Lessons Learned from Thailand's Solar PV Roadmap Initiative

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22 April 2015

British Embassy Bangkok

Energy Research Institute

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

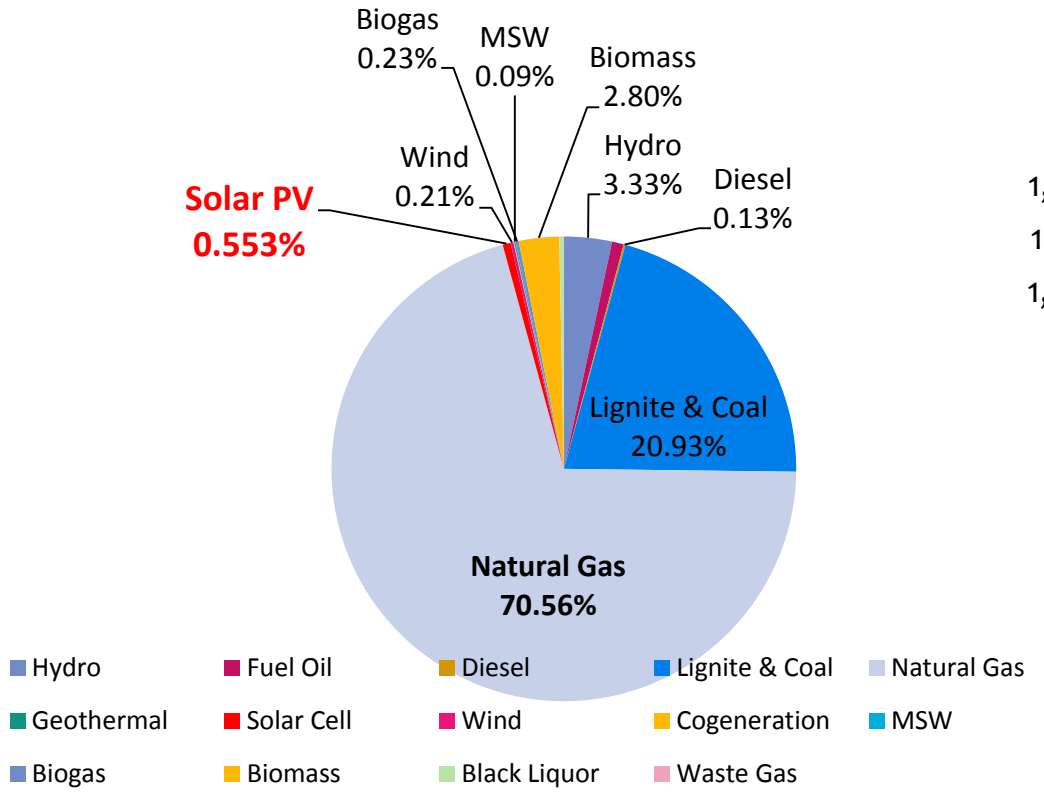
PURPOSES

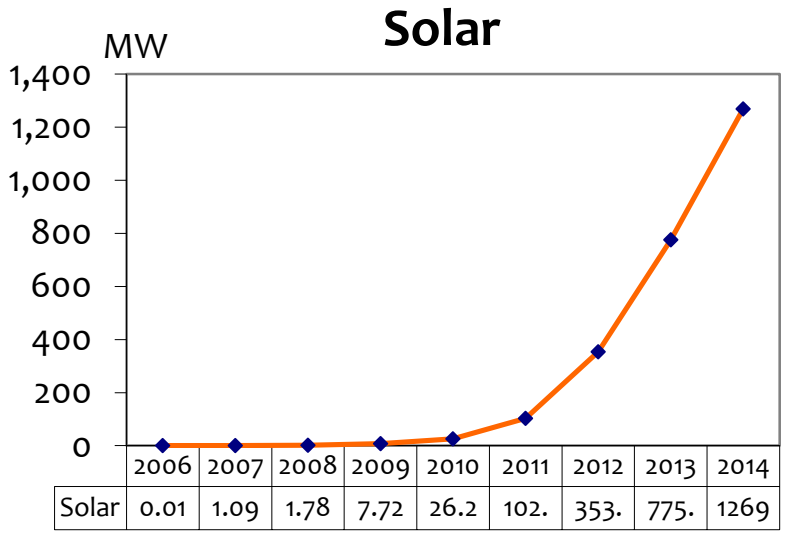
YEAR 1 To contribute to the expansion of Thailand's rooftop solar power market through the production of Thailand's Solar PV Roadmap.

YEAR 2 To analyse the feasibility of innovative business models and smart pricing options for solar photovoltaics (solar PV)

1	• ***Where we are today?***
2	• ***What kind of barriers the Thai solar market has been facing?***
3	• ***What we, the stakeholders, imagine our solar future to be?***
4	• ***How do we get there?***

Share of Generation by Fuel in 2013 (MWh)



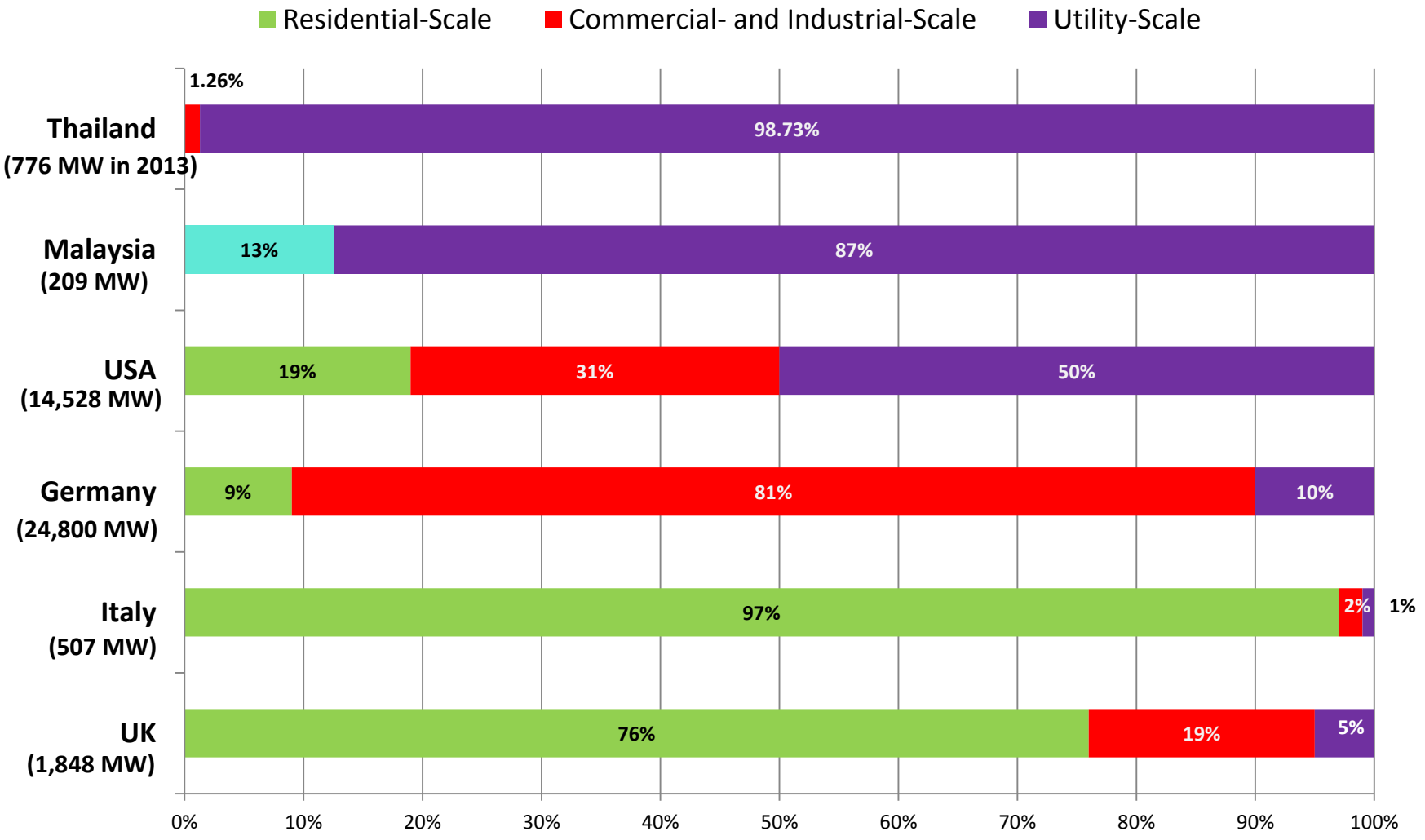


Total Generation = 168,478 GWh

Share of renewables in total share of MWh = 4% (Excluding Hydro)

Source: Department of Alternative Energy Development and Efficiency

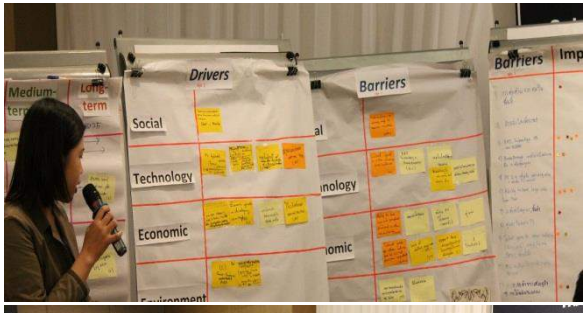
On-Grid Solar Power in Different Countries by Scale of Installations



Notes: status at various dates---UK (March, 2014); Italy (July, 2014), USA (first half, 2014); Malaysia (Jan 2014); Thailand (Dec 2013); Germany (2011)

Thailand's Solar PV Roadmap Initiative

5 Seminars and 4 Workshops



Thailand's Solar PV Roadmap Initiative

5 Seminars and 4 Workshops

Strategies

3 Scenarios

Benefits

Vision

Targets

Barriers

VISION

Which of these elements of Thailand's solar power development do you think should be included in the Solar PV Roadmap Vision?

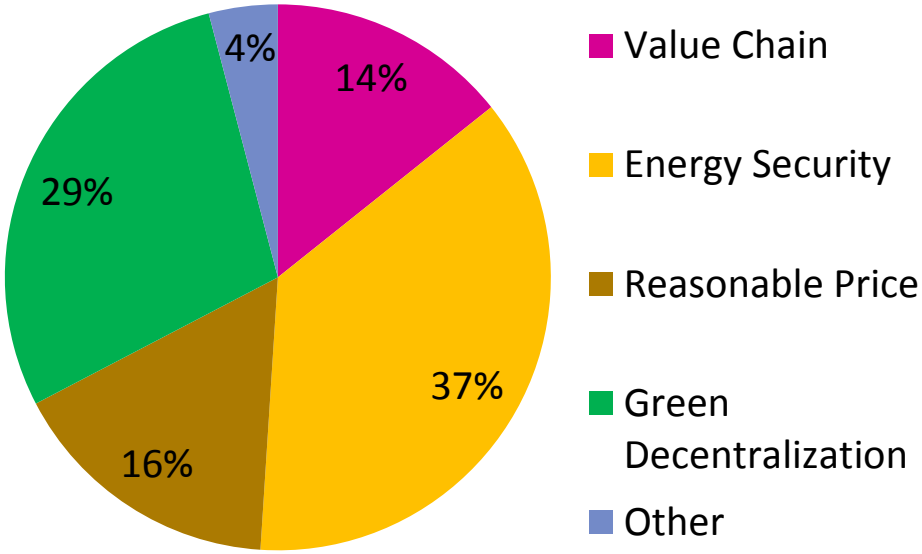
1) Value Chain – Thailand becomes the ASEAN leader in the Solar PV Value Chain

2) Energy Security Thailand is able to decrease reliance on natural gas for power generation through Solar PV.

