scale: utility-scale only (solar farm)**	
2.1 Ownership Structure	
Private developers offer bids on the FiT rate and the level of FiT rate to be offered to the community that hosts the solar farm. The winning bidder would offer a Build-Own-and-Operate contract to the community and receive FiT income, which it shares with the	

community.	
2.2 Sources of Capital	
The source of capital is sought by the private investor after winning the bid.	
2.3 Benefit Sharing Structure	
The FiT rate is split between the community and the private developer. For example, if the winning bid is 6.50 Thai Baht/kWh, around 1.50 Thai Baht/kWh may be offered to the community.	
2.4 Approval Procedure	
Open bidding process or reverse bidding.	
2.5 Advantages	**2.6 Challenges**
-In the absence of market power, the winning prices can be efficient and present a lower overall cost for ratepayers. -Communities earn income streams which can be supplemented by bidders' communities outreach programs.	-The government needs to set rules on the maximum installed capacity to be gained by each company to prevent monopolization.

6.2 Strategies for the Private Sector

1) Lobby for legal and regulatory changes to enable the emergence of innovative business models to widen access

To the date of this writing, financial institutions still provide limited financing options for households and businesses to pursue solar power. At the same time, current regulatory barriers are preventing new business models to emerge. For example, in the Solar PPA model developers receive FiT income directly from the government and install solar systems for households. This model cannot happen yet because the FiT income stream can only be assigned to the meter owners. Thai businesses need to form stronger lobby capacities to remove the numerous barriers listed in Table 6.3 below.

Table 6.3: Regulatory barriers make it difficult for new business models to emerge:

Barriers	Responsible Agencies
1. Assignment of Income Stream The FiT income stream is assigned to the meter owner and cannot be assigned to a third party. This makes it difficult for financial institutions to justify retail lending for solar systems. At the same time, private companies that would like to initiate new business models, such as solar PPA or solar leasing, would have more confidence if the income stream can be assigned to them.	ERC, PEA, MEA
2. Registration of Roof Rental: For developers that would like to rent a roof to install solar PV systems and produce income, they may require roof rental registration over a long term. The rental contract of a roof needs to be registered with the Land Department. However, the Land Department may not allow the registration due to their unfamiliarity of the business transactions. Many issues remain unresolved. For example, if the building is already a rental property, the term of the building rental may not match with the term of the roof rental required by the developer.	Land Department
3. Transferability of FiT contract Each FiT contract is associated with the meter and the location of the building, and there is currently no rules whether the contract can be transferred to a new location in the case that the building owner moves or whether the contract can be transferred to a new party that purchases the site.	PEA, MEA
4. Absence of Regulations to Legalize Crowdfunding Platforms: Currently, any fundraising platform designed to provide fund for solar power can only be legal if it is based on donation only. If the fundraising platform is designed to issue securities and pay interests to investors, it must be registered with the Securities and Exchange Commission of Thailand. Alternatively, if the fundraising platform borrows from individual lenders and gives interests, it must be registered with the Bank of Thailand. Both approaches involve high transaction costs, which are too high for small-scale crowdfunding platforms.	SEC, Bank of Thailand

2) Engage in more effective consumer education campaigns

The private sector can play an active role in educating a broader base on potential consumers to understand solar power applications. Education campaigns should be focused on technical, financial, as well as practical aspects of solar PV. Consumers should understand what it means to have solar systems on their

roofs and how it may affect them. With these goals in mind, the private sector should form a strong industry association that serves as a knowledge hub for educating companies and the public through marketing surveys, publications, seminars, training workshops, and online tools. A good example is the U.S. Solar Energy Industries Association which regularly publishes policy and regulatory updates, research findings, market status reports, and polls results.

3) Develop a transparent third-party certification scheme for industry practitioners who design and install PV systems.

The relatively new rooftop solar scheme in Thailand has invited many new players into the market. The current government-backed certification scheme has no transparent criteria for the selection of the certified installers. Consumers would have more confidence about the quality of products and installations if there is a third-party certification body that is overseen by industry associations as well as the government. The private sector should develop a certification scheme that is systematic and transparent. The certification body would issue both a product certification scheme and an installer certification scheme to which the certified installers will need to comply. In addition, the certification body should serve as a one-stop service for consumers to file complaints and receive remedies for the problems. Certified installers would have to at least on an annual basis undergo an audit to ensure compliance to the certification scheme's requirements.

4) Working with academic institutions to increase PV knowledge and skilled workforce

Private companies and business associations need to form strategic partnerships with schools, research labs, universities, and vocational schools to build widespread knowledge and necessary skills on solar PV. Industry associations can work with vocational and technical schools to enable them to become training centers and providers of certificates for solar PV installation. At the same time, existing research labs and universities can enhance their impacts through closer collaboration with the private sector. Research labs and universities in Thailand already have developed expertise on solar PV new technology R&D, performance evaluation, testing, and grid integration simulation, and close collaboration with the private sector will allow local industries in Thailand to reap greater benefits from the solar PV value chain.

