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Community Solar PV System for Sustainable Development in Thailand

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ABSTRACT

Cash flow analysis and System Advisory Model (SAM) are utilized to verify the economic viability of the investment in ground-mounted solar PV systems with various subsidy amounts. It has been found that a typical solar PV system with a capacity of 90 kWdc, which is adequate to supply daytime electricity for a community of 171 households, requires an investment of USD 135,555. With a 7% annual interest rate and 9.06% discount rate, a subsidy of 32.8% of the total investment is needed for break-even. In case the solar PV system is totally invested by the authorities, the revenue from the community's residential users and the savings from payments to the electricity generators (SPP or VSPP) will be realized and result in an NPV of USD 600,480 at a discount rate of 9.06% and a 52% IRR. The payback period for the case where the authorities invest in the system is around three (3) years. By pro-rata, a total investment of USD 6,838.9 million is required to install solar PV of the total capacity of 4,540.6 MWdc to provide electricity for all residential customers of 8,627,138 households, which could reduce GHG of 4,450,306.3 tCO2e.

Keywords*:* Solar PV, Community, Sustainable development, Thailand, Cash flow analysis, System Advisory Model (SAM), GHG reduction, SAM: System Advisory Model, USD: United States Dollar, UScent: United States Cent, NPV: Net Present Value, IRR: Internal Rate of Return, PPA: Power Purchase Agreement, EPPO: Energy Policy and Planning Office, ERC: Energy Regulatory Commission, DEDE: Department of Alternative Energy Development and Efficiency, SPP: Small Power Producer, VSPP: Very Small Power Producer, EGAT: Electricity Generating Authority of Thailand, PEA: Provincial Electricity Authority, MEA: Metropolitan Electricity Authority, FiT: Feed-in Tariff.

INTRODUCTION

The Ministry of Energy, Thailand, has encouraged private investors in the energy business since 1996 by specifying the private capacity in the Power Development Plan (PDP). Power from renewable energy and community participation were included in the later version of the

plan. This study intends to provide a community-owned model of ground-mounted solar photovoltaic system as a tool to achieve the sustainable development of the power generation system in Thailand. The background of power business in Thailand will be mentioned, followed by a brief history of power from renewable energy promotion. The most recent guidelines for the next Power Development Plan, which were given by the Energy Policy and Planning Office (EPPO), the Ministry of Energy, Thailand, and the requirement for sustainable development, will be highlighted in this section.

Power Business in Thailand

National Energy Committee (NEC) and Ministry of Energy (MoE)/Energy Policy and Planning Office (EPPO) establish a Power Development Plan (PDP) for the country. Energy Regulatory Commission (ERC) regulates the system according to the PDP. Electricity Generating Authority of Thailand (EGAT), Metropolitan Electricity Authority (MEA), and Provincial Electricity Authority (PEA) are the main governmental bodies that carry out the generation, transmission, and distribution. EGAT acts as the main generator, while MEA and PEA are the distributors for Bangkok and its vicinity areas, and the provincial areas, respectively. EGAT is also assigned to be the enhanced single buyer (ESB) to purchase electricity from private producers, namely independent power producers (IPPs), small power producers (SPPs), and very small power producers (VSPPs), as depicted in Figure 1.

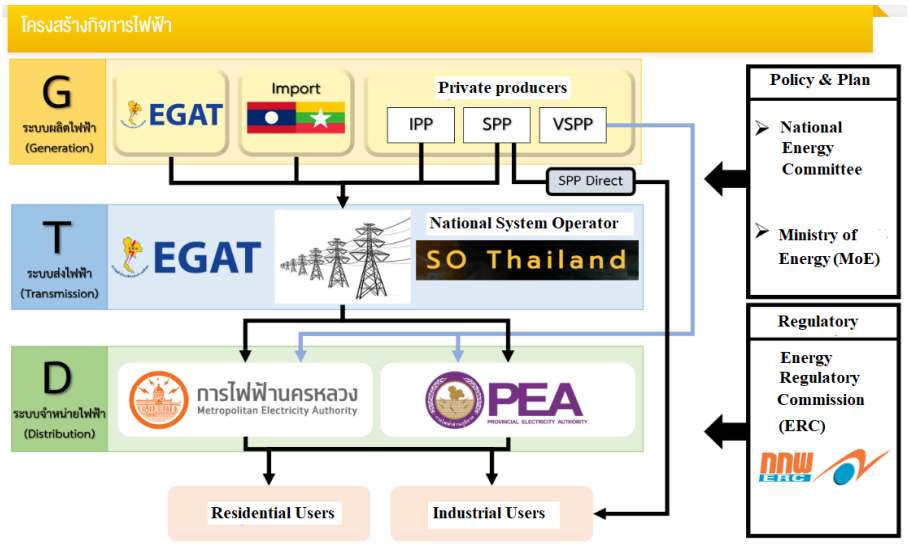

Figure 1: Power business structure in Thailand
Source: Energy Regulatory Commission (ERC, 2025)

