Comparative customer economics on different financial options in support the adoption of residential rooftop photovoltaic in Thailand

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Abstract. The Thai Government has supported the use of solar photovoltaic systems for green electricity production toward the self-consumption policy since 2016. A photovoltaic support program with an installed capacity target of 100 Megawatt was announced in December 2018 to promote self-consumption and compensate for any excess photovoltaic generation at 1.68 Thai Baht/kilowatt-hour. However, the target was not achieved as a result of high upfront investment costs that are one of the main barriers in household application. To make solar photovoltaic systems more accessible to a larger group of users, financial mechanisms are required. The economic feasibility of financial options (cash, solar power purchasing agreement, solar leasing, solar loan) was analyzed for photovoltaic systems under the current Thai household solar rooftop scheme. The System Advisor Model, an open source techno-economic analysis tool, was employed to simulate photovoltaic production and cash flows to calculate the economic feasibility including the levelized cost of electricity, net present value, internal rate of return and payback period. Results showed that investment in a 3-kilowatt photovoltaic system with debt fraction of 50% and 100% cash was profitable, while investment in a 3- kilowatt photovoltaic system through a solar power purchasing agreement and leasing was not economically viable.

Keywords: Solar photovoltaic, self-consumption, net billing, financial options

1. Introduction
In 2018, Thailand revised the Power Development Plan (PDP) to adjust the proportion of energy sources to accommodate future demand, address concerns on energy security, and contribute to the global effort of reducing greenhouse gas emissions. The final aim for renewable energy (RE) share in overall electricity generation by 2037 was set at 32.5 % or approximately installed capacity of 25,086 MW [1]. Within the RE share of total generation capacity, new solar photovoltaic (PV) contributed to 12,725 MW divided into 10,000 MW of private solar systems and 2,725 MW of floating solar systems [1].

The Thai Government promoted the use of solar PV systems for the first time in 2007 [2]. The first policy in support of solar PV projects allowed private companies to install large-scale solar PV projects by providing monetary support in the form of premium Feed-in Tariff (FIT) or Adder program. Later, in 2013 and 2014, as investment costs of PV systems continuously decreased, new FIT programs in support of solar rooftops at residential and commercial scale were approved with lower FIT rates. Under these programs, a PV system owner was paid for generated PV energy at a fixed FIT rate for 25 years.
After the successful FIT programs, no further solar rooftop programs were launched from 2014 to 2019 due to decreasing costs of PV systems, and rapidly changing trends of global support for self-consumption schemes. During this time, in 2016, the Thai Government launched a solar rooftop pilot project for self-consumption with the aim of evaluating net metering and net billing schemes [3].

Recently, under the latest version of the PDP, a new household solar scheme launched in 2019 set an annual target of 100 MW for 10 consecutive years. This program is a net billing scheme and designed to encourage residential customers to install PV rooftop systems that match their consumption requirement. Any surplus energy is channelled into a distribution grid and purchased by a distribution utility at 1.68 THB/kWh or 0.048 USD/kWh for 10 years.

However, this new program has not proved a success, with total installed capacity of participants at 1.1 MW1, far lower than the target of 100 MW. The low number of participants results from three main reasons2 including the very low buyback rate as the current electricity rate is approximately 4 THB/kWh or 0.114 USD/kWh, lack of proper advertising before launching the program, and the short period of program application. High upfront investment is also one of main barriers preventing residential customers from participating in new PV programs in many countries. According to the report [4], investment cost of household photovoltaic systems was ranged between 51-64 THB/Watt or 1.46-1.83 USD/Watt.

To make solar PV more accessible and attractive to residential customers, four available financial options in Thailand namely cash, solar loan, solar power purchasing agreement (PPA) and solar leasing were selected, and the economic feasibility of each of these four options under the current Thai household solar rooftop scheme was assessed and analyzed. A comparative analysis of customer economics under these financing options is presented, including policy recommendations for scaling up the adoption of residential rooftop PV in Thailand.

2. Background and literature review
Adoption of rooftop PV systems in households can be accelerated by offering solar financial options that differ according to the economic policies, market conditions, and regulations of each country [5]–[9]. In Thailand, solar rooftop PV energy generation gained prominence between 2013 and 2015 due to the FIT program that allowed both consumers and developers to gain benefits such as direct consumer revenue from selling all generated electricity, or profit-sharing between consumers and developers through a PPA. Favored financial options during that time were self-financing and third-party financing, which are explained and expanded upon below.

2.1 Self-financing
The self-financing option can be generated either through cash or a home equity loan (or a combination of both) [2]. Self-financing with cash is the most widely adopted method worldwide as conventional self-financing. The host owner purchases the system assuming liability of the installation and maintenance costs through their own financing. Home equity loans in Thailand have been promoted and offered actively by Kasikorn Bank. Recently, this bank launched a home equity loan scheme for installing rooftop PV systems with an expected interest rate of around 4.73-4.77% for a 20-year contract3.