6.3 Strategies for End-Users and Communities

1) Enhance consumers' and communities' energy awareness

Communications through social media have demonstrated to be powerful ways of raising awareness on renewable energy, energy conservation, and the government's energy

policies. As more and more successful community-level projects are emerging, it is important to spread out the information to the wider public. In the end, the high level of energy awareness can lead to meaningful policy changes.

2) Establish urban and rural solar pilot communities to demonstrate the net benefits of solar PV applications

Pilot projects on solar power in the past have yielded little impact in terms of making the difference to people's lives. They have been designed based on a hands-off approach in which communities played no role in helping the design or install the projects and rather served as government hand-outs. Today's community solar projects should be focused more on enhancing the capacity of the urban and rural people by building important skills related to the technology, including project planning, financing, and the design of appropriate end-use applications that match with the consumers' needs. This process will not only help build new skilled jobs but also boost the local economies.

3) Encourage PV applications for sustainable agriculture

Local communities have great potential to adapt the use of solar PV for the purposes of sustainable agriculture. Sustainable agriculture requires reduction of the use of fossil fuels both as energy and inputs into the production of fertilizers. In the past, solar PV was already competitive with diesel use in remote agricultural applications such as water pumping. Today, as cost of solar power continues to decline, the use of PV modules are becoming economic for more diverse applications, for example (adapted from Chel and Kaushik, 2011):

-power for feed or agricultural product grinding
-electric-powered egg collection and handling equipment
-product refrigeration;
-livestock feeder and sprayer motors and controls;
-compressors and pumps for fish farming;
-electric fencing to contain livestock;
-batter charging for flashlights and electric lamps
-water circulation for livestock drinking

Conclusions

Thailand leads Southeast Asia in solar capacity. Despite this significant expansion, the development pathway for solar power in Thailand remains uncertain. The Solar PV Roadmap Initiative identified gaps and crystallized a vision for Thailand's solar future based on stakeholder consultations. Furthermore, the roadmap process developed strategies needed to achieve this vision. Solar power can enhance Thailand's energy security through the decentralization toward green power sources and reducing its dependence on fossil fuels. With this vision in mind, the Thai government needs to create strong linkages between solar power policy and industrial policy so that Thailand can advance and become a regional hub for all stages along the solar value chain, with a special niche on tropical climate applications. The framework needs political stability to enable market competitiveness. Appropriate measures can be refined further to ensure transparency, accountability, and encourage competition.

This report also highlights three solar development paths. Each path paints a unique picture but all converge toward a self-sustaining market, where solar power generation for self-consumption becomes a norm. And under all scenarios, scaling up solar PV investment in Thailand will require a strong and unified vision that considers all parties involved—industry, government utilities, and consumers-- as emphasized throughout the Thailand Solar PV Roadmap Initiative.

References

BRE (Building Research Establishment). 2013. Planning Guidance for the Development of Large Scale Ground Mounted Solar Systems, p.7, http://www.bre.co.uk/filelibrary/pdf/other_pdfs/KN5524_Planning_Guidance_reduced.pdf, Accessed May 22, 2014.

Chel, A. and G. Kaushik. 2011. "Renewable Energy for Sustainable Agriculture," *Agronomy for Sustainable Development*, 31: 91-118.

DEDE (Department of Alternative Energy Development and Energy Efficiency). 2013. The Renewable and Alternative Energy Development Plan (AEDP 2012-2021), http://www.dede.go.th/dede/images/stories/dede_aedp_2012_2021.pdf, Accessed January 14, 2014.

Department for Communities and Local Government. 2012. "Planning Practice Guidance for Renewable and Low Carbon Energy," Page 9, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/225689/Planning_Practice_Guidance_for_Renewable_and_Low_Carbon_Energy.pdf, Accessed May 21, 2004

Department of Industrial Works. 2014. " List of Hazardous Materials," http://www.diw.go.th/hawk/law/haz/announce56.pdf, Accessed May 21, 2014.

Eclareon. 2014. " PV Rooftop Development in Thailand. Analysis of Regulation and Challenges. A Study Commissioned by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH," http://www.thai-german-cooperation.info/download/20140408_pdp_th_report_pv_regulations.pdf, Accessed May 19, 2014.

EPIA (European Photovoltaic Industry Association). 2011. " Solar Photovoltaic: Competing in the energy sector," (September 2011), http://www.epia.org/fileadmin/user_upload/Publications/Competing_Full_Report.pdf, Accessed September 13, 2013.