Promotion of Electricity from Renewable Energy

The Alternative Energy Development Plan (AEDP), which was included in the Thailand Integrated Energy Blueprint (TIEB), Figure 2, introduced by the Ministry of Energy, Thailand, in 2015, targeted a total capacity of electricity from solar power of 6,000 MW by 2036. Later, the target was revised to 15,574 MW by 2037 (Sawasawanee, 2015). Private investors were invited to participate in Small Power Producer (SPP) program for plants sizing 10 MW and above, but not exceeding 50 MW, and Very Small Power Producer (VSPP) program for plants smaller than 10 MW, via competitive bidding for feed-in tariff (FiT).

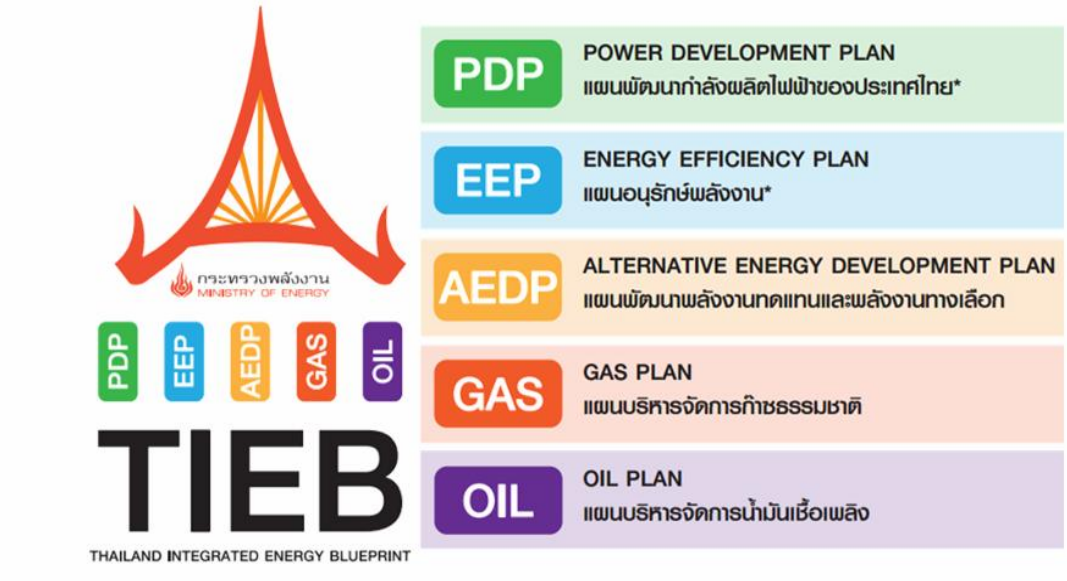

Figure 2: Thailand Integrated Energy Blueprint (TIEB)
Source: Energy Policy and Planning Office (EPPO)

The latest announcement of Feed-in Tariff (FiT) made by the National Energy Policy Committee (NEPC) on 6 May 2022 for the authority to purchase electricity from the producers who generate their electricity from ground-mounted solar photovoltaic systems at 2.1679 Baht per kWh or 6.194 US cents per kWh (ERC, 2022).

Guidelines for Power Development Plan and Sustainable Development Goal (SDG) as the Country Targets

The latest revision of the Power Development Plan was the PDP2018 rev.1 issued in October 2020. The revision of the PDP has been in process. Meanwhile, the Energy Policy and Planning Office (EPPO), Ministry of Energy, provided guidelines for the next revision as follows (EPPO-PDP, 2025):

1. Sufficiency: to meet the domestic demand,
2. Diversity: to balance the dependency on fuels,
3. Efficiency: to increase the efficiency of supply and demand,
4. Renewable energy: to promote power from renewable energy,
5. Participation: to encourage participation of the community and society.

