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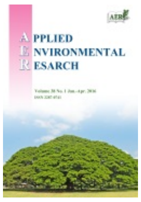


# Stakeholders' Perspectives of Design Options for a Rooftop Solar PV Self-consumption Scheme in Thailand

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## Abstract

Adoption of solar photovoltaic (PV) power generation systems has been accelerating around the world, contributing to the debate about the future of policy and regulation in a high distributed energy resources future. As one of the leaders in solar investment in Southeast Asia, Thailand has recently shifted its policy framework for the support of small scale, distributed solar PV systems from subsidizing power export through feed-in tariff toward a policy that is focused on self-consumption. This paper investigates stakeholder perspectives of the detailed design options for self-consumption schemes for supporting rooftop solar PV installations. The research methodology employed questionnaires and focus group discussion in order to capture stakeholder perspectives for each element of rooftop solar PV self-consumption schemes. In all, the data derived from questionnaires and focus group discussion involved a total of 72 stakeholders. The results indicate that most stakeholder groups expressed a strong desire for compensation for excess generation of PV electricity from rooftop PV systems. While the majority of electric utilities prefer a system of net billing with real-time buyback, designed to minimize revenue losses, consumers and policymakers preferred a net-metering-based compensation scheme for supporting use of rooftop PV electricity in Thailand.

**Keywords:** Self-consumption scheme; Net metering; Net billing; Thailand's solar PV rooftop

## Introduction

The increasing popularity of distributed energy resources, particularly solar photovoltaic technology, has driven a transition in policy and regulatory schemes to encourage self-production and self-consumption by electricity users. During the past decades, the installed photovoltaic (PV) capacity has grown due to the falling cost of solar PV panels and support schemes to incentivize installation of solar PV worldwide [1-4]. The global total installed capacity in 2015 was 227 gigawatts, a 25% increase over 2014 [5]. The majority of all PV installations worldwide are grid-connected systems, which enjoy the advantage of more efficient utilization of generated power [6-7].

Several countries have introduced self-consumption policies in order to promote the use of PV electricity by compensating for excess electricity using various compensation mechanisms such as net metering and net billing [6-7]. Since the cost of locally produced PV electricity is below the price of retail electricity price in many countries [8], PV electricity production for self-consumption is increasingly more profitable, even without subsidy. However, a high penetration of distributed PV system for power generation might impact on ratepayers in terms of increasing distribution network charges or taxes [6, 9].

Among emerging economies, Thailand is a leader in solar PV investment. Though the majority of such investments has been for utility-scale systems, the government has recently shifted its support towards smaller-scale, distributed solar PV systems [9]. The Thai government began to promote the use of rooftop PV for exporting power between 2013 and 2015 and for self-consumption since 2016 onwards. In 2016, Thailand launched a rooftop solar PV Pilot, designed for self-consumption in residential and commercial buildings. The government is currently designing a support scheme on how to support rooftop solar PV systems for self-consumption. The details of the support scheme will have an impact on how consumers produce and use distributed solar PV systems in the future [10-11].

Given the importance of policies, incentives and regulations driving the transition to self-consumption schemes in influencing stakeholder interest, it is important to identify and understand stakeholders' viewpoints on PV self-consumption schemes in order to ensure successful implementation and widescale adoption [12-13]. This has triggered numerous studies on Thai stakeholders' perspectives towards design options for rooftop solar PV self-consumption schemes and related topics, including challenges and constraints to adoption. This study thus aims to inform policymaking by investigating perspectives of stakeholders on detailed design options for self-consumption schemes to support rooftop solar PV installations in Thailand. This paper discusses the role of key scheme design elements and their implications in order to contribute to future policy-making processes.

**Literature review**

A self-consumption scheme refers to a system whereby PV-generated electricity is first used for direct onsite consumption (e.g. a domestic home) in order to reduce electricity bills. No surplus power is fed back into the distribution grid [1, 6]. However, to promote adoption, incentives are needed. Two categories of compensation are available: with and without premium. Self-consumption without premium simply aims to prioritize use of PV electricity to reduce the total electricity bill. In contrast, self-consumption with premium allows for a subsidy in addition to the savings against the bill. To add extra generation on self-consumed part of PV electricity can be valued at below, equal, and above retail rate. For example, in China, self-consumed part of PV electricity originally received an extra tariff on top of the saved retail price and later they reset the rate at wholesale price for self-consumed PV electricity [6]. Self-consumption schemes can be divided into two forms of compensation: Net metering and Net Billing (sometimes used interchangeably). Net metering and net billing are electricity policies that assign compensation to excess electricity generated by ‘prosumers’, particularly for solar power [14-16]. The term “prosumer’ refers to energy consumers who both consume the electricity from the grid and have the ability to produce their own power from a range of different onsite generators, such as a rooftop solar PV system [17]. The main differences between net metering and net billing are the value of excess of electricity, the number of meters and the compensation terms (in kilowatt-hours (kWh) and in monetary units). This research categorizes net metering and net billing schemes according to the definitions used by Hughes and Bell (2006), Dufo López and Bernal-Agustín (2015) as described below:

**1) Net metering schemes**

Net metering uses a single bidirectional meter to record the cumulative amount of imported and exported electricity. Electricity exported to the grid has the same value (retail rate) as electricity imported from the grid. Net metering schemes can be categorized into four types as follows:

1.1) Simple net metering

This scheme generally uses a single, bi-directional meter to record the amount of electricity consumed. The billing period in this scheme is usually one or two months. In this scheme, there is no financial compensation if the prosumer generates more electricity than the load. However, compensation will be credited in the form of kWh.

1.2) Net metering with buy back

This scheme is an extension of simple net metering, in which the utility will pay the prosumer for any excess electricity generated during the billing period. Compensation for surplus electricity production is paid monthly. In this case, the value of the surplus electricity is paid as monetary compensation at the end of the month, which can be valued at below the retail rate (avoided cost of the utility), retail rate (buy at the same rate as prosumers pay), or above retail rate (premium rate), which would be more attractive for PV installations.

1.3) Net metering with rolling credit

This scheme is also an extension of simple net metering by which the banking period extends across more than one billing period, typically one year. Compensation in terms of monetary credit will not be applied but this scheme allows prosumers to bank their surplus electricity by receiving credit in kWh.

1.4) Net metering with rolling credit and buyback

Thus scheme combines rolling credit and buy-back features, whereby the prosumer receives a monetary credit for surplus electricity generated at the end of the banking period (usually one year). This scheme works similarly to net metering with rolling credit but with an additional feature: if there remain credits available in the last billing period within the banking period. The prosumer will receive monetary compensation from the utility, which can be valued in three rates. The credit will be valued in the same way of net metering with a buy back scheme.

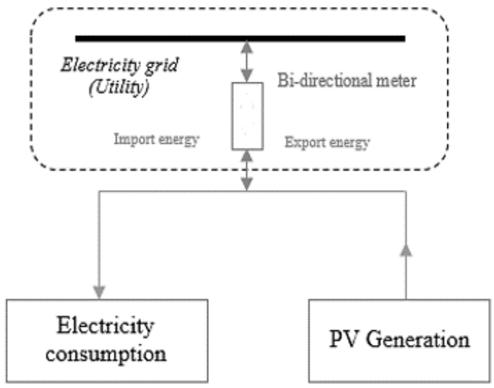


**Figure 1** Concept of net metering scheme [14-15].

**2) Net billing schemes**

Net billing uses two registers to record the amount of electricity consumed and amount generated per hour by prosumers within the billing period. This mechanism allows prosumers to receive payment from surplus electricity as represented in Figure 2. Net billing can be categorized into three schemes as follows:

2.1) Net billing with buyback

This scheme allows prosumer to be financially compensated for surplus electricity at the end of each billing period or hour period. Prosumers pay for all electricity imported from the grid at the retail price, and receive payment for the surplus generated at an agreed price, which may be below, equal, or above the retail rate.

2.2) Net billing with rolling credit

This scheme allows prosumers to roll over their monetary credit throughout the banking period (typically one year). This credit can be used to offset charges in the next billing period. This scheme is functionally the same as net metering with rolling credit, except that this scheme requires two registers. This is because the utility needs to know the amounts of electricity consumed and generated so that these can be combined in order to determine the net amount billable.

2.3) Net billing with rolling credit and buyback

This scheme combines rolling credit and buyback features, allow surplus electricity to be banked between billing periods. At the end of the banking period, the surplus credits will be purchased by the utility at an agreed rate (below, equal, or above the retail rate).

