A Framework for Evaluating Economic Impacts of Rooftop PV Systems with or without Energy Storage on Thai Distribution Utilities and Ratepayers

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A Framework for Evaluating Economic Impacts of Rooftop PV Systems with or without Energy Storage on Thai Distribution Utilities and Ratepayers

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Abstract. Driven by decreasing PV and energy storage prices, increasing electricity costs and policy supports from Thai government (self-consumption era), rooftop PV and energy storage systems are going to be deployed in the country rapidly that may disrupt existing business models structure of Thai distribution utilities due to revenue erosion and lost earnings opportunities. The retail rates that directly affect ratepayers (non-solar customers) are expected to increase. This paper focuses on a framework for evaluating impacts of PV with and without energy storage systems on Thai distribution utilities and ratepayers by using cost-benefit analysis (CBA). Prior to calculation of cost/benefit components, changes in energy sales need to be addressed. Government policies for the support of PV generation will also help in accelerating the rooftop PV installation. Benefit components include avoided costs due to transmission losses and deferring distribution capacity with appropriate PV penetration level, while cost components consist of losses in revenue, program costs, integration costs and unrecovered fixed costs. It is necessary for Thailand to compare total costs and total benefits of rooftop PV and energy storage systems in order to adopt policy supports and mitigation approaches, such as business model innovation and regulatory reform, effectively.

1. Introduction

Thailand is facing an energy security problem due to high dependence (more than 50 percent of total primary energy supply) on imported non-renewable energy and continuous depletion of scarce domestic energy reserves [1-2]. Apart from the fact that integration of a wider variety of energy resources, especially distributed solar photovoltaic (PV), could be a cost-effective and risk minimizing approach, there is increasing interest in the potential of solar PV in Thailand. According to the latest Alternative Energy Development Plan 2015-2036 (AEDP 2015) approved in September 2015, the solar power capacity target of 6,000 MW has been set [3]. By third quarter of 2016, the cumulative installed capacity of solar PV that has already connected to the grid was approximately 2,753 MW, which increased more than 200 percent from 2013. Out of the total installations of PV, 95 percent is accounted for solar farm, while rooftop PV shares the installed capacity approximately 5 percent [4].

Currently, Thailand tries to eliminate solar rooftop quotas with feed-in tariff scheme. Instead, a self-consumption scheme for rooftop PV is encouraged [5-6]. To date, there is only a self-consumption pilot project of 100 MW. However, this policy has not yet fully developed into net-metering scheme, of which electricity generated from rooftop PV system must be consumed on-site and any excess electricity fed back to the grid will not be credited at any monetary rate [4]. There has been a plan for drafting a compensation scheme for excess generation (e.g. with buyback, or rolling credit option) in Thailand [7], pending the completion and evaluation of the self-consumption pilot project to provide full understand of the scheme to the government.

Driven by falling PV and energy storage system prices, rising electricity costs, and policy supports, the increasing share of distributed PV and energy storage is expected to disrupt the existing utilities' business models and the tariff design as occurred in many places in recent years [8-10]. These problems lead to the objective of this research that is to introduce the framework for evaluating the economic impacts of rooftop PV and energy storage on Thai distribution utilities and ratepayers. It is expected that the full knowledge of economic impacts will be useful for the utilities' executives and the regulators to design their future business models, appropriate tariff structure, and policy supports for solar and non-solar customers.

2. Evaluation framework: Cost-benefit analysis

Cost-Benefit Analysis (CBA) is a systematic approach to evaluate strengths and weaknesses of each proposed alternative. It can be done from many perspectives such as from solar customers, non-solar customers (ratepayers), utilities and overall society's points of view [9]. As stated, scope of this work mainly focuses on introducing a framework to evaluate economic impacts of rooftop PV and energy storage on distribution utilities and ratepayers. The analysis can be separated into two main parts as shown in Figure 1. It should be noted that this calculation method can be adapted into both main scenarios: without energy storage and with energy storage.

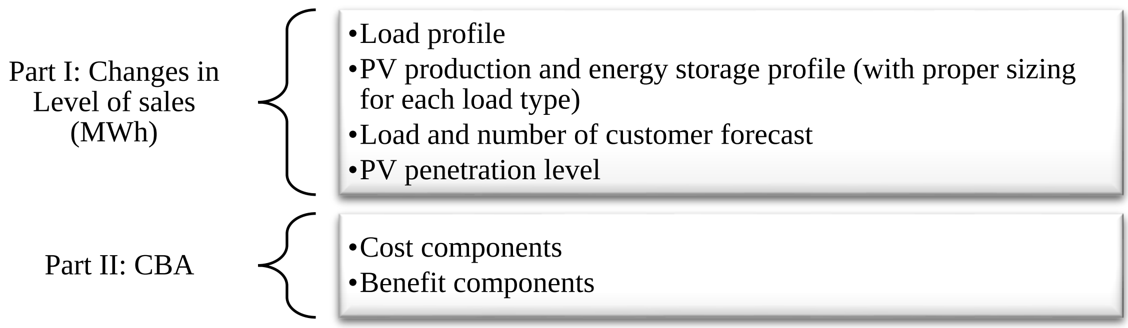

Figure 1. Big picture of Cost-Benefit Analysis (both without and with energy storage) (Adapted from [8], [10]).