The guidelines emphasize the participation of the community, which is a major requirement for sustainable development. SDG7, "Ensure access to affordable, reliable, sustainable and modern energy for all", has established a target to expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries. The 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change call for "ensuring access to affordable, reliable, sustainable and modern energy for all" to be achieved by 2030 (UN-SDG7, ม.ป.ป.).

A ground-mounted photovoltaic system is modelled for a community to determine the generation cost of electricity used as self-supply in section 2. The calculation results are

provided and compared with the electricity purchase under another promotion program in Section 3. The policy recommendations are discussed in Section 4. Toward the end, conclusions are given in Section 5.

MATERIALS AND METHODS

Information Used for Analysis

Information of a community, west of Bangkok, Thailand, was used to model for the analysis. The community of 171 households is located at latitude 14.05670 degrees and longitude 99.73067 degrees, where its weather data was retrieved from the National Solar Radiation Database (NSRDB) as follows:

- annual average direct normal (beam): 3.93 kWh/m^2/day,
- annual average diffuse horizontal: 2.38 kWh/m^2/day,
- annual average temperature: 28.7 °C,
- annual average wind Speed: 2.0 m/s.

Electric Load and Electric Rates:

Daily electricity load in 2019, supplied by PEA to its residential customers, was used as the initial demand information for the simulation. The load information in 2019 was intentionally selected to avoid the irregularity of the demand during the pandemic in 2020. The daily load was prorated with the ratio of the number of households in the community (171 households) and the total residential users (8,627,138 households). The monthly loads for the community in 2019 were summarized in Table 1.

Table 1: The monthly load summary of the community in 2019.

	Energy (kWh)	Peak (kW)
Jan	37,826.76	72.69
Feb	35,946.24	78.78
Mar	45,097.59	85.63
Apr	48,504.54	93.05
May	53,090.29	101.90
Jun	46,897.00	96.10
Jul	48,038.92	93.80
Aug	45,809.01	88.31
Sep	41,693.18	82.70
Oct	44,190.36	81.19
Nov	41,120.40	81.58
Dec	37,197.99	71.60
Annual	525,412.28	101.90

Source: Input into SAM by authors.

The monthly charge for a residential customer (>150 kWh) consists of

1. a fixed monthly charge (USD 0.736) (PEA-Charges),
2. an energy charge (USD 0.1154) (PEA-Charges),
3. a fuel adjustment (Ft) charge (USD-0.3314) (ERC-Ft) in 2019,
4. VAT (7%)

All of the monthly charge items are in Thai Baht (THB), which are converted into USD by the conversion rate of 35 THB/USD for readers' convenience.

Design of a Ground-Mounted Solar Photovoltaic Power Generating System for a Community

System Advisory Model (SAM) with PVWatts mode, which is supported by IRENA and available for free download, was used to simulate the power generation and costs of a ground-mounted solar PV system to partially meet the daytime load of the community. The night-time energy demand will be matched by the electricity supplied by the PEA grid.

Induction of Ground-Mounted Solar Photovoltaic Power Generating Systems for all Residential Users in Communities in the Country by Pro Rata

It is expected that the newly introduced solar PV system will ease the grid burden and save costs for the stakeholders. The simulated savings of the community will be proportioned to all residential users of the country.

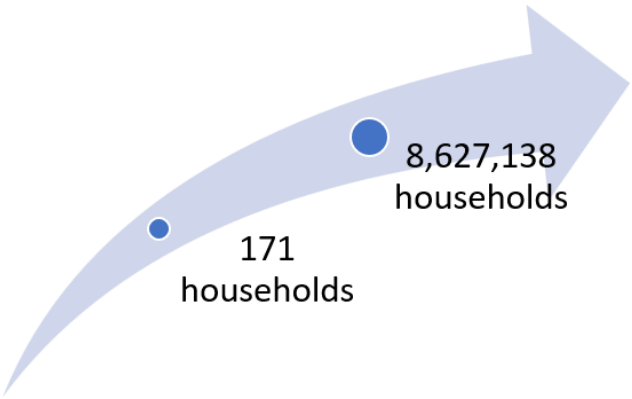

Figure 3: Induction of calculated figures from 171 HH to 8,627,138 HH.
Source: By authors.