3) Reasonable Price Thailand is able to achieve a balanced energy mix at a reasonable price with high reliability of the electric grid system.

4) Green Decentralization Households and businesses can increase their energy self-reliance by choosing their power sources, either through self-generation or buying from greener power options.

Voting results: Vision



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

Note: Voting results from 65 participants

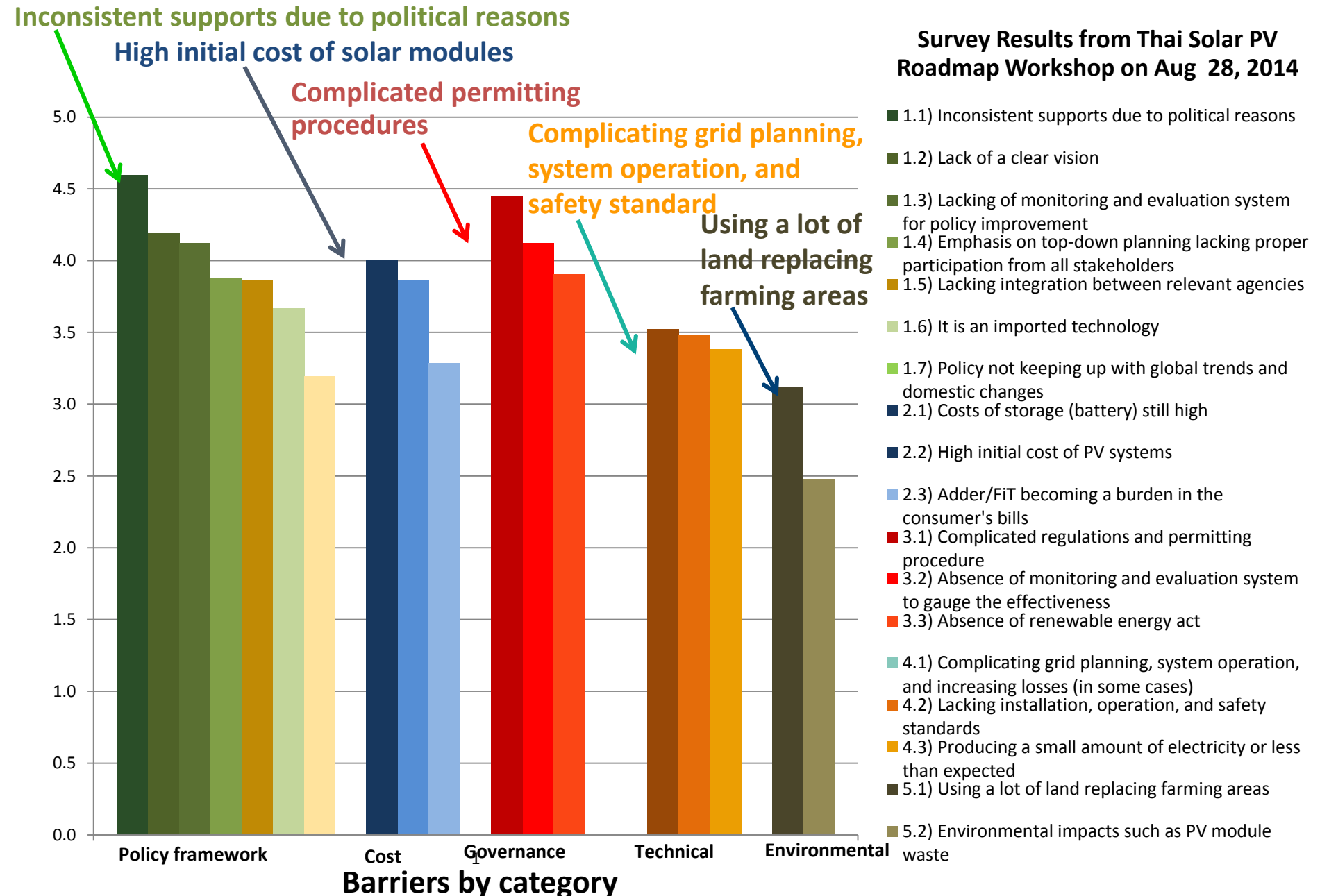
VISION

Vision Statement for Thailand's Solar PV Roadmap

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

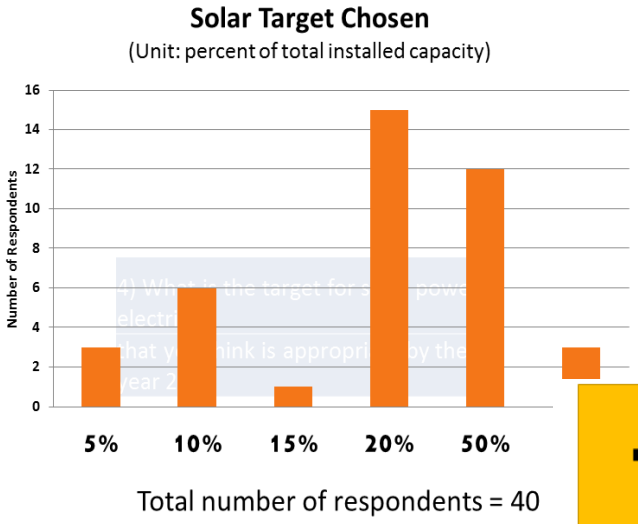
Note: Voting results from 65 participants

The survey about barriers in Thailand's solar PV development were conducted three times during the participatory workshops.



TARGET

What is the target for solar power electricity that you think is appropriate by the year 2035?

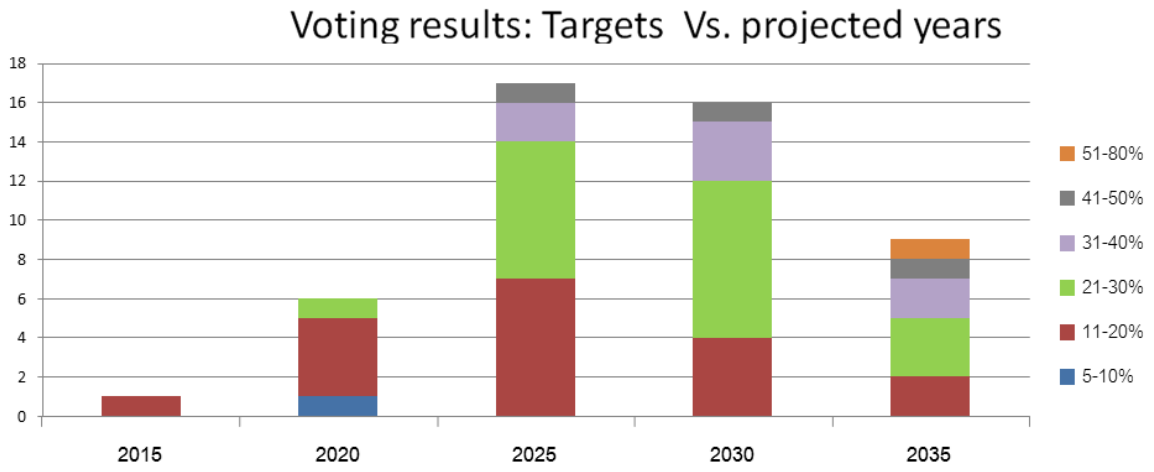


TARGET

What should be the target for the installed capacity of Thailand's solar PV?

And by which year?

Note: In 2013, solar installed capacity amounts to 2 percent of the total installed capacity.



- At the end of 2020, the expected target is 10%.
- At the end of 2025, the expected target is 20%.
- At the end of 2035, the expected target is 30%.

Notes: *In 2013, solar installed capacity amounts to 2 percent of the total installed capacity.*
By 2021, the government's 3,000 MW target will amount to 5.7% of the total installed capacity.

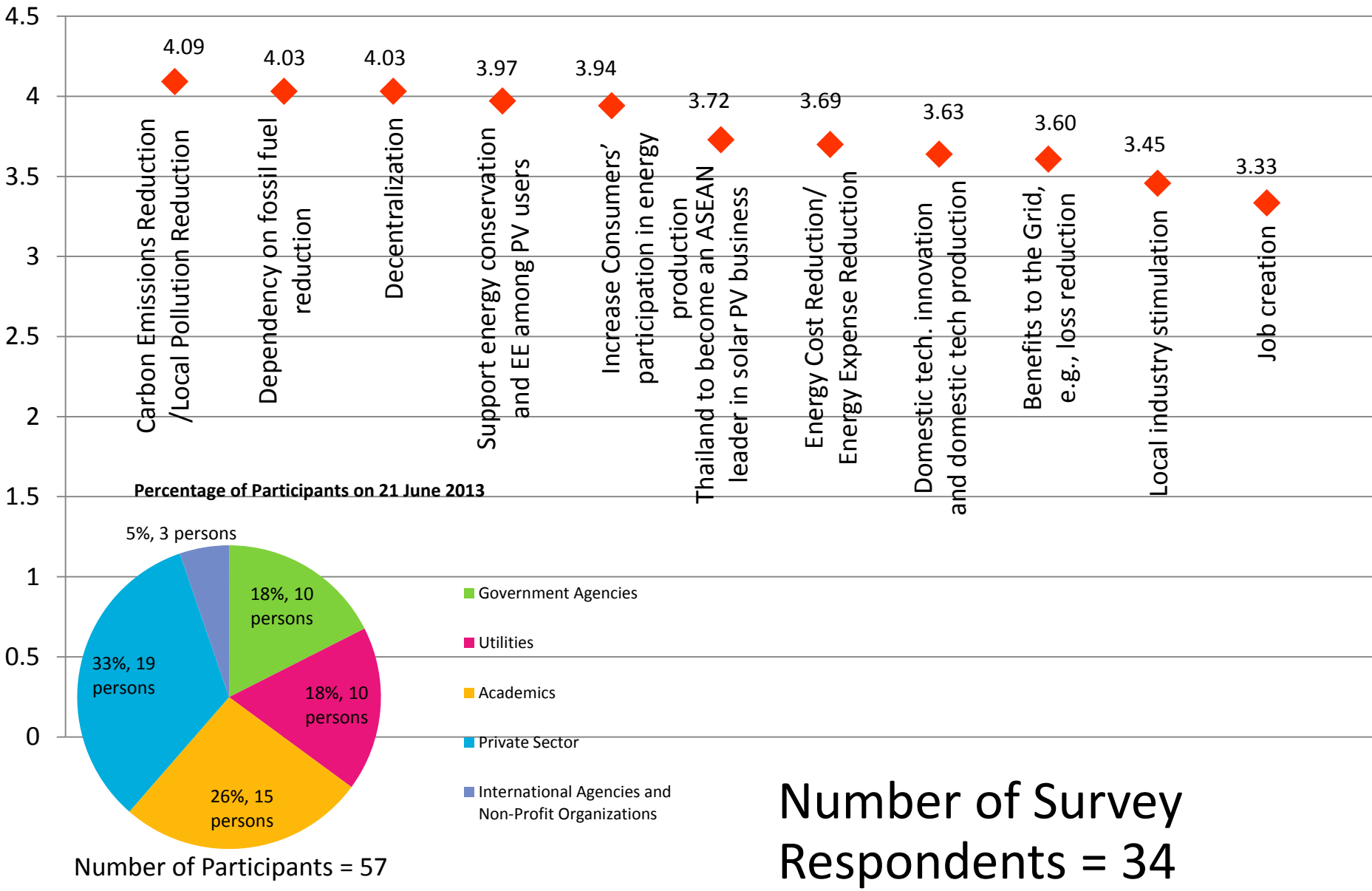
BENEFITS

What kinds of benefits should solar policy aim to achieve?

