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Business Perspectives of Distributed System Operators for Solar Rooftop-as-a-Service

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Abstract: Rising fossil energy prices and the significantly decreasing prices of energy technology have resulted in electricity consumers having the option to install solar PV rooftops to rely on the self-consumption of clean energy. However, the increase in this amount is affecting the revenue of electricity as a utility, which must adapt and develop its business model to accommodate the situation. If the utility cannot be adapted in time, it may lead to a loss of income from services and the sale of electricity from fossil energy. The utility in Thailand's electricity market that acts as the distribution system operator (DSO) is known as the Provincial Electricity Authority (PEA), and the Metropolitan Electricity Authority (MEA) is responsible for managing distribution networks and customers. There are four types of solar rooftop-as-a-service (RaaS) business perspectives they could consider as opportunities through which to minimize revenue impact. The business services were designed for the DSO customer as follows: Consulting, Design, and Installation (CDI); Operation and Maintenance (O&M); Energy Service Company (ESCO); and Power Purchase Agreement (PPA). The model comprises four customer segments: residential buildings and small-, medium-, and large-scale commercial buildings. This paper applies SWOT, Five Forces, 4P marketing, and economic impact analyses to identify the possibilities when using the DSO business model. The SWOT analysis demonstrates that ESCO and PPA are strengths in the DSO's performance characteristics and existing customer data. In the electricity industry, both models offer enormous customer bargaining power in terms of a Five Forces analysis. The main reason is that there is currently high competition in the installation service. In the 4P analysis result, the price per unit is found to be significantly lower than in residential scenarios. Therefore, there is a format for presenting promotions with an advantage over competitors. Deploying an after-sales service that brings convenience to all customer segments is needed. The economic analysis conducted using Cournot competition game theory shows a significant differential in the Medium (M) and Large (L) customer sectors' competition due to lower technology prices. In conclusion, with the current regulatory framework and criteria, the ESCO and PPA show the best practical model from a utility business perspective. The recommendation for DSO is to create a strategic ecosystem and to link it with private companies as their partnership business.

Keywords: liberalized solar rooftop; energy-as-a-service; electricity sector; business model analysis; energy service company

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1. Introduction

The National Reform Council (NRC) has resolved to approve a proposal for a Quick Win Project on the promotion of liberalized solar rooftops (LSRs) for residential and commercial building sectors by the Department of Alternative Energy and Energy Efficiency (DEDE), Ministry of Energy. The DEDE has arranged meetings since March 2015 to discuss the promotion project of LSR for residential and commercial buildings with representatives from the Office of Energy Regulatory Commission (OERC), the Electricity Generating Authority of Thailand (EGAT), the Metropolitan Electricity Authority (MEA), and the Provincial Electricity Authority (PEA). The definition of the promotion project of LSRs for

residential and commercial buildings is producing electricity with the solar energy obtained from installing solar PV panels on the roofs of houses and commercial buildings, or, indeed, any parts of houses and buildings, with the specification that the electricity produced will be used first in the home or building from which it is produced; after that, the owner is able to sell to the utility organization for distribution. As per the forecast by the discussion under the NRC, in the first 5 years, from 2015 to 2020, small PV rooftops for residential homes were installed with a size of no more than 10 kW per system, with at least 100,000 systems of 500 MW production capacity electricity. In 20 years, there will be at least 1,000,000 small PV roof installations, with a total installed capacity of no less than 5000 MW. The Ministry of Energy requires relevant agencies, including the OERC, MEA, PEA, EGAT, and DEDE, to consider issuing regulations, announcements, criteria, and methods through which to allow homeowners and commercial building owners to participate in the "Promotion Project of LSR" in the most convenient and fastest way by setting up a joint service at a single point or one stop service (OSS). The agencies should determine the purchase price for the remaining electricity used in the homes and buildings that can participate in that project widely and concretely. In the long-term power development plan (PDP 2015–2036), there should be adequate and appropriate investment in transmission and distribution lines and measures to promote investment in import and income taxes. Therefore, the project can proceed quickly, thoroughly, and efficiently by distributing electricity production close to the generation source to reduce losses in the distribution systems. The meeting emphasized producing electricity for personal use in the household and ensuring that the selling of excess electricity to utility organizations is kept to a minimum by determining the amount of electricity purchased from these special projects. However, the targets of the NRC's proposal will not be included in the Alternative Energy Development Plan (AEDP), and the price of electricity purchased from these promotion projects must not burden general electricity users. Most of them want to sell the electricity from the "Promotion Project of LSR" for residential homes to enter the system during peak electricity demand (PEAK), where the rate for electricity sales is to be calculated at the rate during PEAK and where there may be a need to improve the electricity metering system as both purchasing meters and selling meters must be consistent.