DESIGN AND RESULTS

With the System Advisory Model (SAM) and the site information described in section 2, a ground-mounted solar PV system for the community of 171 households was designed, and the system parameters are detailed as:

- system capacity: 90 kWdc,
- module type: standard,
- DC to AC ratio: 1.3,
- rated inverter size: 69.23 kWac,
- inverter efficiency: 96%,
- estimated total module area: 473.684 m2,
- total system loss: 14.08%.

Daily average profiles throughout the year 2019 are plotted in Figure 4.

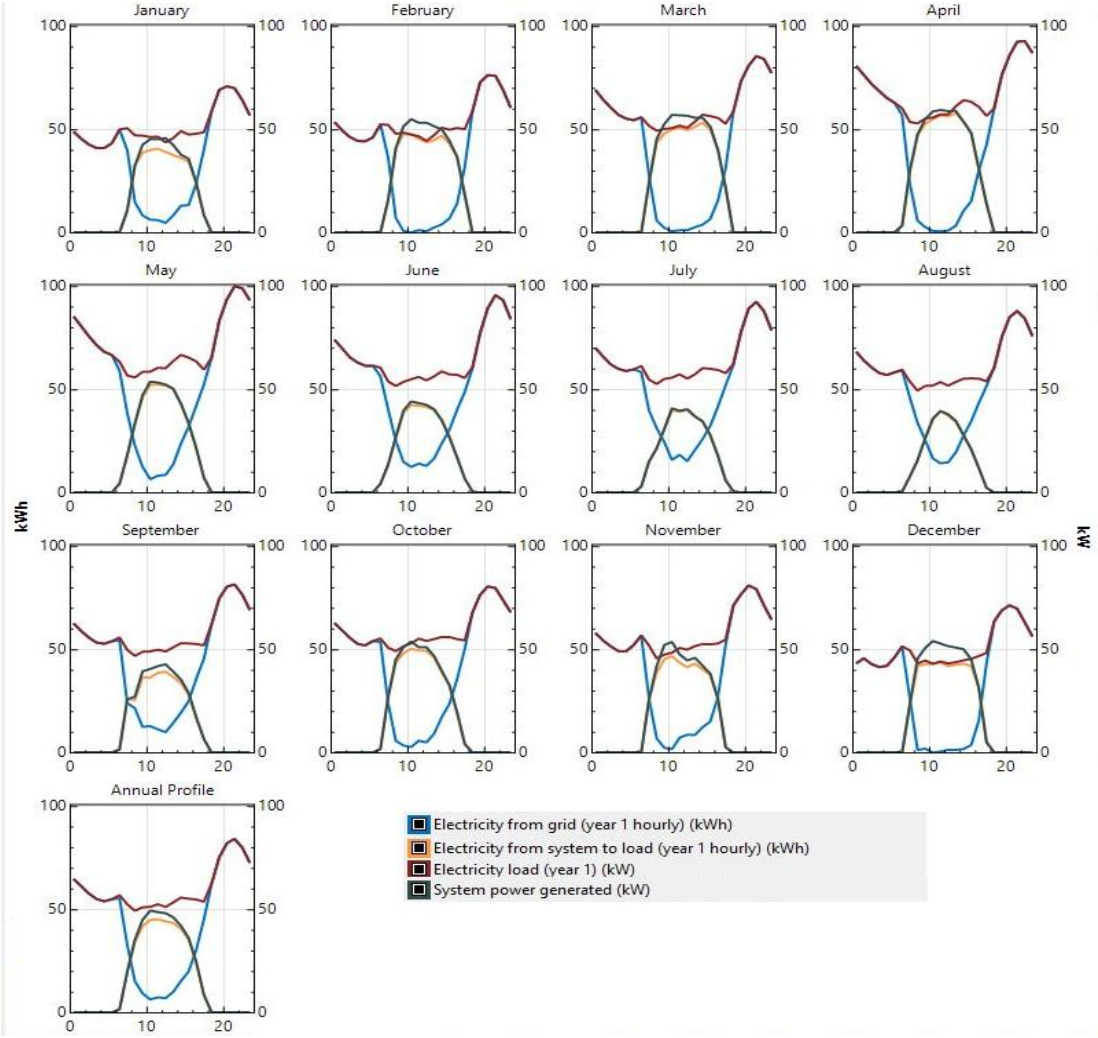

Figure 4: Profiles of the solar PV system
Source: System Advisory Model (SAM)