2.1. Changes in energy sale

The first step is to identify changes in energy sale in terms of physical unit (e.g. MWh). In general, the changes in MWh can be determined by comparing grid consumption between the case without rooftop PV and the case with rooftop PV (or rooftop PV with energy storage). The main calculation steps (see Figure 2) include:

- compare daily load profiles of sample customers for the cases without rooftop PV, and with rooftop PV and energy storages to find out the amounts of self-consumed PV electricity in year 1, and consumer's bill savings, where the consumer's bill savings are equivalent to utility's revenue reduction.

- apply first year PV penetration level to estimate bill savings and utility's revenue losses for the whole system.
- project the future situation of changes in energy sale by applying load growth, PV penetration growth, and number of customers forecast based on available data from relevant stakeholders (distribution utilities, regulator, ministry of energy, etc.).

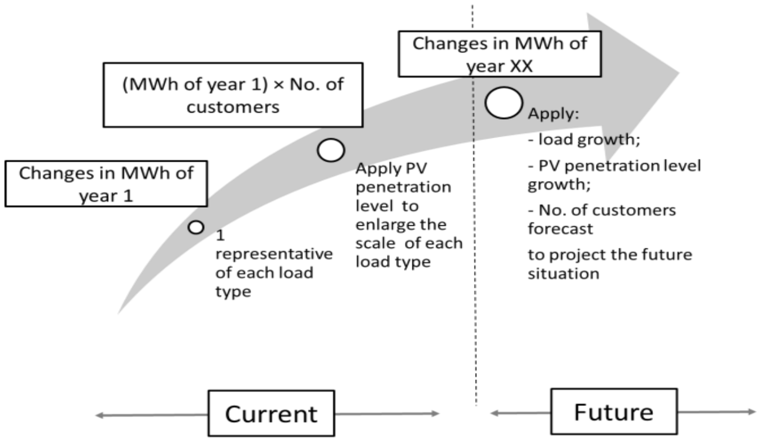

Figure 2. Conceptual model of changes in energy sale calculation (Adapted from [8], [10]).

The changes in energy sale, or bill savings from solar customer's perspective depend on details of policy features of compensation schemes for solar electricity, including, number of meters, banking period, and buyback rate [7, 11-13]. It is obvious that different policy features affect each stakeholder differently depending on how effective the policies are. It can be anticipated that more benefits to prosumers (e.g. additional bonus is allowed to compensate self-consumed PV, buy back rate is above retail rate, banking period is longer than one billing period, energy storage is allowed, etc.) lead to more negative impacts to distribution utilities and ratepayers [14].

2.2. Cost and benefit components

After understanding how energy sales change due to the increase in distributed rooftop PV and energy storage installation, the next step is to address cost and benefit components as summarized in Table 1.

Table 1. Cost and benefit components of rooftop PV systems with or without energy storage impact evaluation on Thai distribution utilities and ratepayers from stakeholder interview and literature review [8-10, 15]

	Benefits	**Costs**
Ratepayer Cost Test and Utility Cost Test	-Utility avoided costs (Avoided costs of loss and avoided costs of deferring distribution capacity)	- Consumer's bill savings depending on policy features - Program cost (related to administrative cost due to excess generation to the grid) - Integration cost (associated with upgrading generation, transmission and distribution system cost due to excess generation to the grid) - Unrecovered fixed cost

The cost and benefit components were suggested by relevant stakeholders during interviews, including MEA (Metropolitan Electricity Authority), PEA (Provincial Electricity Authority), ERC (Energy Regulatory Commission), EPPO (Energy and Planning Policy Office), DEDE (Department of Alternative Energy Development and Efficiency) and private sector, which are in line with those given in literatures [8-10, 15].

Considering the inclusion of energy storages, there are about the same cost components. Greater revenue losses from consumer's bill savings and decreases in program cost and integration cost due to less excess PV generation to the grid can be anticipated. As for benefit components, the difference is only on their magnitudes because energy storage will allow users to store their excess generation from rooftop PV and to draw less electricity from grid.

3. Cost-benefit analysis interpretation

With CBA, cost and benefit components would be identified as stated in previous section. Then, the final output is the comparison between net benefits and net costs as shown in equation (1).

$$\text{Net Costs (Benefits)} = \text{Total Costs} - \text{Total Benefits} \tag{1}$$

There two possible cases for the net costs/benefits calculation; they are (i) benefits greater than costs and (ii) benefits less than costs [8-10,15].In case of greater costs than benefits, the incremental costs will either be passed to ratepayers through base tariff and/or fuel adjustment charge (Ft), so called cost-shifting issues between solar and non-solar users, or absorbed by the distribution utilities to the extent allowed by regulations [16]. Thailand's distribution utilities are mainly operated under cost-of-service regulation that provides utilities with a return on capital investments as an incentive to drive utilities towards building and maintaining their systems in order to provide customers with reliable and affordable service, or electricity supply in this context. Thus, the real negative impacts are probably passed to ratepayers.