- Based on the same survey mentioned earlier, conducted 3 times, the *expected benefits* of solar PV were voted

- Top three benefits are:
  - Reducing CO_2 emission, air pollution
  - Easing the dependent upon fossil fuels
  - Decentralization of power generation sources

Survey Results from Thai Solar PV Roadmap Seminar on June 21, 2013

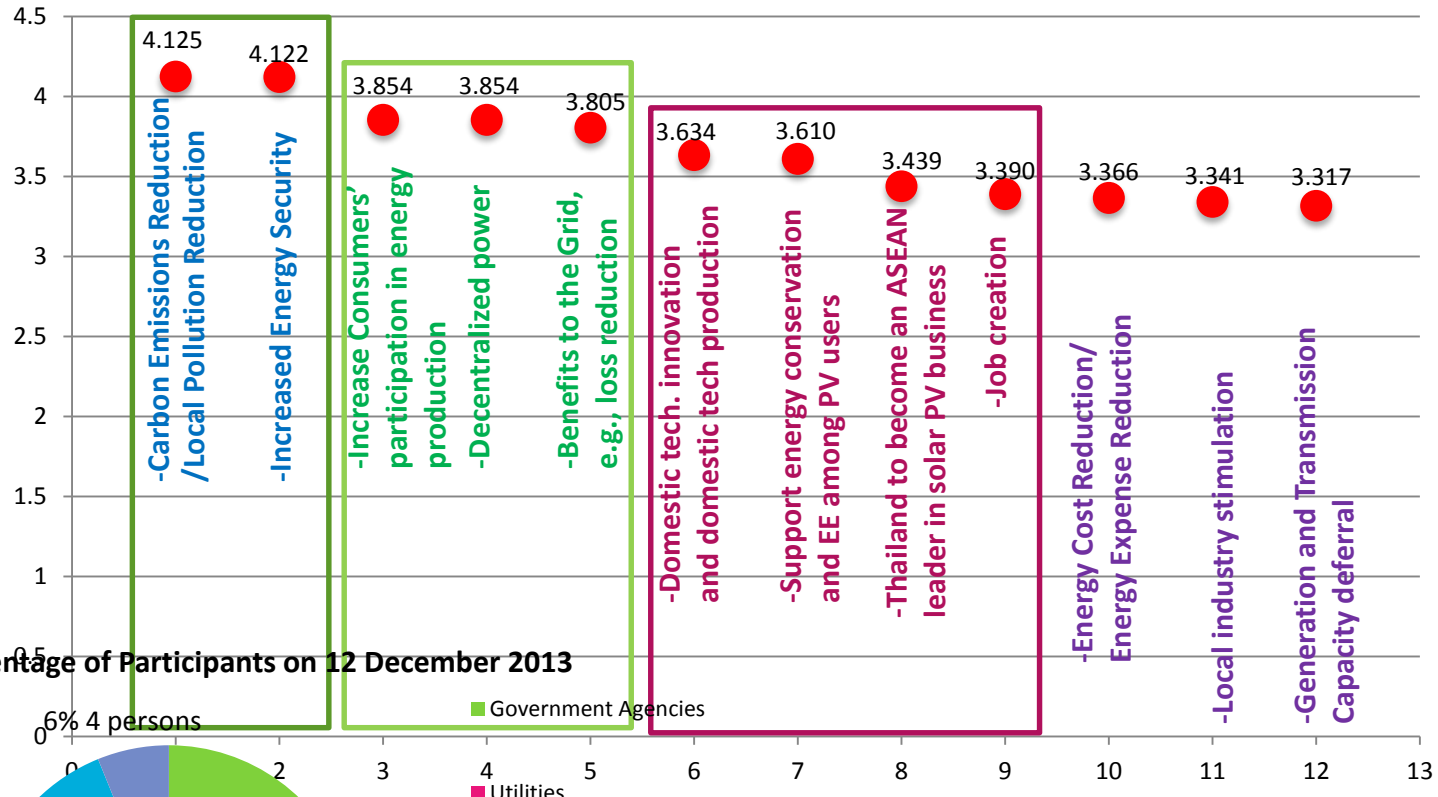


Percentage of Participants on 21 June 2013

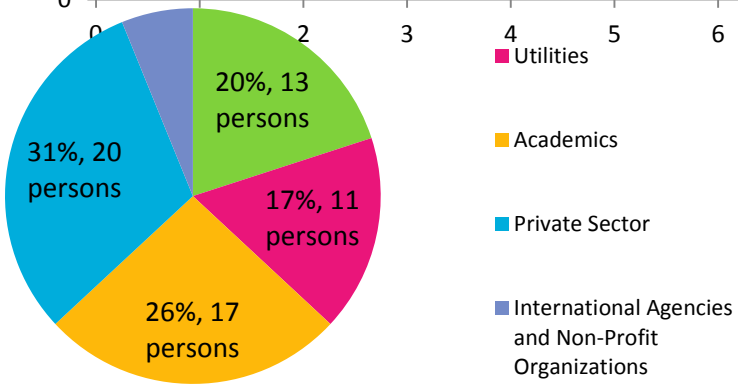
Number of Participants = 57

Number of Survey Respondents = 34

Survey Results from Thai Solar PV Roadmap Workshop on Dec 12, 2013



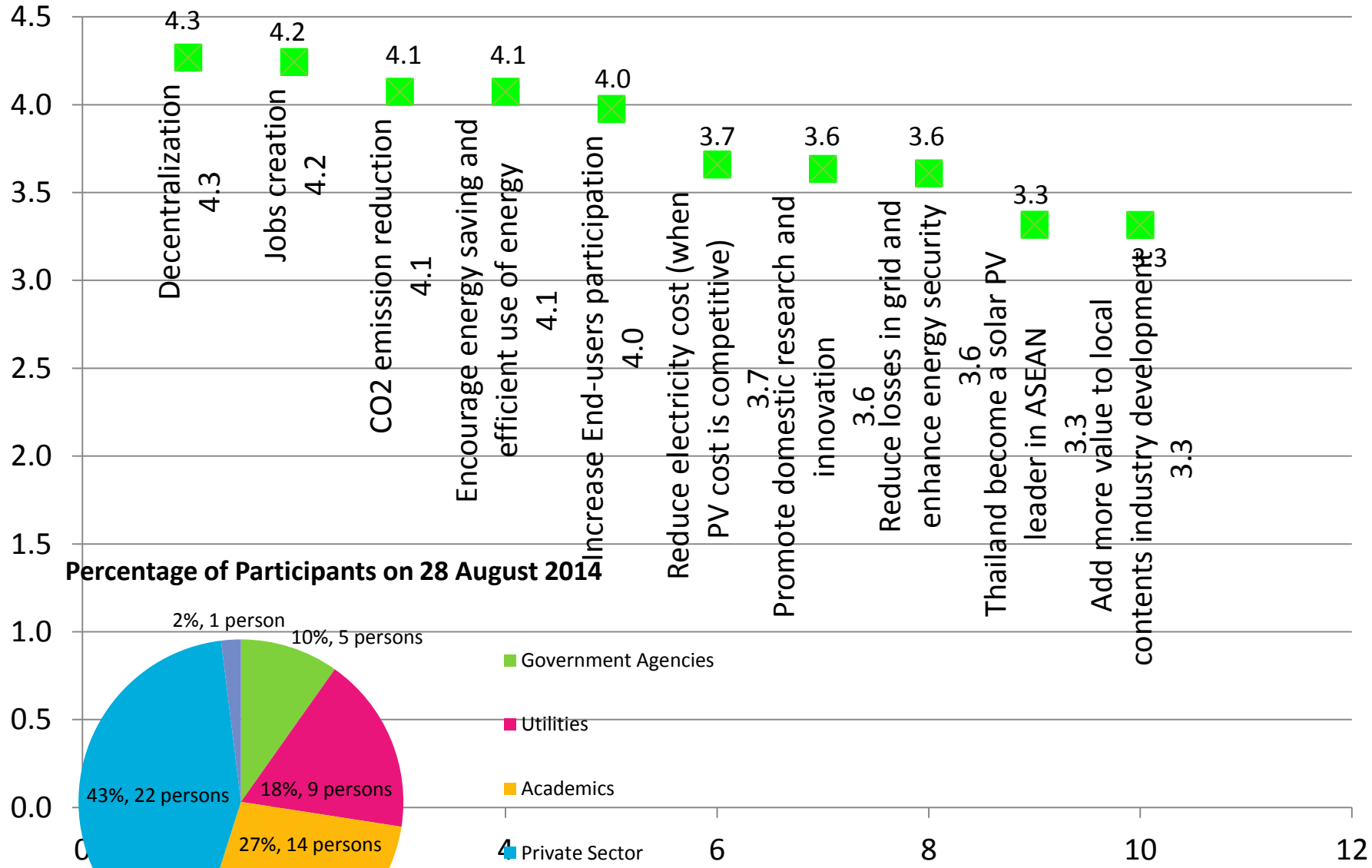
Percentage of Participants on 12 December 2013



Number of Participants = 65

Number of Survey Respondents = 40

Survey Results from Thai Solar PV Roadmap Workshop on August 28, 2014

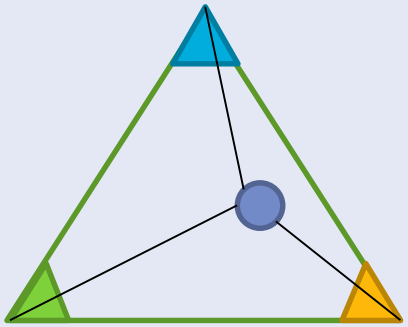


Number of Participants = 51

Number of Survey Respondents = 43

Development of the Three Scenarios to 2035

Effectiveness/
public agencies



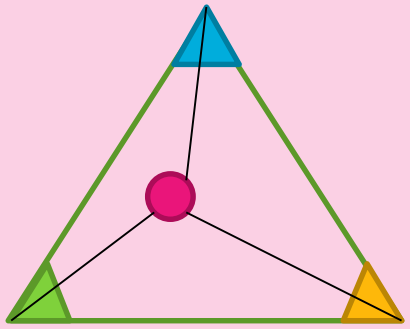
Competitiveness
/private sector

Proactiveness/
users

Scenario1
Domestic Market Boom

- **Government** provides strong and continuous FiT and BOI privilege.
- **People** are highly aware and interested in solar PV
- **Private sector** responds to a fast growing domestic market by providing services at all scales. Manufacturers open new plants in Thailand to serve the growing market.