System Costs

The costs of the system were estimated based on the information in the program and can be summarized as:

- Direct capital costs;
  + Module: (1 unit, 90.0 kWdc/unit, USD 0.34/Wdc): USD 30,600.00
  + Inverter: (1 unit, 69.2 kWdc/unit, USD 0.05/Wdc): USD 4,500.00
  + Balance of system: (1 unit, USD 0.36/Wdc): USD 32,400.00
  + Installation labor: (1 unit, USD 0.18/Wdc): USD 16,200.00
  + Installer margin & overhead: (1 unit, USD 0.25/Wdc): USD 22,500.00
  + Contingency: (3%): USD 3,186.00
    - Total direct cost: USD 109,386.00
- Indirect capital costs;
  + Permitting & env. studies: (1 unit, USD 0.03/Wdc): USD 2,700.00

+ Inverter: (1 unit, USD 0.15/Wdc): USD 13,500.00
+ Grid interconnection: (1 unit, USD 0.03/Wdc): USD 2,700.00
+ Land purchase: (0.39 acres1 unit, USD 0.00/Wdc): USD 0.00
+ Land prep. & transmission: (1 unit, USD 0.02/Wdc): USD 1,800.00
    - Total indirect cost: USD 20,700.00

– Sale tax: (5.0% of direct cost): USD 5,469.30
    - Total costs: USD 135,555.30
    - Total cost per capacity: USD 1.51/Wdc

Operating and Maintenance

- Operating and maintenance costs: USD 22/kW-yr

Financial Parameters

- Debt fraction (mortgage): 100%,
- Initial debt amount (Net capital cost): USD 135,555.30,
- Loan term & rate: 25 years, 7%/year,
- WACC: 5.14%
- Analysis period: 25 years,
- Inflation: 2.5 %/year,
- Nominal discount rate: 9.06 %/year,
- Salvage value: 0% of installation cost.

Summary of the Financial Model

- Annual AC energy in year 1: 147,361 kWh,
- DC capacity factor in year 1: 18.7%,
- Energy yield in year 1: 1,637 kWh/kW (147,361 kWh/90 kW),
- LCOE nominal: UScents 5.81 per kWh (not adjusted for inflation),
- LCOE real: UScents 4.64 per kWh (adjusted for inflation),
- Electricity bill without system in year 1: USD 60,641,
- Electricity bill with system in year 1: USD 43,636,
- Net savings with system in year 1: USD 17,005,
- Net present value (Before Financial services): USD 114,963,
- Net capital cost: USD 135,555,

The system advisory model (SAM) simulates cash flows, from the financial inputs, with various subsidies and detailed in Table A.1 to A.9 in Appendix A.

Induction By Pro Rata

- Modelled capacity: 90 kWdc,
- Residential users: 171 households,
- Net capital cost: USD 135,555,
- Total residential users: 8,627,138 households,
- Induced capacity: 4,540,598.95 kWdc,
- Total investment (by induction): USD 6,838.9 million.

DISCUSSIONS AND POLICY RECOMMENDATIONS

Savings For Community Members

SAM simulates the cash flow with general financial conditions. In order to analyze the model of the community, specific financial parameters are input into the SAM program as follows:

- Interest rate: 7% per year,
- The principal repayment schedule has been revised as in Table 2.

Table 2: Principle repayment schedule

Year												
1	2	3	4	5	6	7	8	9	10	11	12	13
0%	5%	5%	5%	7%	7%	7%	9%	9%	9%	12%	12%	13%

The cash flow for the given financial parameters is depicted in Table A.2 in Appendix A. The net present value (NPV) calculated with the discount rate of 9.06%, as specified by SAM, is a negative value (USD-576,922), which can be interpreted as a project loss. With the typical financial conditions, it is not viable for the investment by the community.

Promotion of Community Participation in Electricity Generation with Support from the Authority

As described in section 4.1, the model conducted by the community with 100% finance is not viable; the analysis is extended to include support by authority. Various amounts of subsidies, i.e. 25%, 50%, 75%, and 90% of the total capital investment, are considered, while loans from financial institutions match the subsidies to accommodate the total investment of USD 135,555. The case of 90% subsidy is analyzed in lieu of 100%, because 100% subsidy will actually be the total investment by the authority, which will be considered in the following section. Subsidies from authority increase both NPV and IRR of the investment, from NPVs of USD64,195, USD95,269, USD126,342, and USD 144,986, and IRRs of 16.13%, 23.92%, 46.25%, and 112.76%, for 25%, 50%, 75%, and 90% subsidies, respectively, as shown in Table 3, and depicted in Figure 5.