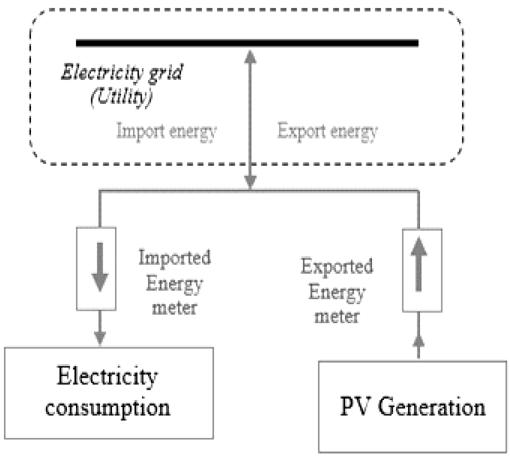


**Figure 2** Concept of net billing scheme [1, 13-14].

**3) Thailand rooftop solar PV development**

Thailand's grid-connected solar power capacity has seen remarkable growth since 2011; almost 99% comes from large-scale solar installations with installed capacities over 1 MW. This growth was incentivized by the adder scheme implemented since 2007. The adder scheme provides incentives to power producers who sell electricity produced by RE at an attractive tariff for a specified period of time. However, the adder scheme was eventually discontinued due to concerns over impacts to ratepayers, and converted to a new Feed-in-Tariff (FiT). The rooftop FIT scheme assigns a fixed rate for each scale of rooftop PV systems in order to encourage customers to install solar PV systems to sell power to the grid. FiT is financed through a levy on electricity bills (FT rate) for all consumers, and is valid for 25 years. The roofop FiT program launched between 2013 and 2015 set a quota of 200 MW of power purchase agreement (PPA) available, allocating 100 MW to commercial rooftops (10-1000 kW) and another 100 MW to residential (0-10 kW) rooftop solar systems. The result showed that the quota for commercial rooftop systems was reached quickly, while the residential quota was only slowly subscribed.

By the end of 2014, the residential rooftop sector had grown only slightly, with an expected volume of less than 26 MW; this indicated the infeasibility of the scheme for residential-scale solar PV systems [9]. The FiT policy was discontinued in 201, and was replaced by another support scheme. In January 2015, the Thai cabinet announced the "Net metering scheme" as a pilot project for the purpose of self-consumption. Later, in March 2016, National Energy Policy Council (NEPC) proposed a pilot project for the purpose of self-consumption. This pilot project aimed to support rooftop solar PV systems for on-site consumption only, without compensation for surplus electricity injected back into the grid. The objective of this rooftop solar PV pilot project was to study, monitor and evaluate the impact of self-consumption on the utilities, the distribution systems, and investors. Within a total quota of 100 MW, 20 MW was allocated to residential roofs, divided equally between the Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA) areas. The remaining 80 MW was allocated to commercial roofs, again split equally between MEA and PEA. The application process was already closed for submission and all participants were required to install their rooftop solar PV by 31 January, 2017. Currently, uptake of rooftop solar PV in the pilot project was low, with less than 50% applied out of the quota of 100 MW [10-11].

## Methodology

This study employed both qualitative and quantitative methods through a questionnaire and focus group discussion, conducted and verified between September and December 2016. Details of the methodology are provided in the following section.

### 1) Sampling

This study used purposive sampling to identify stakeholders involved in the decision making process. Key stakeholders in this research included consumers, private companies, policy-makers, and electric utilities as shown in Table 1.

### 2) Questionnaire design

The questionnaire was designed as a quantitative investigation of perspectives for each selected scheme option. The questionnaire survey of this research was part of Thailand's rooftop PV pilot project evaluation, which specifically focused on the future design supporting scheme for rooftop solar PV system in Thailand, based on the needs of each stakeholder. In order to design a support scheme for the future, researchers selected options for support schemes based on a literature review which pointed towards more adopted schemes of net metering with buyback and net billing with real-time buyback. Before responding to the questionnaire, the stakeholder groups were briefed on the details of the various supporting schemes in order to an provide an informed grounding to support their responses to the questionnaire. The questionnaires was divided into two sections. The first section covered respondent demographics: respondents were asked to provide their personal information, including age, gender, occupation, position, and organization. The second section included a list of support schemes for rooftop solar PV self-consumption, divided into two parts: self-consumed and surplus PV electricity. Key aspects considered in this set of questions focused on the feasibility and of future compensation schemes, acceptable compensation rates, and the optimal timeframe of the banking period. Details of the questionnaire design are provided in Table 2.

The questionnaires elicited data from 72 respondents selected by purposive sampling. The data obtained were subjected to quantitative analysis using MS Excel software to obtain descriptive statistics.