Alternatively, if rooftop PV and energy storage systems still leads to negative impacts for utilities and/or ratepayers (costs are higher than benefits), then, it is necessary for utilities to define specific grid codes in order to limit rooftop PV penetration, as well as promote new business models and/or new regulatory models in order to maintain their profits. However, these mitigation approaches require careful consideration and debate as they could lead to losses of opportunity to maximize the benefits of rooftop PV and energy storage systems of relevant stakeholders and the country.

4. Conclusion

Due to increases in self-consumed PV and energy storage installations and concerns on Thai distribution utilities' revenue losses, Cost-benefit analysis (CBA) is then proposed to address these economic impacts. There are two main steps of this evaluation: changes in electricity sale determination and cost/benefit components calculation. The CBA results are expected to depend on the excess generation compensation scheme and the inclusion of battery based on Thai context. If costs are greater than benefits, it is possible that utilities will pass their incremental costs through to ratepayers via increases in retail rate, which is known as cost-shift between solar and non-solar users. There have been heated debates on the issue internationally to find suitable business models/regulatory models in order to mitigate the impacts. Therefore, it is necessary for Thailand to pay attention on this topic and try to quantify cost and benefit components of rooftop PV and energy storage systems as well as start finding appropriate solutions to not only increase distributed PV generation, but also minimize impacts on relevant stakeholders, including utilities and ratepayers.

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References

[1] U. S. Energy Information Administration. International Energy Data and Analysis. 2015 [Cited 25 Mar 2017]. Available from: https://goo.gl/kei8tA
[2] EPPO-Energy Policy and Planning Office. Electricity. 2016 [Cited 26 Mar 2017].Available from: www.eppo.go.th/images/Energy-Statistics/energyinformation/.../06Electricity.pptx.
[3] DEDE-Department of Renewable Energy Development and Energy Efficiency. Alternative Energy Development Plan: AEDP 2015. 2015 [Cited 26 Mar 2017]. Available from http://www.dede.go.th/ewt_news.php?nid=42195.
[4] GIZ- Deutsche Gesellschaft für Internationale Zusammenarbeit, Thailand Solar PV Policy Update 09/2016, Federal Ministry for Economic Affairs and Energy, Bangkok, September 2016.
[5] Tongsopit S, Gracen C, An Assessment of Thailand's Feed-in Tariff Program, *Renewable Energy*, 2013, **60**, 439-445.
[6] Tongsopit S, Moungchareon S, Aksornkij A, Potisat T, Business Models and Financing Options for a Rapid Scale-up of Rooftop Solar Power Systems in Thailand, *Energy Policy*, 2016, **95**, 447-457.
[7] Tongsopit S., Julakarn S., Chaitusaney S., and Wibulpholprasert W, Evaluation of Rooftop PV Pilot Project, Bangkok, Thailand, 2017.
[8] E3-Energy + Environmental Economics, California Net Energy Metering Ratepayer Impacts Evaluation, San Francisco, CA, 2013
[9] E3-Energy + Environmental Economics, Nevada Net Energy Metering Impacts Evaluation, San Francisco, CA, 2014.
[10] Satchwell A, Mills A, and Barbose G, Financial Impacts of Net-Metered PV on Utilities and Ratepayers: A Scoping Study of Two Prototypical U.S. Utilities, Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA, 2014.
[11] Hughes L, and Bell J, Compensating Customer-Generators: A Taxonomy Describing Methods of Compensating Customer-Generators for Electricity Supplied to the Grid, *Energy Policy*, 2006, **34**, 1532-1539.
[12] Dufo-López R and Bernal-Agustin JL, A Comparative Assessment of Net metering and Net Billing Policies. Study cases for Spain. *Energy*, 2015,**84**, 684-694.
[13] IEA-PVPS - International Energy Agency- Photovoltaic Power Systems Program, Review and Analysis of PV Self-Consumption Policies, IEA Photovoltaic Power Systems Program, 2016.
[14] Eid C, Guillen JR, Marin PF, and Hakvoort R. The Economic Effect of Electricity Net-metering with Solar PV: Consequences for Network Cost Recovery, Cross Subsidies and Policy Objectives. *Energy Policy*, 2014, **75**, 244-254.

[15] CPR-Clean Power Research: Austin, The Value of Distributed Photovoltaics to Austin Energy and the City of Austin, Clean Power Research, Austin, TX, 2006.
[16] ERC- Energy Regulatory Commission, Retail Restructuring B.E. 2558, 2015 (in Thai).