Table 3: NPVs and IRRs for various subsidies.

Subsidy	Loan	NPV(USD)	IRR
0%	100%	(76,922)	3.43%
10%	90%	(53,487)	4.78%
25%	75%	(18,337)	7.34%
32.8%	67.2%	(59)	9.05%
40%	60%	16,813	11.00%
50%	50%	40,246	14.54%
75%	25%	98,831	36.23%
90%	10%	133,982	103.52%

NPVs and IRRs for different amounts of subsidy are plotted in Figure 5.

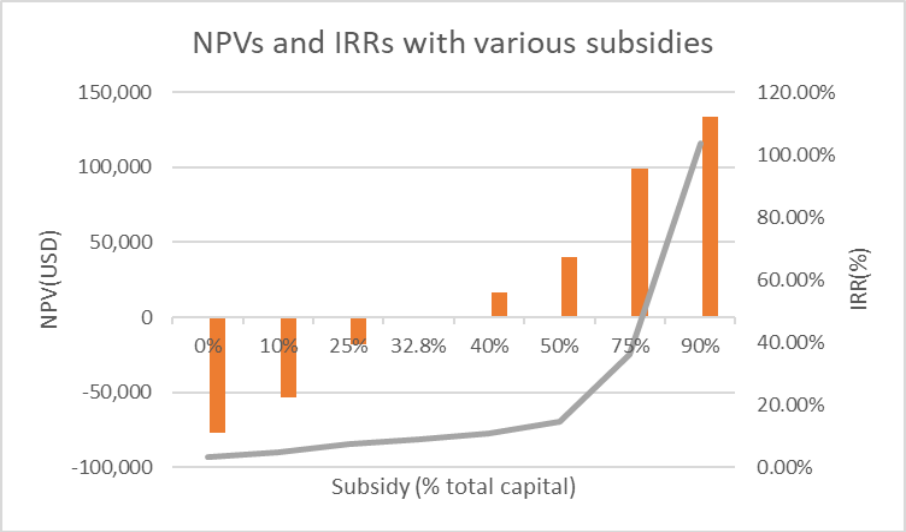

Figure 5: NPVs and IRRs at various subsidies

It can be seen that the investment with subsidies, starting from 32.8% and more, can make the investment by the community viable. The IRR for the case of 32.8% is approximately equal to the discount rate of 9.06%. Thus, if the discount rate decreases, the threshold for the subsidy for viable investment decreases.

Total Investment by Authorities

The analyses in sections 4.1 and 4.2 are based on the benefits to be realised by the community and residential users. In case the authorities decide to handle and own the PV system, all benefits to be gained by the authorities will be considered. The major benefits, which the authorities will receive, are the revenue from the community's residential users and the savings from payments to the electricity generators (SPP or VSPP). Those are USD 0.1154/kWh of revenue received from the residential users in the community and USD 0.06914/kWh of savings from waiving the purchase of electricity from generators (SPP or VSPP).