### 3) Focus group discussion

The researchers conducted four focus groups comprising representatives of private companies, policymakers and electric utilities, to discuss the elements of self-consumption scheme design. Following completion of the questionnaires, their opinions were sought through a focus group discussion based on the questions contained in the questionnaire. Stakeholders were asked to state their support scheme preferences and to identify possible impacts for each stakeholders. The outcomes of the focus group discussion were interpreted qualitatively using content analysis. The data were coded and classified to highlight the findings, and compared with the questionnaire findings.

**Table 1** Stakeholder groups

| Stakeholder groups | Details |
|---|---|
| Consumers | Participants in Thailand's Rooftop Solar PV Pilot Project. |
| Private companies | Solar EPC contractors, developers, consultants, and representatives from the Federation of Thai industries, all of which have been involved in solar rooftop projects. |
| Policy makers | Government officials at executive and non-executive levels from the Bureau of Solar Energy Development of the Department of Alternative Energy Development and Efficiency, Ministry of Energy, Ministry of Finance, and the Energy Regulatory Commission, |
| Electric utilities | There are two distribution electricity utilities in Thailand, namely MEA, which is responsible for providing service and electricity power in Bangkok, Nonthaburi and Samut Prakan, and PEA, which is responsible for electricity distribution in 73 provinces. Most of these utility representatives are from the Power System Planning Department. |

**Table 2** Questionnaire components

| Components | Questions | Details |
|---|---|---|
| Section 1 | 9 | Personal information: Name, age, organization, position, gender, email, contact number, and role as stakeholder. |
| Section 2 | 2 | This set of questionnaire focused on selecting future design option of support schemes for rooftop solar PV systems in Thailand. This section was divided into two parts:<br>1) Should self-consumed part of PV electricity be compensated or not?<br>1.1) Possible compensation rate for self-consumed part of electricity.<br>2) Should the surplus part of PV electricity generated be compensated or not?<br>2.1) Possible compensation schemes for surplus generation.<br>2.2) Possible compensation rate for each support scheme.<br>2.3) The maximum time-frame of the banking period<br>2.4) Compensation rate at end of the banking period. |

**Results and discussions**

**1) Stakeholder respondents group**

Table 3 shows the total number of respondents and category by group. There were four groups: consumers, private companies, policy makers and electric utilities from both MEA and PEA. The total number of questionnaires engaged 72 respondents with the majority of stakeholders from private companies. The collected feedback from each stakeholder groups provided the basis for the conclusions of this study.

**2) Self-consumption scheme design**

Figure 3 presents stakeholder perceptions of self-consumed electricity schemes, showing that the majority of respondents (58%) selected no compensation for the self-consumed part of PV electricity, with the remaining 42% of respondents preferring PV self-consumption to be compensated. Figure 4 shows that most stakeholders preferred no compensation for the self-consumed part of electricity. This preference corresponds to the design of most self-consumption schemes worldwide, which do not compensate for the self-consumed component.

**Table 3** Survey respondents

| | Consumers | Private companies | Policy makers | Utility (MEA) | Utility (PEA) | Total |
|---|---|---|---|---|---|---|
| Stakeholder engaged | 13 | 21 | 9 | 16 | 13 | 72 |