Effectiveness/
public agencies



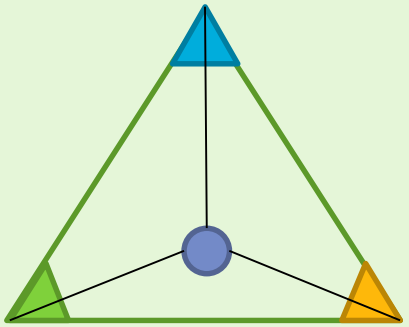
Competitiveness
/private sector

Proactiveness/
users

Scenario 2
ASEAN Market Leader

- **Government** limits domestic market due to fear of rate increases. However, the government creates a solar industrial policy in attempt to capture upstream value.
- **People** are moderate consumer awareness
- **Private sector** use EPC skills to invest in ASEAN

Effectiveness/
public agencies



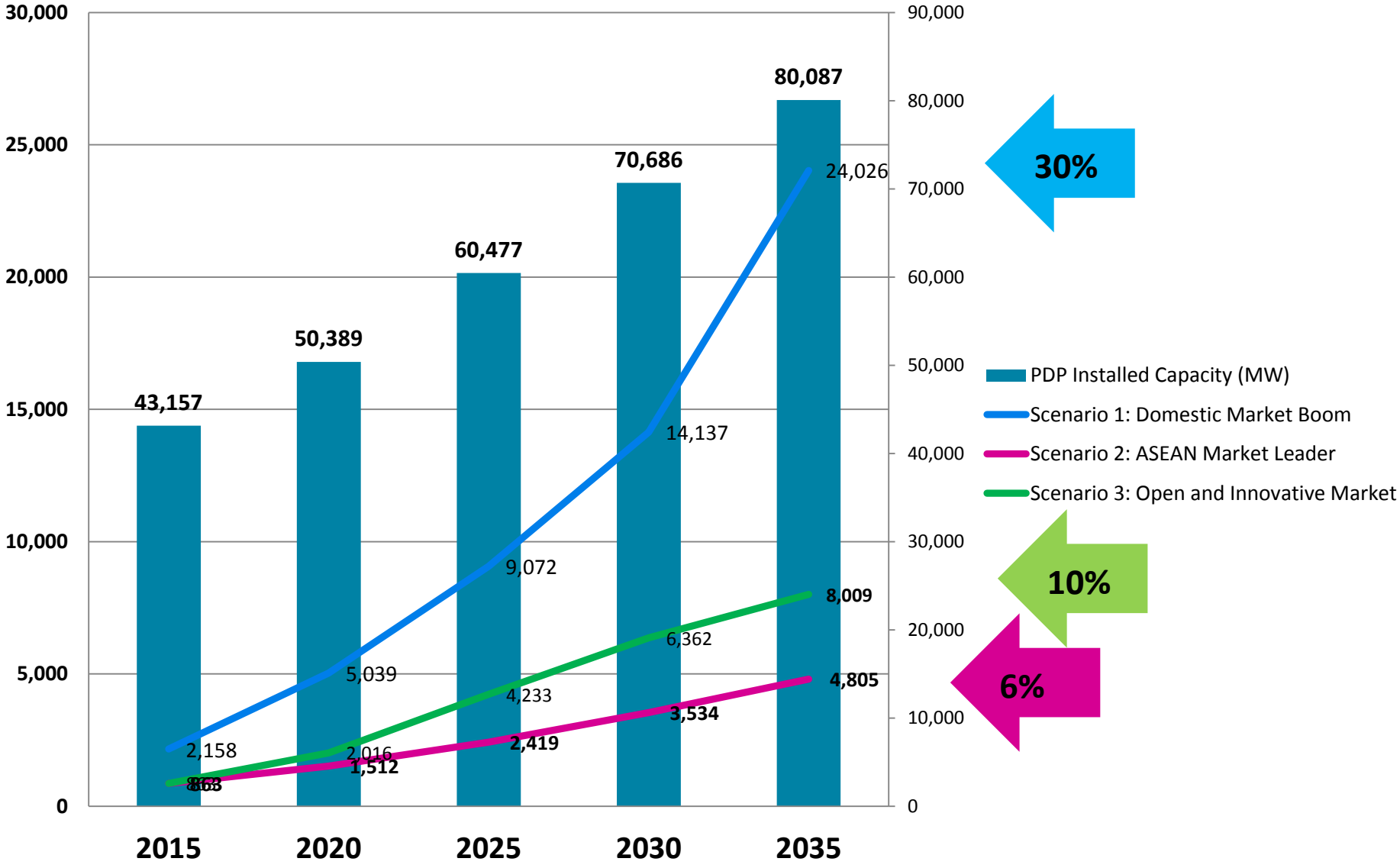
Competitiveness
/private sector

Proactiveness/
users

Scenario 3
Open and Innovative market

- **Government** offers no new incentive. However, restriction on grid integration eases due to smart grid technologies.
- **People** are very active and acutely aware of their consumption patterns/behaviors.
- **Private sector** competes with utilities in offering solar electricity at competitive prices. Utilities also begin to offer solar power services

Comparison of 3 Scenarios and Forecasted Installed Capacity (MW)



Total benefits of solar PV installation

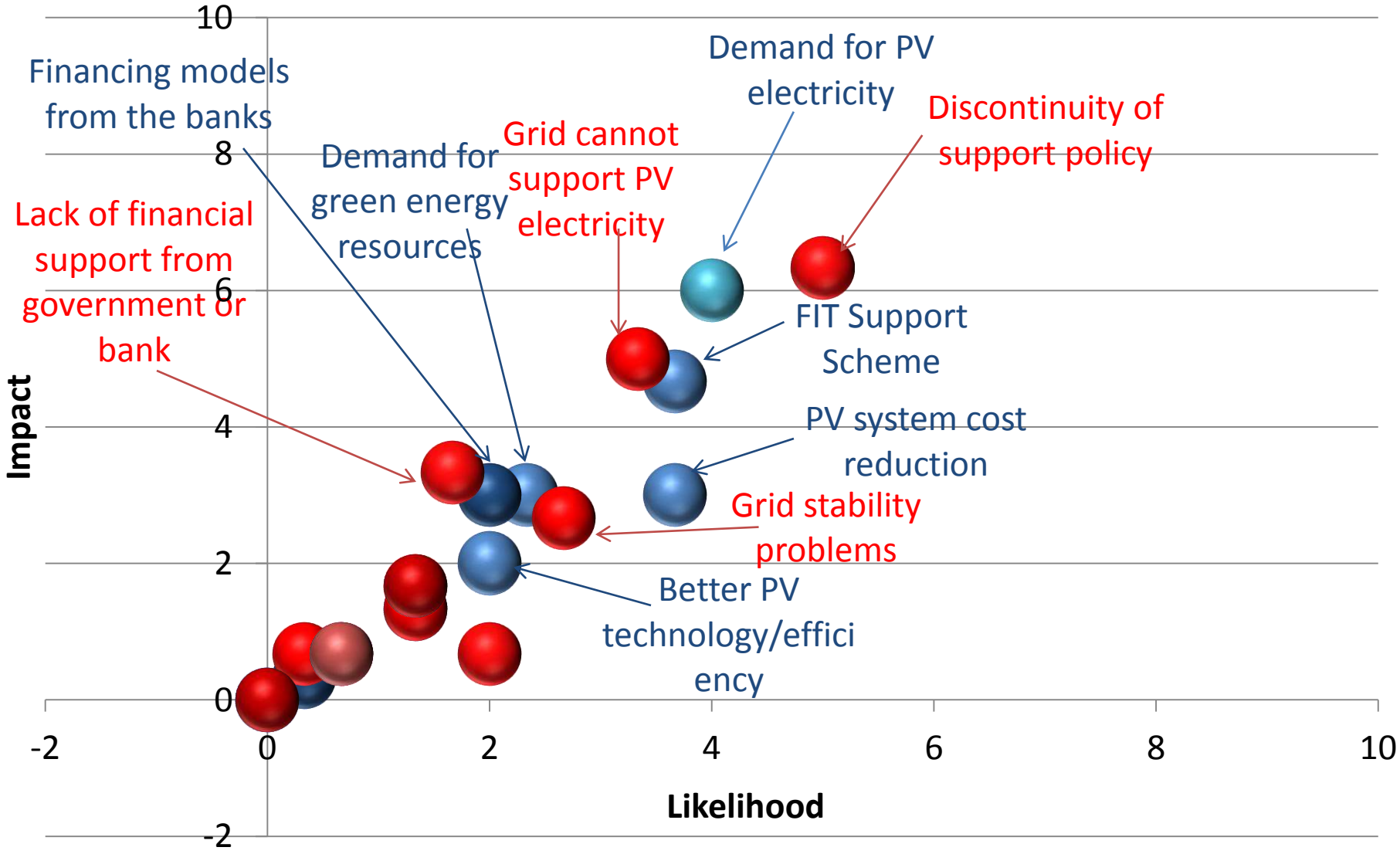
Benefits	Domestic Market Boom (High Case)	ASEAN Market Leader (Low Case)	Open and Innovative Market (Moderate Case)
CO_2 emission reduction (tCO2)	18,703,163.89	3,740,632.78	6,234,387.96
Fossil Fuel Reduction (ktoe)	2,895.54	579.11	965.18
Jobs Creation (Jobs)	70,052.65	15,523.84	17,975.51