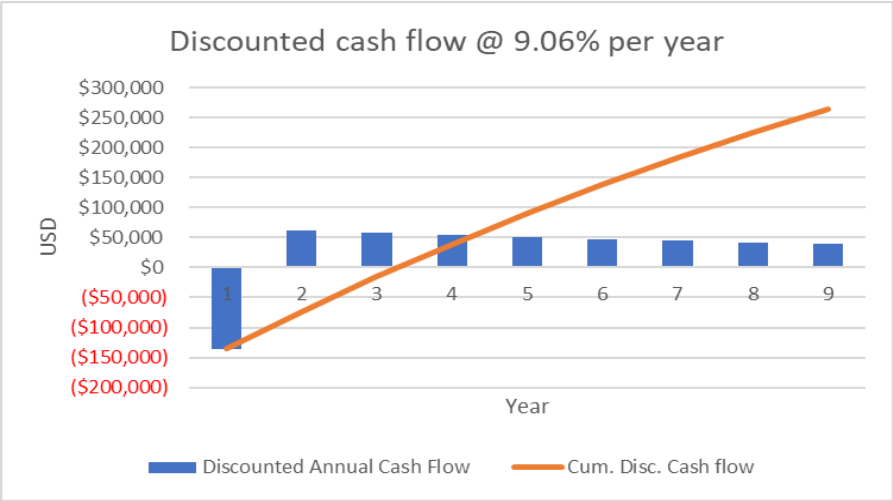

Figure 6: Discounted annual cash flow and payback period

Source: By authors

The cash flow for the model owned by authorities is provided in Table A.7, which yields an NPV of USD 600,480 at a discount rate of 9.06% and a 52% IRR. As shown in Figure 6, the annual discounted cash flow can be plotted on a time scale to determine the payback period. As a result, the payback period for the case where the authorities invest in the system is around three (3) years. The result implies that if the authority commits to SPP or VSPP with power purchase agreements, the authority will have to bear the burden throughout the length of the PPA. Instead, an investment in the ground-mounted PV system for residential users in a community can release the authority from its burden in about three (3) years. Afterwards, the authority can enjoy the positive inflows from sales revenues and savings from waiving the payment due to PPA.

Business Creation

It has been a problem for residential users to install and maintain their rooftop PV systems, as they lack the expertise to do so. The failed rooftop PV systems were left unattended and useless for the owners. The electricity authorities, including EGAT, PEA, and MEA, who do not only have the capability, but also the world-class expertise to carry out the installation and maintenance for the PV systems for communities. It is an opportunity for the authorities to create a business. There are many MEA and PEA branch offices scattered throughout the country to provide services to their customers. They should be able to commit to contractual agreements to provide installation and maintenance services for the communities. In the cash flow analysis by SAM, an annual maintenance expense of USD 1,980 (1.5% of the installation cost) is included, which should be adequate for a regular visit and emergency maintenance for a PV system.

Savings-useful Proceeds

The savings from the differences between collected revenues and costs of electricity production can be considered as proceeds for the community, which can be used as the community prefers, such as:

- used as a deduction to the electricity cost,
- used to repay the debt due to earlier cost reduction program,
- used as seed funds for household initiated business.

Ownership-as Encouraged by the Constitution and SDG7 and SDG17

It is worth noting that ownership of the PV systems is one of the essential issue, which implies the community participation encouraged by the constitution B.E. 2560. SDG7-Affordable and clean energy aims to ensure access to affordable, reliable, sustainable and modern energy for all, while SDG17- Partnerships for the Goals targets to strengthen the means of implementation and revitalize the global partnership for sustainable development. The investment and management can be performed totally or partially, by the community to ensure the ownership. In case the system is invested solely by the authority, the PV system can be transferred to the community on a later date.

Burden of the Electricity Price Increase

It was pointed out that on the promotion of rooftop solar PV system installations, “higher benefits to prosumers lead to more negative impacts to utilities and ratepayers” (Chaianong, Tongsopit, Bangviwat, & Menke, 2019). That implies that the more prosumers install solar PV

systems on their rooftops, the less energy they require from the central grid, which will result in less revenue to the authorities. The base tariff, which is scheduled to revise every five years, will be raised to cover the revenue loss. Those, who are not prosumers with solar rooftop PVs, will have to bear the increasing base tariff.

Reduction in Transmission Loss and CO2 Emission

Electricity loss in PEA's transmission network has increased drastically, from 3.33% in 2009 (Mungkung, et al., 2009) to 5.45% in 2021 (PEA, 2021) and 5.46% in 2023 (PEA, 2023). The electricity loss 5.46% in 2023 was equivalent to approximately 6,845.22 million kWh or 781,417.8 kW (divided by 8,760 h per year), or 781.4 MW. The value of the electricity loss can simply be calculated by multiplying the loss units by sale price, 6,845.22 million kWh x USD 0.1154/kWh or USD 790 million. The energy loss (kWh) in the transmission network tends to pile up due to the increase in transmitted energy. Installation of PV systems near or in the community will increase efficiency by reducing the electricity transmission losses. The savings from loss reduction may, in turn, be used to invest in the community PV systems.

A GHG reduction from solar power generators of 2,761.0 tCO2 in 2023 is also reported by PEA (PEA, 2023). An addition of solar PV systems for communities will help reducing GHG emission. According to the emission factor for electricity from grid in Thailand, which is 0.5986 kgCO2e per kWh (TGO-Emission_Factor), the emission reduction will be 88, 210.29 kgCO2e (147,361 kWh x 0.5986 kgCO2e per kWh) for the 90 kWdc system in the first year, or 4,450,306.3 tCO2e (4.45 million tCO2e) for 4,450.6 MWdc for all residential users in the country for the first year, as shown in Table 4.