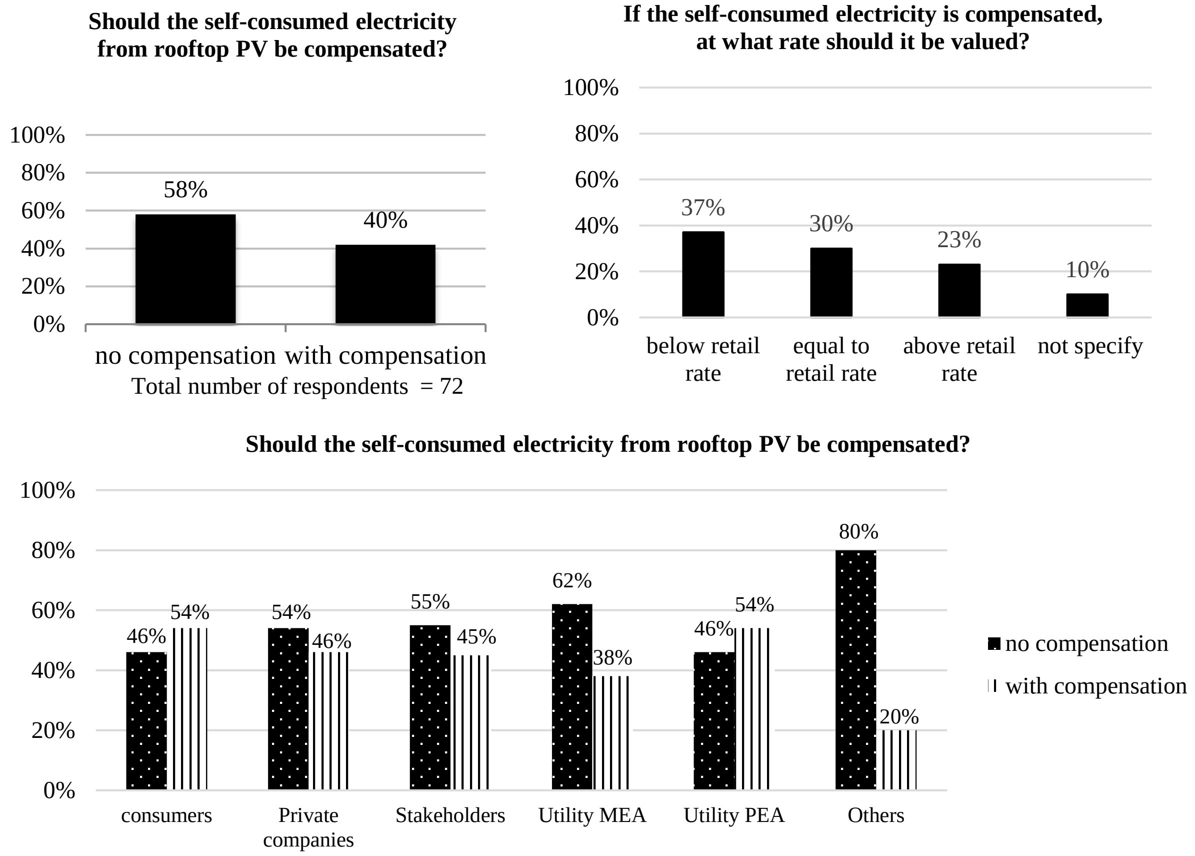


**Figure 3** The result of self-consumption scheme design from all stakeholders.

When classifying stakeholder types to understand the responses of each stakeholder groups, the study found that the most respondents who represented the PEA and consumer groups preferred to give compensation to the self-consumed part of electricity. The majority of members from other groups preferred not to have compensation for surplus electricity.

For self-consumption scheme, most respondents were satisfied with no compensation for self-the consumed part of PV electricity. The responses suggested that respondents believed this scheme to be already profitable without adding a premium tariff on the self-consumed component of PV electricity. Since self-consumed electricity is allowed and prosumers are able to consume their own PV generation which is valued at the retail rate, it will immediately reduce their electricity bills. However, in some countries (e.g. United Kingdom and China) an extra generation tariff is added to the self-consumed part of PV electricity in order to incentivise the PV self-consumption scheme [5].

**3) Excess generation scheme design**

Figure 4 shows that the majority of respondents (79%) preferred to gain compensation for the excess part of electricity from rooftop PV systems. Respondents expressing a preferred for compensation for surplus electricity were asked whether the compensation should be in the form of collected credits or in the form of real-time payments. Respondents were split equally between these two compensation options. Among those who chose to have excess generation compensated in the form of credits, 63% of them indicated that the value of credits should be equal to the retail rate. In regard to real-time compensation, respondents were asked what the real-time buy-back rate should be. Again, respondents were split equally between below retail rate and equal to retail rate.

Respondents were asked for their views on optimal timeframe for the banking period. The majority of respondents preferred a one-year banking period for keeping surplus generation as credits. A one-year banking period is a typical maximum timeframe for credit compensation, mostly applied in net metering rolling credit and buyback schemes [14-15]. The maximum timeframe for a banking period can range from one day to a month, or up to one year, depending on national regulations. Canada, Chile, the Netherlands allow one year for compensation credits (kWh) in the form of net metering scheme at retail price [5]. On the other hand, Brazil allows compensation for excess generation credit for a longer banking period of up to 36 months [20]. In addition, respondents were asked what rate should be valued for credits remaining at the end of the banking period. Most stakeholders (52%) preferred below retail rate.