Results from Thai Solar PV Roadmap Workshop on Mar 31, 2014

Drivers, Barriers, and Action Plans under Each Scenario

Scenario 1: Domestic Market Boom

Drivers and Barriers



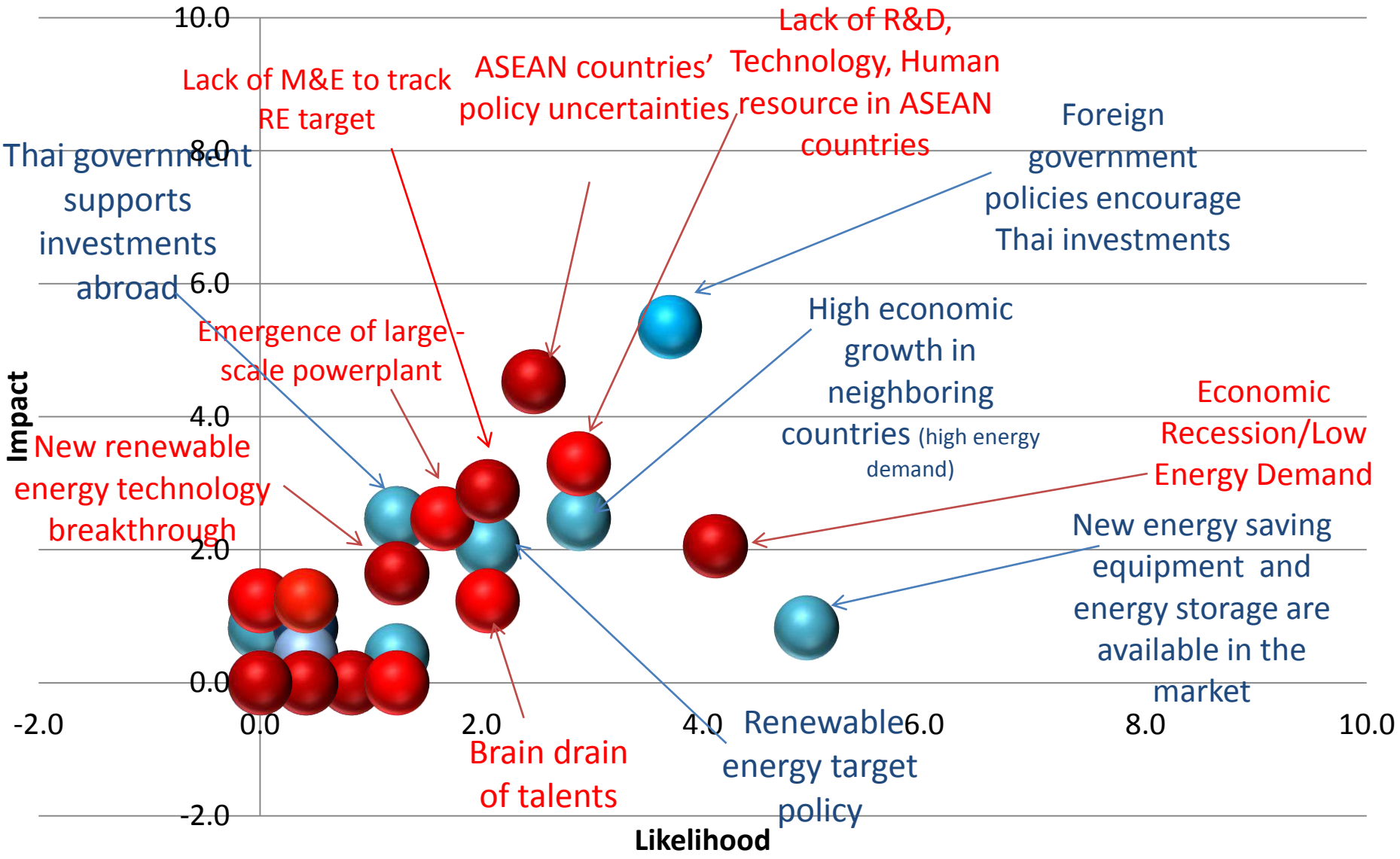
Scenario 1: Domestic Market Boom

Action Plans

Player/ Term	Short term	Medium term	Long term
Public	EPPO and ERC receive inputs from all relevant agencies, then formulate a plan that synchronizes their responsibilities. They better integrate energy with green environmental plans.		
	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 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		

Scenario 2: ASEAN Market Leader

Drivers and Barriers

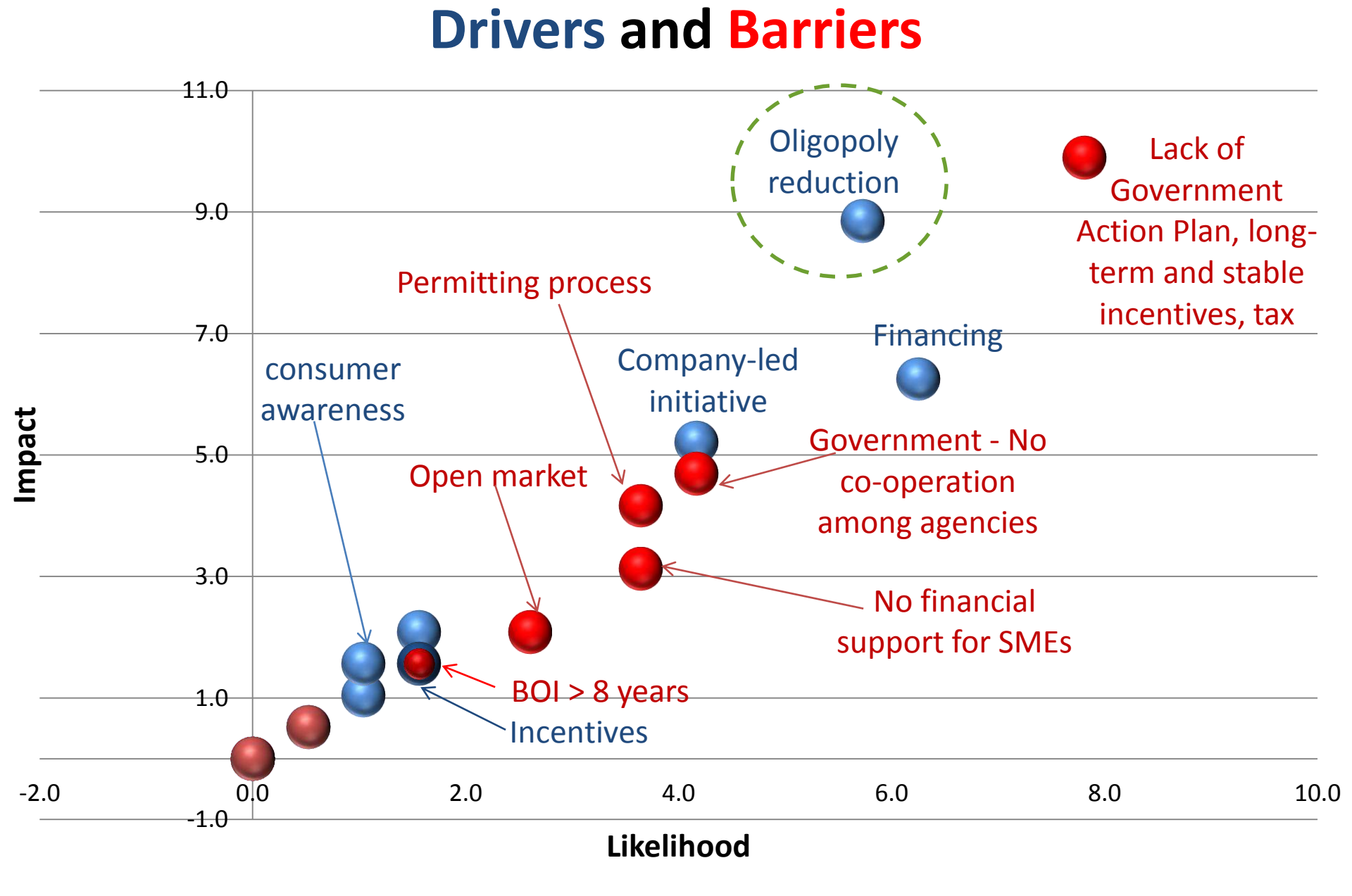


Scenario 2: ASEAN Market Leader

Action Plans

<table>
<tr><th>Player/ Term</th><th>Short term</th><th>Medium term</th><th>Long term</th></tr>
<tr><td rowspan="5">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="3">-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>

Scenario 3: Open and innovative market



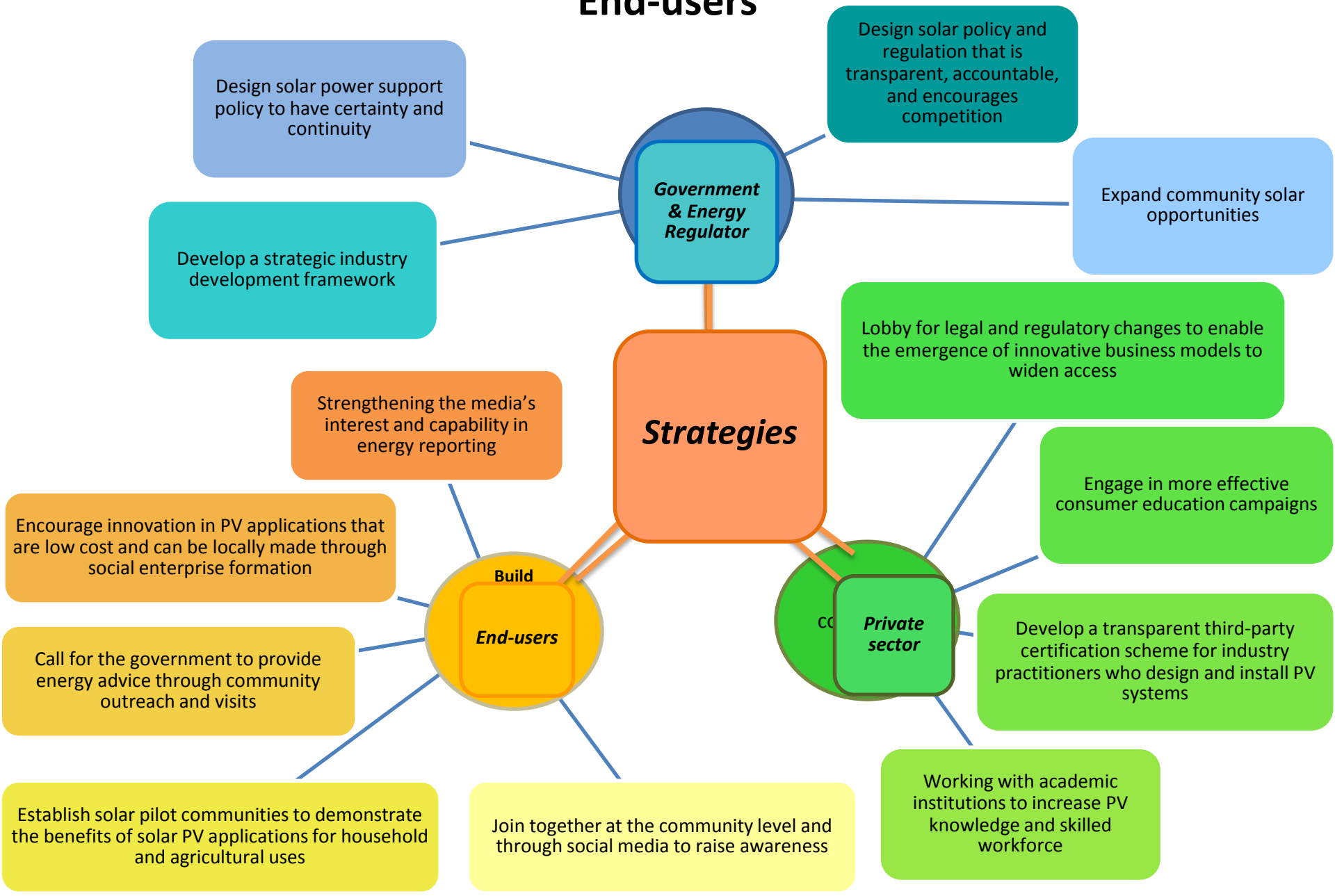
Scenario 3: Open and innovative market

Action Plans

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		

Strategies for the Government, Energy Regulator and Private sector

Strategies for the Government, Energy Regulator, Private sector and End-users



Design solar power support policy to have certainty and continuity

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 (taret 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%

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

- **No capacity cap for rooftop applications** and moderate volume through **degression rates or** impose an **annual cap with a clear policy announcement timeframe**
- **Use volume-based FiT adjustment mechanism:**

Corridor Degression: The degression rate will depend on whether the additional PV capacity is within the corridor. If the deployment in the previous 12 months exceeds the target volume, a higher degression rate would be applied.