There should be a designated area for the pilot project to consider the feasibility and advantages/disadvantages of project implementation. They should consider other limitations, such as the technical aspects of distribution systems, improving related regulations and various safety standards, and methods for determining electricity rates for these LSR projects. The DEDE revealed the amount of self-consumption for solar rooftop pilot projects in 2016; the total capacity of the residential and commercial sectors was 5.63 MW, with 3.934 MW in MEA and 1.696 MW in PEA. The project continues and shows a rising number of self-consumption of 469.5 MW, 558.2 MW, and 654.3 MW in 2018, 2019, and 2020, respectively. Presently, the government continues to provide subsidies for residential prosumers (less than 10 kW) with a buyback rate of 2.2 THB/kWh (USD 0.06/kWh) and a maximum contract of 10 years. The quota has been launched in PEA and MEA for 5 MW each. No subsidy is available for the commercial sector, which is already operating as usual.

The support from the government is allowing for the continuing growth of solar rooftop utilization, and the market size is expected to increase in the future. Increasing electricity tariffs and clean electricity demand due to climate change are also the key drivers stimulating the solar rooftop market. The price of solar modules is decreasing [1], and there is cost efficiency, allowing the residential and commercial sectors to become self-sufficient in their energy and investment. In Germany, the forecast for solar rooftops was about 73 percent in 2020 and will be about 78 percent in 2050 [2], and these numbers may be similar to Thailand's. As a result, large amounts of energy are leaving the electric grid and affecting the utility companies' incomes. Thailand first launched solar rooftops in 2013, and The International Energy Agency (IEA) [3], Tongsopit et al. [4,5], and Chaianong et al. [6–8] have shown that the country continues to present different rates of subsidy in the form of feed-in tariffs toward self-consumption policies. This is a growth opportunity, and the

government's efforts in creating various mechanisms to support it have been effective. The business model canvas reviewed requires multiple degrees of government involvement, whether through financial support for smaller-scale solar leasing, hosting an equipment registration system, or by providing more legal clarity on a third party's sale of PV power. It is recommended that the Thai government implement net-metering regulations to promote market expansion and moderate the utility companies' revenue impacts. The distribution utility companies will have to make potential business model adjustments in the future [4,8]. Akhil V. Sudhakaran et al. [9] showed that consumers in India face challenges such as high capital costs and limitations in their technical knowhow of feasibility studies, installation, O&M, and proper competency assessments of vendors. If, in a few years, the subsidies are expected to phase out, then—by considering the future electricity amendments with an adaptive strategy—a developer with a lower LCOE could offer PPA to an offsite consumer at a lower tariff. Pasapong Gamonwet et al. [10] revealed that residential solar rooftops in Thailand can deliver even more significant financial returns if supported by measures such as a lower loan interest rates and a substantial share of the loan amount. Compared to NB, P2P energy trading is favorable for solar rooftops, which purchase and sell excess solar rooftop energy after self-consumption with the neighboring household. It is crucial to explore the potential impact of electricity rates from solar-rooftop to non-solar rooftop customers and utility companies in the future. Ririka Yamashiro et al. [11] raised issues such as weak and neglectful after-sales services by companies, thereby showing that the third-party ownership–aggression business model could drive adoption. However, the different types of benefits from PV plus energy storage and their distribution can create a conflict of interest between grid companies and end users. Hall S. et al. [12] presented the matching of consumer segments to innovative utility business models. Without intervention, innovation in utility business models risks exacerbating existing social inequalities. They found that institutional trust beyond the energy sector is a crucial driver for consumer segmentation. The increase in self-consumption may also cause utility companies' revenues to drop, and this could impact the distribution network [13]. Barbose [14] found that utility-owned rooftop businesses could result in utility companies losing about 2% or an even more significant reduction in earning opportunities if others also engage in solar rooftop businesses. In current news (i.e., the standard team [15]) and PEA [16], residents' feedback show the need for a convenient and fast project recruitment mechanism.