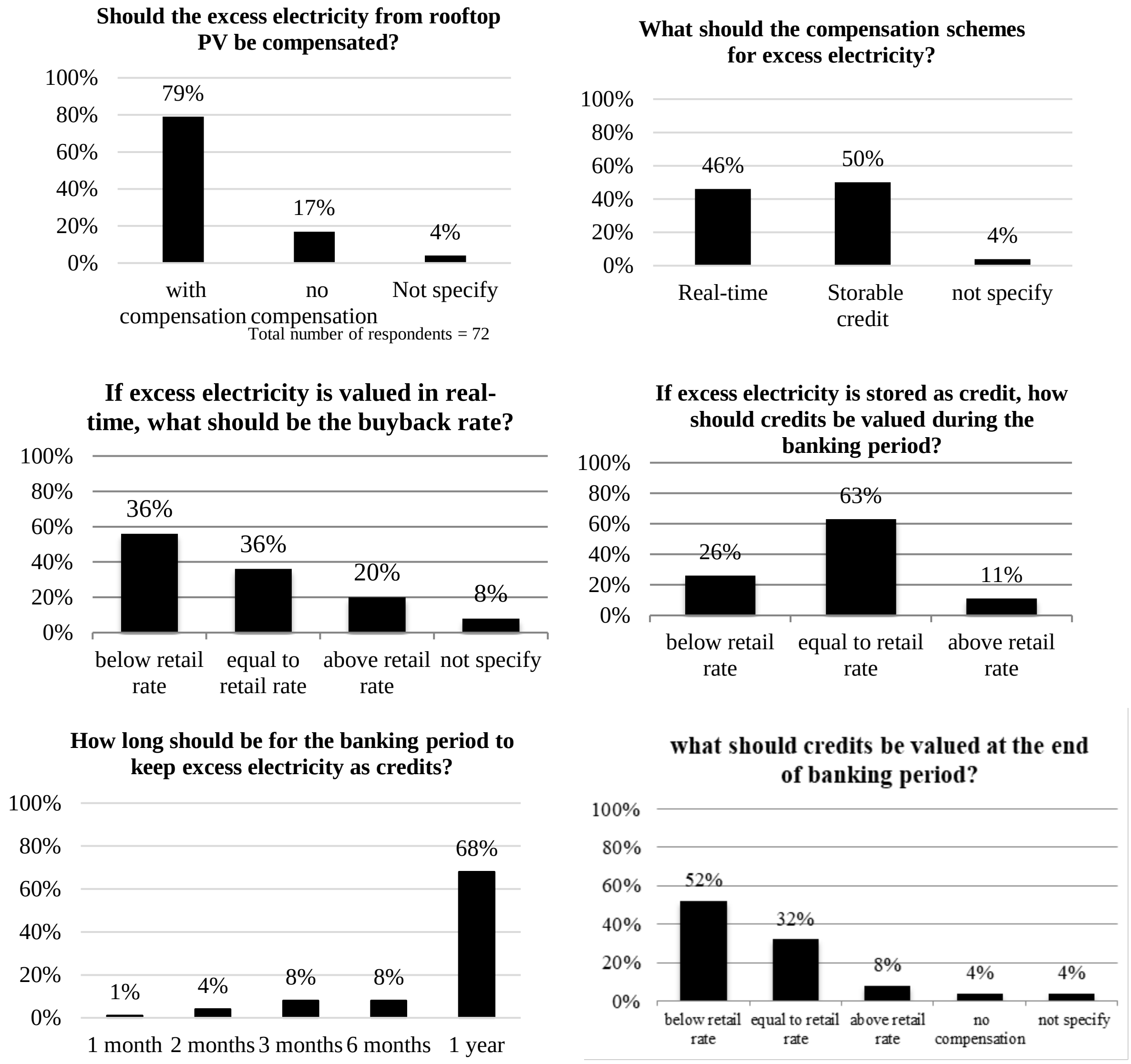


**Figure 4** Stakeholder perspectives on surplus generation scheme designs.

Based on these responses, the study identified differences in opinions and preferences among consumers, private sectors, policymakers and utilities as shown in Figure 5. It is clearly seen that utilities favour real-time payment as the preferred compensation method- a scheme widely used in many countries including Australia, China, Denmark, Finland, France, Germany, Italy, Japan, Spain, Switzerland, and UK [5].