Table 4: Estimated GHG reduction (1st year) by pro-rata.

HH	kWdc	kWh	emission factor (kgCO2e/kWh)	kgCO2e	tCO2e	million tCO2e
171	90	147,361.0	0.5986	88,210.3		
8,627,138.0	4,540,598.9	7,434,524,460.9	0.5986	4,450,306,342.3	4,450,306.3	4.45

Licenses – The Concerns

The National Committee for Energy Regulation announced in 2008, that five (5) types and duration of energy business licenses B.E. 2551 are required for businesses as follows (ERC-Licenses, 2008):

1. Electricity Generation License
2. Electricity Transmission System License
3. Electricity Distribution System License
4. Electricity Distribution License (issued to electricity distributors who are not electricity business licensees)
5. Electricity Control License

If the community is defined as the owner of the PV system, there is a legal issue for the community to acquire the licenses, including the construction permits to be issued by Ministry of Industry.

CONCLUSIONS

The authority has continuously contracted electricity from private producers in the last decade. The newly signed agreement commits to fixed feed-in-tariffs. An option to promote solar PV with community participation is presented in this study, which covers the economic, social, and environmental aspects. It has been verified that less investment will be required than purchasing from private producers, due to the difference in production cost, installation and maintenance costs, and the contracted feed-in-tariff. The authority may choose to subsidize solar PV systems for communities. As a result, the residential users in the community will have electricity bill reductions if the community invests in the solar PV. Different amounts of savings are calculated for various levels of subsidy received from the authority. The authority would save the feed-in-tariff payments as well. A new business for PV system installation and maintenance can be created by the authority to compensate for the profit loss due to the decrease in sales. Solar PV systems for communities will also help reduce GHG emissions, approximately 4,450,306.3 tCO_2e if 4,450.6 MWdc is installed for all residential users in the country for the first year.

References

Chaianong, A., Tongsopit, S., Bangviwat, A., & Menke, C. (2019). Bill saving analysis of rooftop PV customers and Policy implications for Thailand. 131.

EPPO-PDP. (2025). Power Development Plan. Retrieved April 22, 2025, from Energy Policy and Planning, Ministry of Energy, Thailand: https://www.eppo.go.th/index.php/th/electricity/pdp

ERC. (2022, September 30). Power Purchase. Retrieved April 20, 2025, from Energy Regulatory Commission: https://www.erc.or.th/th/power-purchasing3

ERC. (2025). Electricity. Retrieved from Energy Regulatory Commission: https://www.erc.or.th/th/power-statistics-electricity

ERC-Ft. (n.d.). Ft. Retrieved April 24, 2025, from Energy Regulatory Commission: https://www.erc.or.th/th/automatic/1355

ERC-Licenses. (2008). Types and Duration of Energy Business Licenses B.E.2551. Retrieved May 1, 2025, from Energy Regulatory Commission: www.erc.or.th

Mungkung, N., Gomurut, N., Tanitteerapan, T., Arunrungrusmi, S., Chaokumnerd, W., & Yuji, T. (2009). Analysis of Technical Loss in Distribution Line System. The 8th WSEAS International Conference on Telecommunications and Informatics.

PEA. (2021). Shifting to digital utility for sustainable society. Thailand: Provincial Electricity Authority.

PEA. (2023). Retrieved May 2, 2025, from Provincial Electricity Authority: https://sustainability.pea.co.th/en/

PEA-Charges. (n.d.). Energy & Service Chrages. Retrieved April 24, 2025, from Provincial Electricity Authority: https://www.pea.co.th/sites/default/files/document

Sawasawanee, Y. (2015). Department of Alternative Energy Development and Energy Conservation. Retrieved from DEDE.

TGO-Emission_Factor. (n.d.). Emission Factors. Thailand Greenhouse Gas.

UN-SDG7. (n.d.). High-level dialogue on ENERGY. Retrieved April 21, 2025, from United Nations, Sustainable Development: https://www.un.org/sites/un2.un.org/files/2021/11/hlde_outcome_-_sdg7_global_roadmap.pdf