Ceiling and Floor Mechanism: 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 policymakers that the costs of FiT would not skyrocket and hurt ratepayers.

3. Design Solar Policy and Regulation that is Transparent, Accountable, and Encourages Competition

Policy	Regulation
▪ **Policy Consultation** -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** - should allow enough flexibility to enable diverse business models and financing options to thrive. 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 -Coordinate the responsibilities of local, regional, and national agencies in administering solar power support measures.

3. Design Solar Policy and Regulation that is Transparent, Accountable, and Encourages Competition (cont.)

- **Policy Objectives**

The objectives for solar power development should have **corresponding national commitment** or plans.

- **Application Approval Procedures**

-Use an **online application process** for project qualification screening rather than requiring applicants to apply in person.

- Simplified and streamlined process for small-scale residential systems less than 10 kW.

- **Policy Support Mechanisms**

-Implement adequate measures to achieve solar policy objectives

- **Contract details**

- Contract Term: 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).

- Solar Power as "Must-Take" Capacity: A "Must-Take" clause would ensure that solar electricity that is injected successfully into the grid will be paid for.

Outputs

Stakeholders' Solar PV Roadmap (in English)

VAR Pricing Handbook (in Thai)

Solar Crowdfunding Handbook (in Thai)

Briefing Papers (published)

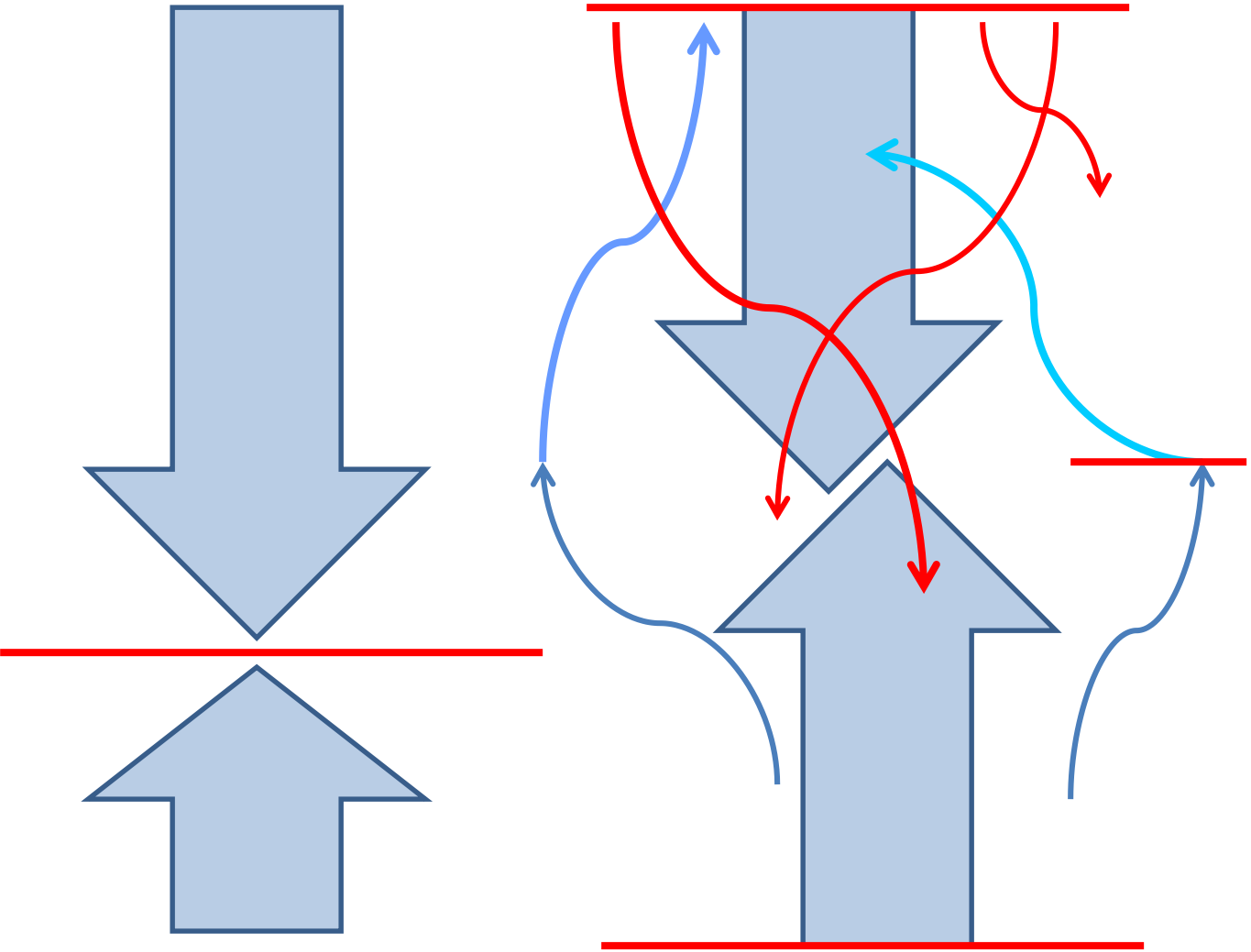
Articles In BKK Post (published)

Academic Papers (under peer review)

Outcomes

- **Aggregate** otherwise scattered voices in the solar PV market
- **Systematize** recommendations for future solar PV development
- **Catalyze** the actions of new players to enter the PV market
- **Network** for future cooperation

Top-down and Bottom-up Actions



YESTERDAY

TODAY

TOMORROW?

Remaining questions

1) What kind of further push do we need that can inform future initiative?

2) How do we mobilize a wider group of the constituency to have a strong support for decentralized generation, including solar PV?

3) What would be impacts on the grid with different levels of DG penetration (including solar)?

4) What kind of benefits of solar PV that we want to materialize? And at what costs?

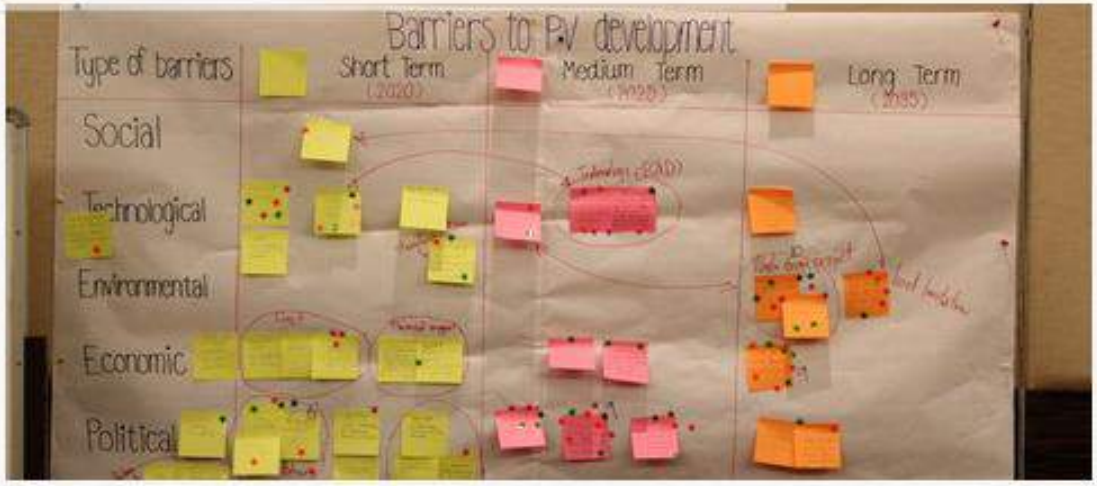
(What kind of solar PV scenario does the public desire?)

NEXT STEPS

British Embassy Bangkok

Energy Research Institute

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY



The Solar PV Roadmap Initiative **is designed to provide a meaningful platform of solar energy discussions among relevant stakeholders. The goal is to increase the awareness and promotion of solar energy to become a significant addition to Thailand's existing energy resources.**

How You Can Contribute:

Research

Creating knowledge base on solar power in the developing country' context.

Solar PV Roadmap's Latest Activities

Program 28 Aug 2014
Pictures August 28, 2014
Presentations 20 Jan 2015
Program 20 Jan 2015

Research Updates

A summary of trends in the expansion of solar leasing and solar crowd-funding in the USA and the UK
A Review of Business Models for Distributed Solar Power Deployment in the U.S. and Japan: Lessons and Prospects for Thailand
Permitting Process: Experiences from other markets.

Media

ERI's article in Bangkok Post Nov 20, 2014
ERI's article in Bangkok Post SEP 15, 2014
Community Solar Incentives in Thailand Stall over Funding Hurdle

Thai Solar Policy & Regulatory Activities

Research Team

Dr. Sopitsuda Tongsopit

Affiliation: Energy Research Institute, Chulalongkorn University
Interest: I would like to help catalyze the expansion of the rooftop solar market so that solar power becomes not just an alternative source of power production but a tool for empowering change.
Bio: Researcher in the Energy Research Institute based in Bangkok, Thailand. Her 2012 book explores the changing technical and regulatory landscape of the electric power grid in an age when distributed energy such as solar systems are gaining prominence in the world's energy mix.

Surachai Chaitusaney

Affiliation: Chulalongkorn University
Interest: Applications and Impacts of Solar PV Generation Systems and the different implementations the government could promote.
Bio: In 2007, Surachai Chaitusaney obtained his Ph.D. degree from the University of Tokyo, Japan, with JICA scholarship. At present, he is a lecturer at Department of Electrical Engineering, Chulalongkorn University.

Noah Kittner

Affiliation: UC Berkeley
Interest : I would like to see more ambitious targets beyond 2 GW by 2020 and longer term strategies to feed solar PV into the grid.
Bio: Graduate student in the Energy and Resources Group at UC Berkeley. Previously, he had a Fulbright fellowship in Thailand investigating technical and policy options for reducing greenhouse gas emissions by using solar electricity. He also has conducted research on biomass fuels at the Carolina Population Center, installed off-grid solar panels in rural Mexico and analyzed deforestation trends in Uganda. He holds a BS in Environmental Science from the University of North Carolina at Chapel Hill.