EPMC (Energy Policy Management Committee). 2013. Resolutions on "Framework for Developing Community Solar Projects," (August 27, 2013), http://www.eppo.go.th/nepc/kbg/kbg-162.html#1, Accessed May 1, 2014.

ERC (Energy Regulatory Commission). 2014a. "Postponed COD Deadline Announcement ," http://www.erc.or.th/ERCWeb2/Front/News/NewsDetail.aspx?rid=1577&CatId=1&muid=36&prid=21, Accessed May 15, 2014.

ERC. 2014b. "Extended Deadline for FiT Application Submission," https://www.pea.co.th/vspp/Documents/Rooftop/ann_extend.pdf, Accessed May 15, 2014.

Erge, T., Hoffmann, V.U., and K. Kiefer. 2001. "The German Experience with Grid-Connected PV Systems," *Solar Energy*, 70(6): 479-487.

Fraunhofer Institute for Solar Energy Systems ISE. 2013. "Photovoltaics Report," http://www.ise.fraunhofer.de/en/downloads-englisch/pdf-files-englisch/photovoltaics-report-slides.pdf, Accessed May 21, 2014

Fulton, M. 2012. "German Feed-in Tariff: Recent Policy Changes," Deutsche Bank Climate Change Advisor (September 2012), https://www.db.com/cr/en/docs/German_FIT_Update_2012.pdf, Accessed July 7, 2014.

Grau, T. 2014. "Responsive Feed-in Tariff Adjustment to Dynamic Technology Development," *Energy Economics*, 44: 36-46.

IEA (International Energy Agency). 2010. "Technology Roadmap - Solar Photovoltaic Energy," (October 2010), http://www.iea.org/publications/freepublications/publication/pv_roadmap.pdf, Accessed September 13, 2013.

IRENA (International Renewable Energy Agency). 2012. Renewable Energy Technologies: Cost Analysis Series. Solar Photovoltaics (June 2012), p.34, http://www.irena.org/DocumentDownloads/Publications/RE_Technologies_Cost_Analysis-SOLAR_PV.pdf, Accessed May 16, 2014.

Kittner et al. 2013. An environmental life cycle comparison of single-crystalline and amorphous-silicon thin-film photovoltaic systems in Thailand. *Energy for Sustainable Development*, 17(6): 605-614.

Konagai, M., Kondo, M., and M. Yamaguchi. 2010." Fundamentals and applications of photovoltaic," Baifukan publisher.

MEA (Metropolitan Electricity Authority). 2014. "Status of Rooftop Solar PV Applications in MEA's Service Areas," Data as of February 2014.

NEPC (National Energy Policy Commission). 2014. Meeting on August 15, 2014.

NREL (National Renewable Energy Laboratory). 2013a. Photovoltaic Systems Pricing Trends: Historical, Recent, and Near-term Projections. 2013 Edition, p.p. 26, http://www.nrel.gov/docs/fy13osti/60207.pdf, Accessed May 16, 2014.

NREL. 2013b. "Life Cycle Assessment Harmonization Results and Findings," October 2013, http://www.nrel.gov/analysis/sustain_lca_results.html, Accessed May 21, 2014

Ontario Power Authority. 2014. “What are Prime Agricultural Land Restriction?,” http://fit.powerauthority.on.ca/program-resources/faqs/prime-agricultural-lands. Accessed May 21, 2014.

PEA (Provincial Electricity Authority of Thailand). 2014. “Status of Rooftop Solar PV Applications in PEA’s Service Areas,” Data as of May 2014.

Rosenberg, R. 2009. “Measuring Results of Microfinance Institutions. Minimum Indicators that Donors and Investors Should Track”, http://goo.gl/BH1KlX, Accessed July 22, 2014.

Royal Dutch Shell, “The Shell Global Scenarios to 2025,” http://www-static.shell.com/content/dam/shell/static/aboutshell/downloads/our-strategy/shell-global-scenarios/exsum-23052005.pdf, Access February 27, 2014.

Schallenberg-Rodriguez, J., and R. Hass. 2012. “Fixed Feed-in Tariff vs. Premium: a Review of the Current Spanish System,” *Renewable and Sustainable Energy Reviews*, 16: 293-305.

Spertino, F., Di Leo, P., and V. Cocina. 2013. “Economic Analysis of Investment in the Rooftop Photovoltaic Systems: A Long-term Research in the Two Main Markets,” *Renewable and Sustainable Energy Reviews*, 28: 531-540.

Tenenbaum, B. et al. 2014. “From the Bottom Up. How Small Power Producers and Mini Grids can Deliver Electrification and Renewable Energy in Africa”. The World Bank.