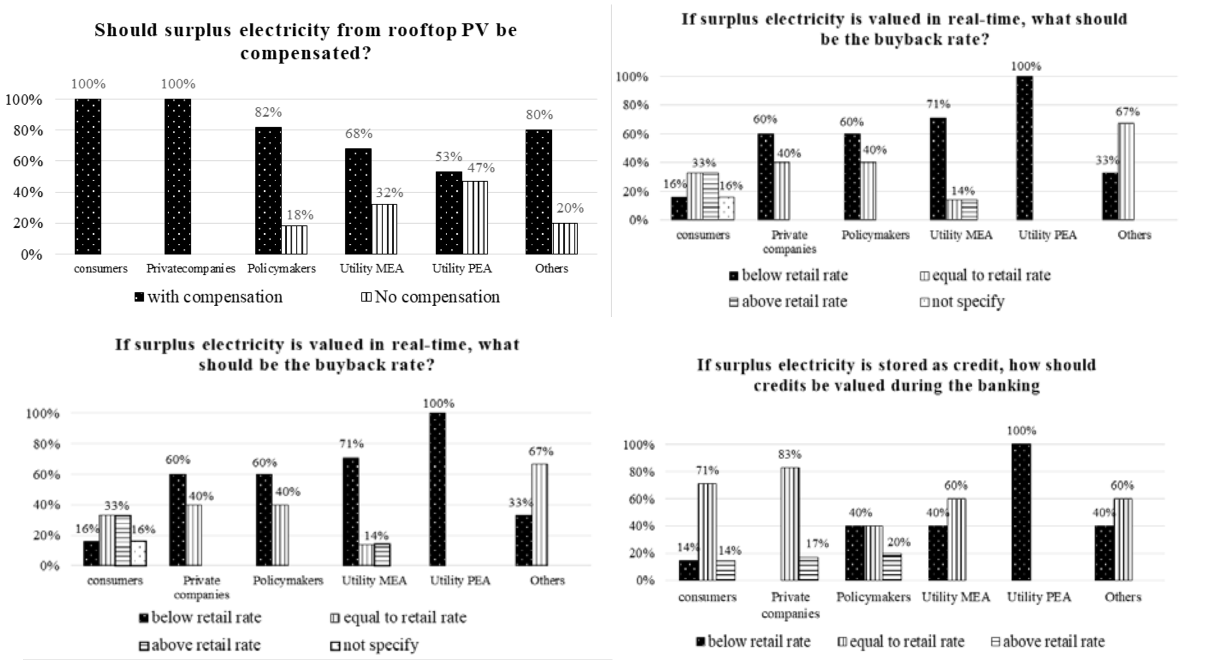


**Figure 5** The result of surplus generation scheme design, classified by each stakeholder.

Surplus PV generation with the rate valued at below the retail rate is referred to as net billing. The majority of stakeholders agreed that surplus electricity should be collected in credits within a one-year period, and should be valued at a price equal to the retail rate. This preference may be make the scheme more attractive to consumers and businesses, and could stimulate market expansion. This scheme design is known as net metering with rolling credit and buyback. In terms of compensation, the net metering scheme has the advantage that self-consumed electricity that flows back into the grid attracts compensation at the retail rate, which is very attractive to consumers. This scheme has been applied in many countries such as India, Canada, Mexico, Sweden, the Netherlands, Israel, Chile and Belgium to promote rooftop solar PV installation. The world's first net metering program was introduced in 1979 in the U.S state of Massachusetts, and Minnesota was the first state to enact a net metering regulation in 1983 [16]. However, compensation for excess generation may result in faster and higher revenue losses to the utilities if there is higher distributed solar photovoltaic penetration. Couture et al (2014) highlighted that the use of PV electricity can reduce the amount of power purchased from the utilities, impacting on revenues for power that flows through the transmission and distribution system. In addition, higher penetration of PV prosumers may pose challenges to grid reliability that utilities provide [21]. Currently, Thailand has implemented the net metering scheme in the form of a self-consumption scheme, by which any excess generation of PV electricity gained no compensation. The new net metering policy has not yet been announced due to concerns over the potential impact of rooftop solar PV on grid operation [22]. Considering a similar case in the United States, where most rooftop solar PV deployment has been implemented under net metering schemes (such as in California, Hawaii and Arizona). However, increasing PV penetration would create financial impacts for he electric utilities- specifically, grid costs and other recovered cost through grid charges. As a consequence, the value of the solar tariff has been introduced in the U.S. in order to compensate for real value provided by the solar installations to the electricity system. Since this program was approved, Minnesota and Hawaii have applied after first rejecting net metering schemes [23-24]. However, in Switzerland, even though the issue of financing the grid have been debated, no additional grid charges have been made to PV system owners [5].