Pimjai Hoontrakul

Affiliation: Environmental Resources Management (ERM) consulting
Interest: I am interested to see solar PV technology adoption in the residential and commercial sectors serve as a driver for transforming Thailand's energy infrastructure into a more sustainable and cleaner system.
Bio: Consultant with ERM. She has a background in mechanical engineering and energy technologies and policies. Her prior experiences include the United States Department of Energy, the University of Texas at Austin IC2 Institute, and the United Nations Economic and Social Commission for Asia and the Pacific.

David Arturo Teran

Affiliation: Energy Research Institute, Chulalongkorn University
Interests: Motivating progressive discussion and implementation of renewable energy's, with a focus on solar PV technology and waste to energy adoption stimulated by a grass roots movement.
Bio: B.A in International relations at Universidad San Francisco de Quito and currently is a graduate student in the Environment, Development and Sustainability program In Chulalongkorn University. Currently is a Researcher Assistant in the Energy Research Institute based in Bangkok, Thailand.

Research Assistant Team

Apinya Aksornkij

Affiliation: Energy Research Institute, Chulalongkorn University
Interests: I would like to see the growth of Thai solar PV development in residential and commercial sectors which will be the potential solution to move towards sustainability.
Bio: She obtained M.A in Energy Technology from Asian Institute of Technology and currently working as Research Assistant in the Energy Research Institute, Chulalongkorn University.

Morakot Tossabanyad

Affiliation: Energy Research Institute, Chulalongkorn University
Interest: I am interested in seeing rapid deployment of renewable energy, especially solar power, in Thailand
Bio: Research assistent in the Energy Research Institute of Chulalongkorn University, based in Bangkok, Thailand. She has a B.E. in Environmental Engineering and an M.E. in Energy Management Technology, King Monkut's University of Technology Thonburi.

Supot Chunhachoti-ananta

Affiliation: PhD candidate at Environment, Development, and Sustainability program, Chulalongkorn University
Interests: small scale/community-based/decentralised renewable energy development; multistakeholder dialogue/deliberation towards policy and partnership development in urban clean energy transition.
Bio: Academic backgrounds in environmental science and management, ecotourism, and renewable energy. Work experiences include natural resource management, alternative economic development, teaching undergrads, and community-based biogas project.

Thank you

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Benefits Calculation: Jobs creation

$$Jobs_t = \sum_i P_{i,t} \cdot I_{i,t} \quad (1)$$

where

- i is each considered link in the supply chain
- $I_{i,t}$ is the employment intensity for a given stage i into the supply chain
- $P_{i,t}$ is the referred MW for the stage i (installed MW for stages related with manufacturing, cumulated MW for O&M stages and manufactured MW for component manufacturing stages)

$$I_{i,t} = I_{i,base}\left(\frac{Cumulated\ MW_{i,t}}{Cumulated\ MW_{i,base}}\right)^{-\alpha} \quad (2)$$

where $I_{i,base}$ is the employment intensity and $MW_{i,base}$ is the cumulated power for a given stage i empirically obtained and the subindex t means the time when this intensity has been evaluated. The exponent α is a correction factor related to the learning curve of the studied technology.

Source: E. Llera, et al. (2013)

Stage	$I_{i,\ base}$ (using 2007 data from Spain)	Fitting parameter related with learning rates (α): Spanish case
Projects/studies	0.83	0.56
Silicon	1.26	0.15
Cells	3.09	
Module assembly	11.59	
Solar tracker	8.15	
Inverter	3.32	
Installation	15.25	0.56
Operation	3.3	0.42

Benefits Calculation: Assumptions

CO2 emission reduction						
	EFgrid, CM	=	Combine margin CO2 emission factor in year			
		=	0.56	tCO2/MWh		
	Source:	TGO (2010)		http://conference.tgo.or.th/download/tgo_or_th/publication/GEF/2009/GEFReport_ENrevise1.pdf		

Note:

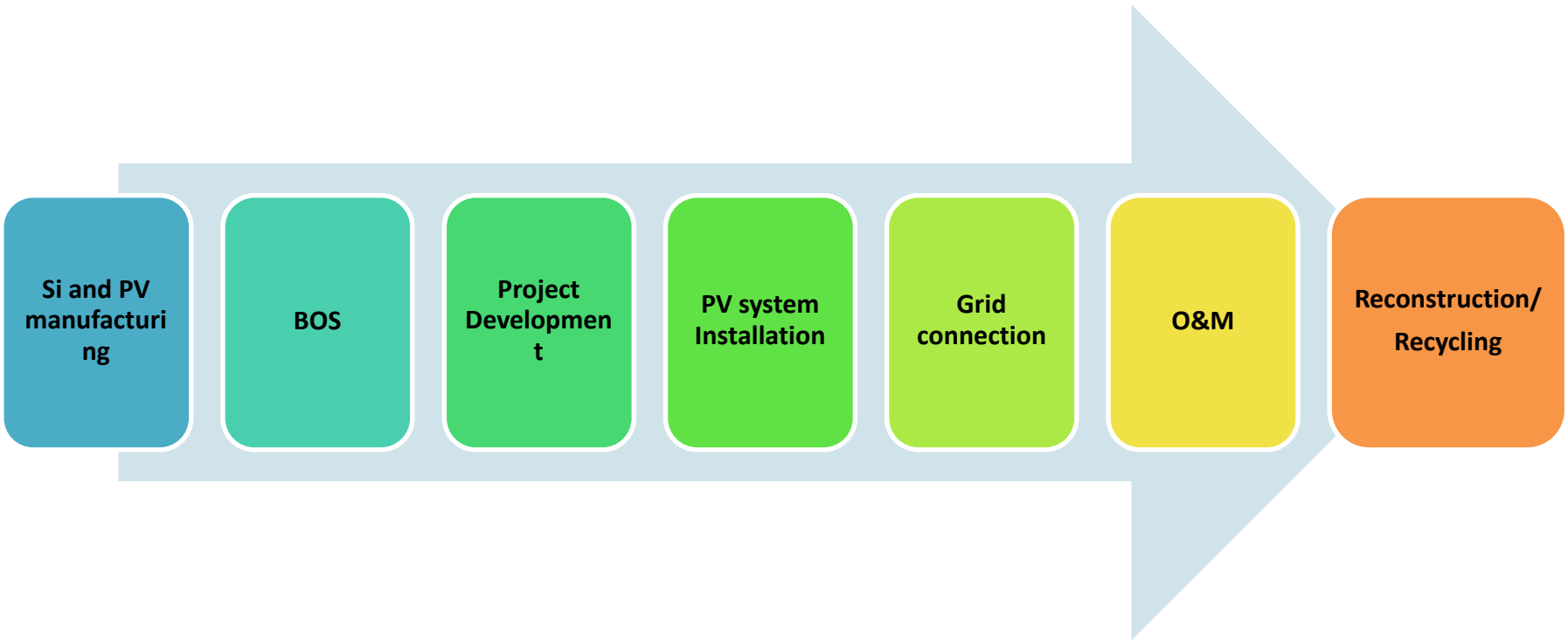
$EF_{grid, CM}$ =Combine margin CO2 emission factor in year y ค่าถ่วงน้ำหนักระหว่าง Operating Margin กับ Build Margin

Fossil Fuel conversion							
	1	MWh	=	8.6E-05	ktoe		
	Source :	IEA	http://www.iea.org/statistics/resources/unitconverter/				

Assumptions on Growth Rate of the Three Scenarios

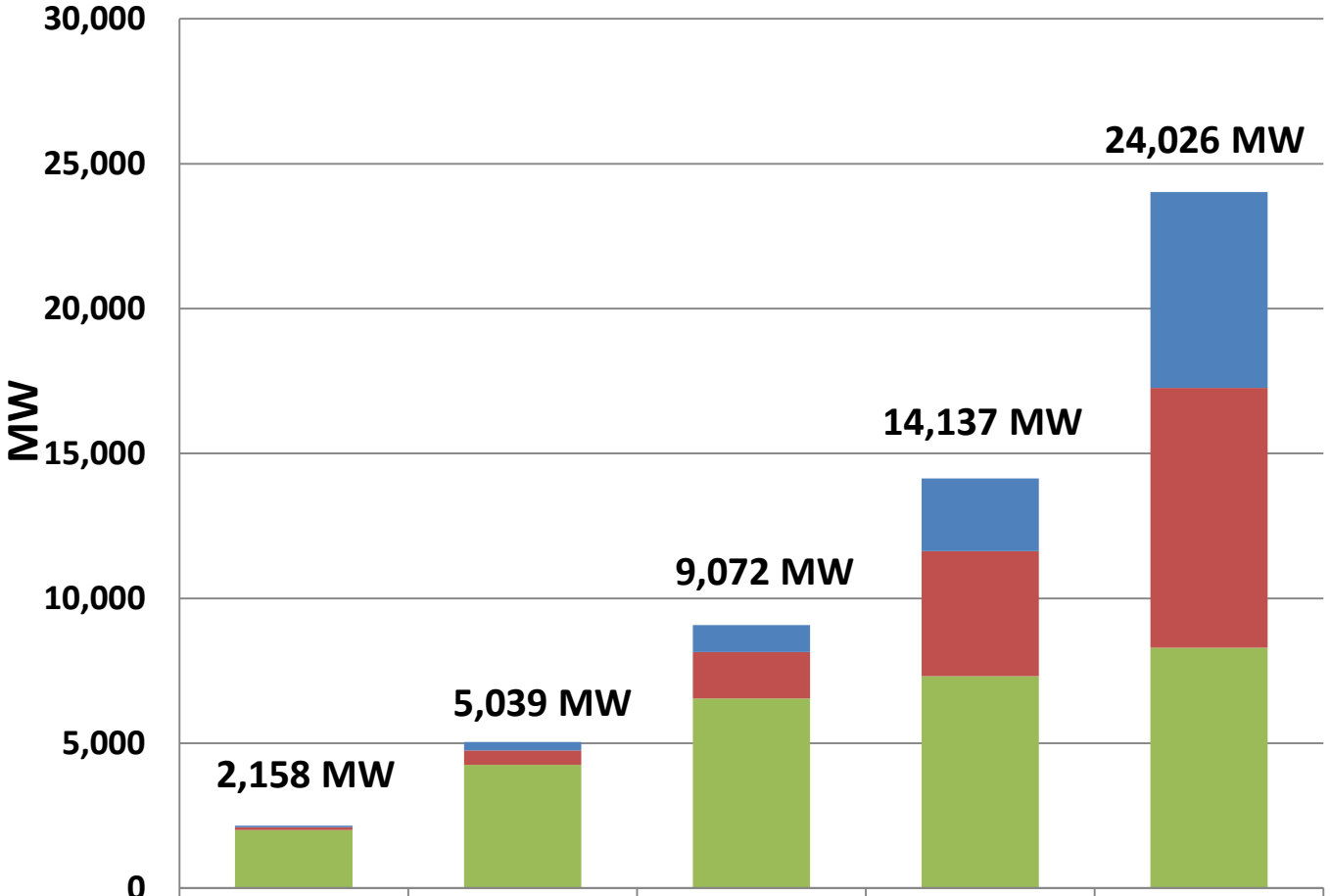
Growth Rate Assumptions (%)								
			2015	2020	2025	2030	2035	
1	Domestic Boom	gov+users	5%	10%	15%	20%	30%	high
2	ASEAN leader	gov+private sector	2%	3%	4%	5%	6%	low
3	Open and Innovative M	private sector +user	2%	4%	7%	9%	10%	moderate
PDP Installed Capacity (MW)			43,157	50,389	60,477	70,686	80,087	
Solar Installed Capacity (MW)--translated from % using PDP load assumptions			2015	2020	2025	2030	2035	
1	Domestic Boom	gov+users	2,158	5,039	9,072	14,137	24,026	high
2	ASEAN leader	gov+private sector	863	1,512	2,419	3,534	4,805	low
3	Open and Innovative M	private sector +user	863	2,016	4,233	6,362	8,009	moderate

PV System Value Chain



30% of System's Installed Capacity by 2035.