2.2 Third-party financing
Third-party financing is also known as a solar service-based business model where companies offer a service package to customers including installation, monitoring, and maintenance of the PV system.

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1 Data from Energy Regulatory Commission on July 2019 acquired from the Prachachat Business newspaper online: https://www.prachachat.net/economy/news-353645 (accessed in Nov 1, 2019)
2 Information from the Bangkok Insight: https://www.thebangkokinsight.com/231038/ (accessed in Nov 1, 2019)
3 These interest rates of Kasikorn Bank are available until the end of 2019: https://www.kasikornbank.com/th/promotion/Pages/HomeloanPEA.aspx (accessed in Nov 1, 2019)
Customers reap the benefits of the system according to agreements that include cheaper electricity, profit sharing, or roof rental payment [2]. This financial option reduces the burden of the high initial investment cost [2],[10]-[11], and can be offered in the form of solar leasing, PPA, and roof rental.

For solar leasing, a solar lease customer or host agrees to pay a fixed monthly fee (fixed, escalating or de-escalating) to lease a PV system over an agreed time period, while a leasing company or developer handles the services of the PV system on the owner’s premises [9]. Once the PV system is installed, the lease customer gains the benefits from the electricity produced or sell it to the grid as FIT [2].

A solar PPA is a financial arrangement between a host customer and a developer. The host customer makes an agreement to purchase the power produced by the PV system at an agreed per-kWh price. The developer owns the PV system and is responsible for its operation and maintenance. The PPA differs from solar leasing in how customers under the PPA system pay for energy that the PV system generates, while customers under leasing pay for leasing the equipment.

For roof rental, a developer rents a roof from a host or roof owner to install and operate a PV system and sells the electricity for the FIT. The roof owner receives a constant payment from the developer as a rent. The rooftop owner has no involvement with the PV system other than renting out the roof [2].

As well as self-financing and third-party financing, other financial options are also available worldwide, such as utility/public financing, or financing in support of shared solar. Utility/public financing can be in the form of low-interest loans, rebates or subsidies provided by local governments or utilities; however, this financing option is subject to the policies and regulations of local governments or utility companies [2]. Shared solar, owned by the community or a third-party, is a new trend that provides customers who are unable to install PV systems at their sites due to issues on shading, structure or ownership with the opportunity to utilize solar energy. Shared solar can be financed in various ways including crowdfunding [12].

This paper examines and analyzes the economic feasibility of self-financing and third-party financing including cash, solar loan, solar PPA and solar leasing under the current Thai household solar rooftop scheme.

3. Methodology
Four financial options were modelled using the System Advisor Model (SAM), an open source techno-economic analysis tool for renewable projects. This tool simulates PV production according to the climate data, and then generates cash flows and calculates the economic feasibility in terms of the levelized cost of electricity (LCOE), net present value (NPV), internal rate of return (IRR) and payback period (PB).

Electricity consumption of residential customers for 12 months was acquired from the load survey of Metropolitan Electricity Authority for the year 2015 as average monthly consumption of 1,000 kWh (Figure 1). In the simulations, load profiles were assumed to increase annually at 3.8%, similar to the gross domestic product of Thailand [1]. The panels were assumed to be crystalline silicon, fixed open rack and optimally facing south and other technical assumptions are shown in Table 1. With these technical assumptions, average monthly PV production profiles generated from SAM are presented in Figure 2. Financial assumptions are shown in Table 2.

| Table 1. Technical assumptions for the simulations. |
|-----------------------------------------------|
| Parameters          | Unit   | Amount |
|---------------------|--------|--------|
| PV size             | kW_{dc}| 3      |
| Panel azimuth angle | Degrees| 180    |
| Panel tilt angle    | Degrees| 15     |
| System lifetime     | years  | 25     |
| Inverter efficiency | %      | 96     |
| Total system losses | %      | 14.08  |
| Degradation rate    | % per year | 0.5 |
DC/AC ratio

1.1

Figure 1. The average monthly load profiles of residential customer.