For net billing, the rate of excess electricity can be valued at below, equal, or higher than the retail rate, depending on market conditions [14, 15]. It may depend on the maximum power generated from the rooftop system, so that even when the buy-back rate is low, it might stimulate the market. However, the key point is that the rate of excess electricity requires certain justification and it needs to be updated on regular basis (e.g. yearly). The reasons why utilities appear to prefer net billing (real-time) over net metering is due to considerations relating to tax and accounting systems. Setting up a net billing accounting system is relatively straightforward, while net metering requires setting up a new accounting system for surplus generation that will flow back into the grid in the current month, to be credited to the next bill. In terms of taxes, since net billing requires two separate meters to monitor electricity consumed from the grid and the surplus flowing back into the grid, Utilities can collect taxes from the surplus electricity purchased, whereas the taxes revenue can be lost from compensated credits, since government tax revenues are linked to electricity sales volume [21]. Additionally, as net metering requires only one meter, so that residential consumers can continue to use their existing electromechanical meter, which can run backward to measure electricity flowing in either direction. Compared with net billing, utilities face higher costs due to the need to provide new meters. Moreover, net billing requires the new meter to be set up with an hourly time stamp. The meters also require more memory and more staff time to read them.

In terms of compensation, consumers prefer the net metering mechanism because the surplus power generated is valued at the retail rate. It offers an attractive incentive to wide-scale adoption. Due to the rise in the price of natural gas, the current electricity tariff has been increased for all categories of power users from 3.38 THB/kWh to 3.508 THB/kWh at the beginning of 2017. The rise in the retail electricity price is due to an increase of 12.52 satang per kWh in the Ft (Fuel tariff) rate. The increase in the retail rate will directly impact on residential users. Thus, adoption of a PV system with net metering offers a solution to reduce dependence on fossil fuels, reduce electricity bills and promote green electricity [22]. One study also highlighted that consumers interested in adopting a distributed generation PV system desired a long term agreement to earn revenues from solar generation to at least recover the cost of their investment [21]. Similarly, private companies preferred net metering because this scheme does not require any payment during the year, since the surplus PV electricity is retained as credits, which means there is no need to set quotas. In addition, at the end of the banking period, remaining credits can be valued at zero. However, this scheme would impact on the utility company as it reduces revenues while increasing the burden in terms of accounting and taxation. Neither utility companies favour net metering as an option as it would require increasing complexity in account setting and complicate tax collection.

These two issues represent the major challenges constraining adoption of the net metering scheme. Moreover, if the rate for surplus generation is valued at the full retail rate, utility companies may lose revenues faster because they typically purchase electricity from the Electricity Generating Authority of Thailand (EGAT) at a wholesale rate. Prior studies indicate that the effect of net metering on utilities revenues and non-PV customers can be smaller at lower penetration levels [19]. However, one study suggested that increasing PV penetration level could affect to utilities in unforeseen ways if a compensation mechanism is in operation. These include loss of grid operator revenues and negative impacts on long term investment options in the electricity sector [12].

## Conclusion

This study investigated stakeholder perspectives of options for PV support scheme designs through questionnaires and focus group discussions. For the self-consuming component of PV electricity generated that does not exceed local demand, most consumers were satisfied with no compensation for this self-consumed component of PV electricity generated. Consumers would prefer a net metering mechanism because the excess generation is valued at the retail rate, which is very attractive and incentivizes rooftop PV system adoption. However, any scheme has an impact on the revenues of electricity utilities. These trade-offs present the government with a dilemma in selecting net metering. The optimal buyback rate may also not be determined easily, as it will need to take into account other non-financial factors. The stakeholders' perspective above reflect their point of views on each element of self-consumption scheme, including net metering and net billing in order to design the potential scheme for promoting rooftop solar PV system in Thailand. Undoubtedly, the transition from fossil fuels to renewable energy sources will bring profound consequences for the utilities; thus a deeper understanding of stakeholder perspectives will be essential in order to prepare and adapt to new technological opportunities and new market realities. This means utilities and the government may be well-advised to be more ambitious and progressive in order to drive a transition toward self-consumption schemes. The implication for scheme selection from stakeholders' perspectives can emerging insights on the future of policy and regulation electric power system point of view to focus greater attention on consumers' attitudes and behaviours, and additionally calls for active inclusion of consumers in decision making processes.

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