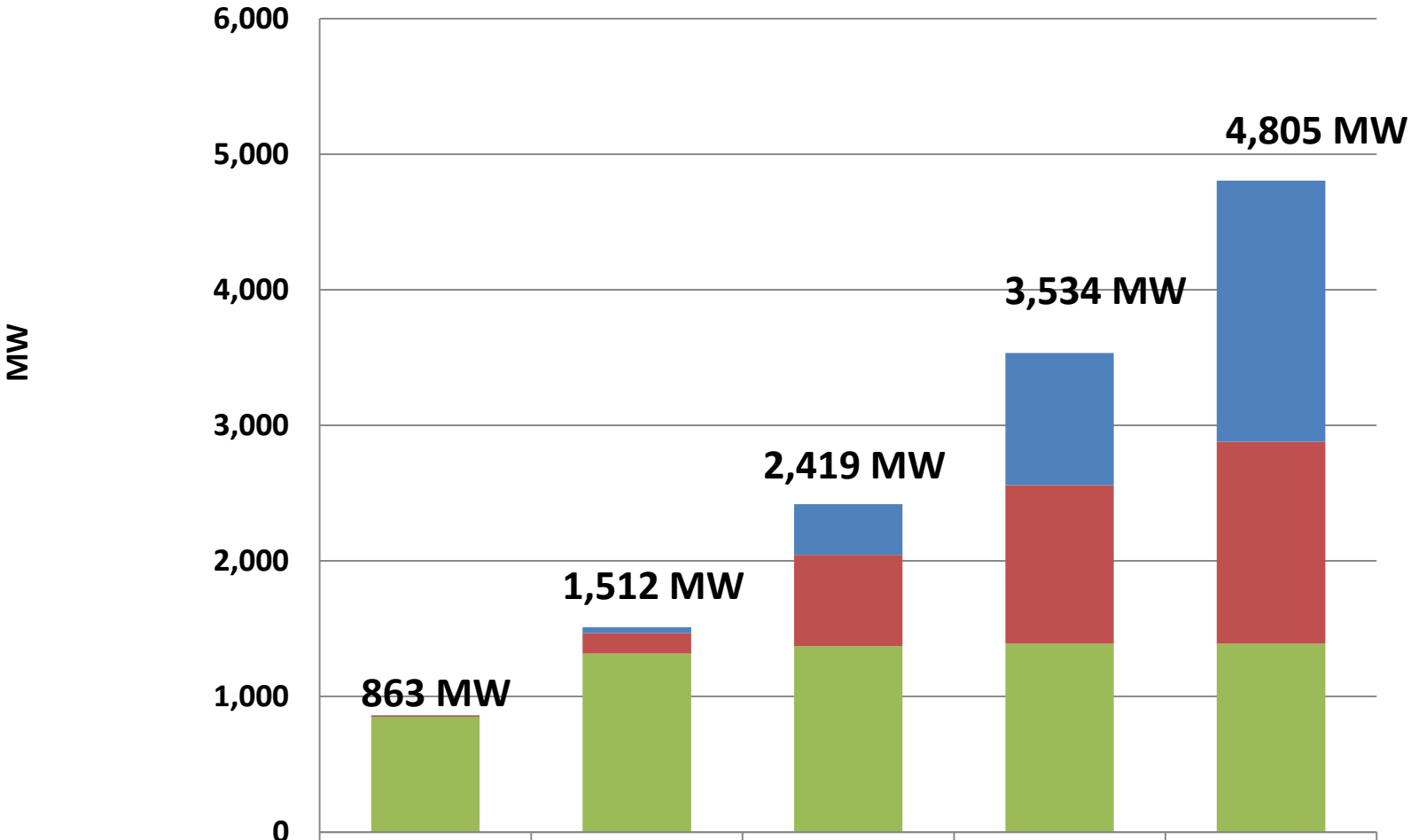
Scenario 1: Domestic Market Boom



	2015	2020	2025	2030	2035
residential (0-10 kW)	58	290	928	2,506	6,765
commercial (10-1,000 kW)	100	500	1,600	4,320	8,961
utility-scale (>1 MW)	2,000	4,249	6,544	7,312	8,300

6% of System's Installed Capacity by 2035.

Scenario 2: ASEAN Market Leader

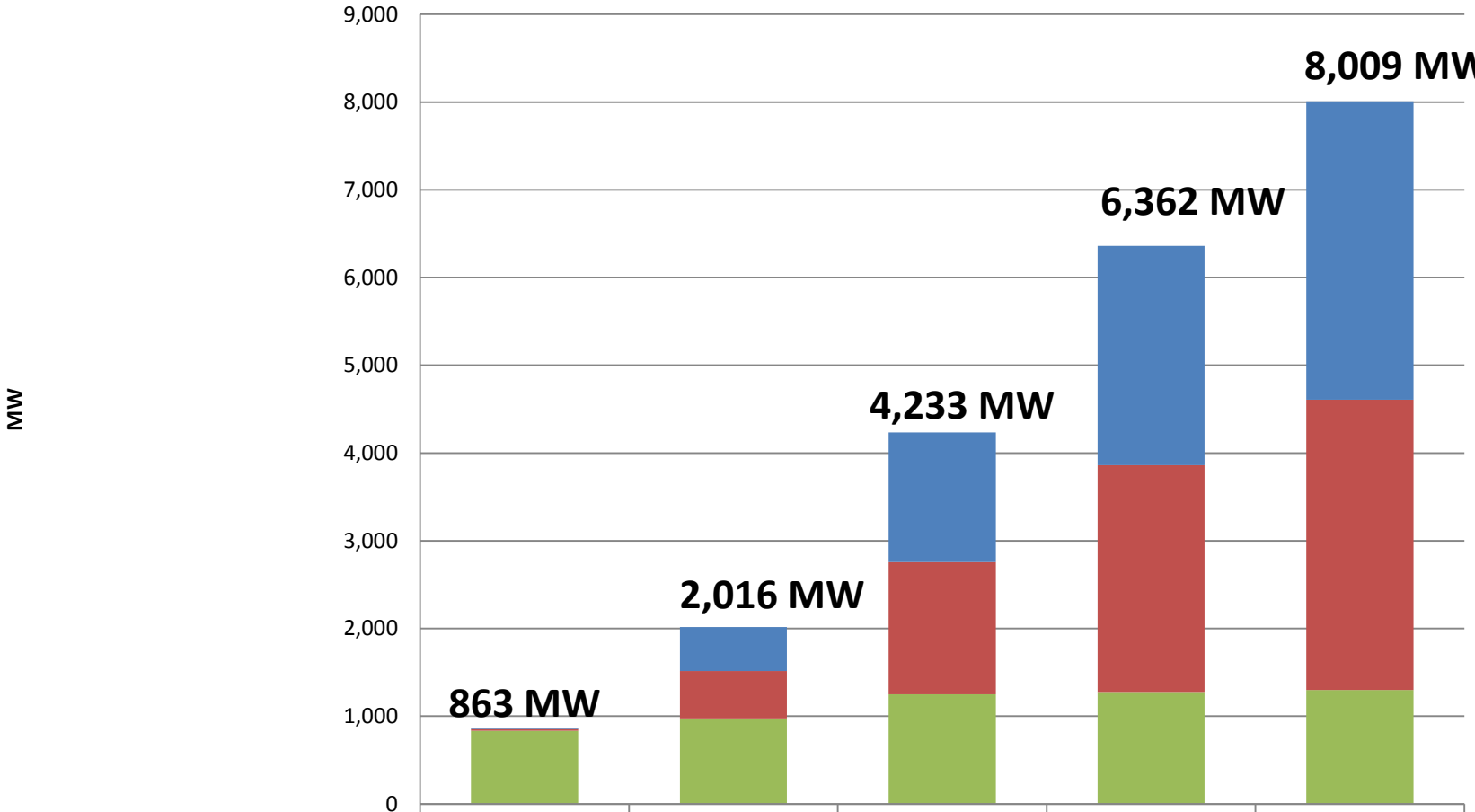


	2015	2020	2025	2030	2035
residential (0-10 kW)	3	45	375	975	1,925
commercial (10-1,000 kW)	10	150	672	1,169	1,490
utility-scale (>1 MW)	850	1,317	1,372	1,390	1,390

* Note: The above numbers are domestic installed capacities.

10% of System's Installed Capacity by 2035.

Scenario 3: Open and Innovative Market



	2015	2020	2025	2030	2035
residential (0-10 kW)	10	500	1475	2500	3400
commercial (10-1,000 kW)	20	541	1,508	2,587	3,309
utility-scale (>1 MW)	833	975	1,250	1,275	1,300

Strategies for the Government and Energy Regulator

1. Develop a Strategic Industry Development Framework
2. Design Solar Power Support Policy to have Certainty and Continuity
3. Design Solar Policy and Regulation that is Transparent, Accountable, and Encourages Competition
4. Expand Community Solar Opportunities

Strategies for the Private Sector

1. Lobby for Legal and Regulatory Changes to Enable the Emergence of Innovative Business Models to Widen access
2. Engage in More Effective Consumer Education Campaigns
3. Develop a transparent third-party certification scheme for industry practitioners who design and install PV systems.
4. Working with academic institutions to increase PV knowledge and skilled workforce

Strategies for End-users

1. Join together at the community level and through social media to raise awareness on renewable energy, energy conservation, and the government's energy policies

2. Establish solar pilot communities to demonstrate the benefits of solar PV applications for household and agricultural uses.

3. Call for the government to provide energy advice through community outreach and visits

4. Encourage innovation in PV applications that are low cost and can be locally made through social enterprise formation

5. Strengthening the media's interest and capability in energy reporting