Figure 2. The average monthly PV production profiles according to the technical assumptions.
Table 2. Financial assumptions for the simulations.

| Parameters                                                                 | Unit          | Amount       |
|---------------------------------------------------------------------------|---------------|--------------|
| Analysis period                                                           | years         | 25           |
| Total installation cost of a 3-kW PV system                               | USD           | 5,160        |
| Inflation rate                                                            | %/year        | 0.6          |
| Host real discount rate                                                   | %/year        | 5            |
| Inverter replacement cost every 10 years                                  | USD           | 870          |
| Operation and maintenance cost                                            | USD/kW-year   | 8.2          |
| Electricity rates as of May-Aug 2019                                       |               |              |
| Fixed charge                                                              | USD/month     | 1.092        |
| Tier 1: 1-150 kWh                                                          | USD/kWh       | 0.090        |
| Tier 2: 151-400 kWh                                                        | USD/kWh       | 0.117        |
| Tier 3: Over 400 kWh                                                       | USD/kWh       | 0.123        |
| Financial option parameters                                               |               |              |
| 1. Cash                                                                   | %             | 0            |
| 2. Loan                                                                   | %             | 50           |
| Loan rate                                                                 | %/year        | 4.77         |
| Loan term                                                                 | years         | 20           |
| 3. PPA and leasing                                                         |               |              |
| Developer’s IRR target                                                    | %             | 10           |
| IRR target year                                                           |               | 25           |
| Developer discount rate                                                   | %/year        | 5            |
| Developer income tax rate                                                 | %/year        | 20           |
| Depreciation class                                                        | 20-year straight line |
| Allocation of depreciation                                                | %             | 100          |

* The exchange rate is 1 USD = 35 THB

4. Result and discussion

Using SAM to simulate PV production, the 3-kW PV system yielded 4,085 kWh/year or a capacity factor of 15.5%. By considering the LCOE, NPV, and IRR of cash and loan options as shown in Table 3, investment in a 3-kW PV system by loan gave higher benefits than investment by cash. However, when the IRR target of a developer was set at 10% for PPA and leasing options, the customer or host did not gain any benefits since the host purchased electricity from the developer at 18.78 US cent/kWh under the PPA option and paid the developer at 61.58 USD/month under the leasing option. These payments caused the host to realize the negative NPVs for both options.

Results implied that the current Thai household solar program is suitable for PV investments by self-financing but not through PPAs or leasing. However, the program did not incentivize developers to be part of the residential PV business. In Thailand, where electricity cost is relatively low, developers are one of the key driver as they are more eager to approach customer than the other way around. If the program benefits both developers and consumers, then this will encourage developers to actively search for both customers and opportunities and adoption of PV will increase.
Table 3. The comparison of economic feasibility of four financial options.

| Financial option | Cash | Loan | PPA | Leasing |
|------------------|------|------|-----|---------|
| **Host**         |      |      |     |         |
| LCOE (cent/kWh)  | 11.69| 11.36| 13.73| 13.73  |
| NPV (USD)        | 755  | 935  | -2,531| -2,531 |
| IRR (%)          | 7.1  | 8.7  | -   | -       |
| PB (year)        | 12.7 | 12.7 | -   | -       |
| **Developer**    |      |      |     |         |
| Levelized PPA price (cent/kWh) | | | 17.67 | |
| NPV (USD)        | | | 2,165| 2,234  |
| PPA price (cent/kWh) | | | 18.78 | |
| Leasing price (USD/month) | | | | 61.58 |

5. Conclusion

This paper compared the economics of four financial options under the current Thai household solar program with the buyback rate at 1.68 Thai Baht/kilowatt-hour or 0.048 US dollar/kilowatt-hour. Based on the technical, economic and financial assumptions noted above, investment in a 3-kilowatt photovoltaic system by debt fraction of 50% and 100% cash is profitable. The first option offers higher benefits than the second. On the other hand, investment in a 3-kilowatt photovoltaic system through a solar power purchasing agreement and leasing is not economically viable. However, further investigation is required to determine key factors that can help to incentivize developers such as a suitable buyback rate that benefits both customers and developers.

References

[1] Thailand’s Ministry of Energy 2018 Power Development Plan 2016-2040
[2] Tongsopit S, Moungchareon S, Aksornkij A and Potisat T 2016 Energy Policy 95 447–57
[3] Tongsopit S, Junlakarn S, Wibulpolprasert W, Chaianong A, Kokchang P, Hoang NV 2019 Renewable Energy 138 395-408
[4] Department of Alternative Energy Development Efficiency Thailand PV status report 2016-2017
[5] Vasseur V and Kemp R 2015 Renewable and Sustainable Energy Reviews 41 483–94
[6] Karjalainen S and Alhvenniemi H 2019 Renewable Energy 133 44–52
[7] Qureshi TM, Ullah K and Arentsen MJ 2015 Renewable and Sustainable Energy Reviews 78 754–63
[8] Haukkala T 2015 Energy Research & Social Science 6 50–8
[9] Bondio S, Shahnazari M and McHugh A 2018 Renewable and Sustainable Energy Reviews 93 642–51
[10] Drury E, Miller M, Macal C, Graziano D, Heimiller D, Ozik J and Perry IV T 2012 Energy Policy 42 681–90
[11] Tao JY and Finenko A 2016 Energy Policy 98749–58
[12] Lu Y, Chang R and Lim S 2018 Renewable and Sustainable Energy Reviews 93 439-50