To answer such rapid growth questions, utility companies could develop their business as part of a strategic opportunity, and they could also digitize its utility. This paper presents a possibility for the DSO perspective on the solar rooftop-as-a-service (RaaS) business model, which will show the element of strategy and technical requirements that fit the DSO. The customer segment is derived from the study of Amanda et al. [17]. The context of the regulatory framework is designed from the current situation. Economic analysis and impacts on society will be presented in view of utility so as to classify the number of customers and the effect of their electric grid and revenue.

2. Business Model for Solar Rooftops

2.1. Typology of the Energy Business Model

Gitelman (2023) [18] found that the business models in the energy sector were related to implementing green technologies in response to the public demand for clean energy, spatial organizations of production based on platforms and digital tools, and active implementations of customized knowledge-intensive services. The energy sector business model, when utilized in a more decentralized landscape, is divided into five models, as shown in Table 1.

Aggregator: Controls various types and sources of distributed energy resources (DERs) to optimize energy distribution. UiTM [19] shows that the global market value of USD 762 million in 2016 is expected to reach USD 4597 million in 2023. The world's largest virtual power plant (VPP) will connect DERs in 50,000 homes to meet 20% of South Australia's daily power demand [20,21]. Projects in the Netherlands, Germany, and Australia are aggregating behind meter batteries to provide grid services. In Thailand, the aggregator

model for utility companies was studied by Parinya et al. [22], in which on-demand response (DR) and analyses using Thailand's power market under the Enhanced Single Buyer (ESB) concept were focused on.

Table 1. The energy sector business model.

Issues	Aggregator	Peer to Peer	Energy as a Service	Community Ownership	Pay as You Go
Definition	Distributed energy resources (DERs): small- and medium-sized power resources connected to the distribution network. AGGREGATORS: DER is aggregated as a single virtual power plant (VPP) platform, and it interacts in a power network or market.	The P2P model creates an online marketplace where prosumers and consumers can trade electricity without an intermediary at their agreed price.	The EaaS model offers various energy-related services to consumers rather than only supplying electricity.	Their users can collectively own and manage energy-related assets, such as energy generation, energy storage, energy efficiency, and district cooling and heating systems.	PAYG is the package that usually includes a home solar system that customers pay for using mobile payment technologies and transferable phone credit.
Driver	Digitalization development and smart metering have created new business models. Aggregators are a new market player that can optimize the use of DERs.	Trading based on P2P models makes renewable energy more accessible, empowers consumers, and allows them to make better use of their energy resources.	Increased deployment of DERs and the widespread availability of smart devices have created room for innovative business models to emerge, thus shifting the value from selling kilowatt hours to service provision.	Through cost sharing, community ownership models enable participants to own key local energy assets, contribute to community energy development, and help scale up renewables.	PAYG can provide affordable energy access from renewable sources to off-grid communities by using available technologies to facilitate payment by installers.
Benefits	Aggregators use a centralized IT platform (VPP) to control the DERs and optimize their operation remotely. VPPs can provide the following: • Load shifting; • Balancing services to TSOs; • Local flexibility to DSOs.	Peer-to-peer (P2P) electricity trading empowers prosumers and consumers, thereby increasing RE deployment and grid flexibility. P2P platforms also aid in balancing congestion management, thus providing ancillary services.	Through different service provision and revenue models, EaaS supports the following: • Increased deployment and operation of DERs; • Increased flexibility through demand-side management.	Community projects can provide flexibility and, when connected to the central power system, increase the reliability and resilience of the whole system. They provide many socio-economic benefits in addition to low-cost renewable energy to the local community.	• Improves energy access in off-grid areas with DERs; • Defers network expansion investments; • Enables other innovative business models, such as peer-to-peer trading or community ownership.
Key success	• Smart meters and communication; • Infrastructure; • Regulatory framework allowing for the participation of new market players; • Accurate data (weather forecast, load projections, and wholesale prices).	• DERs; • Digitalization; • Conducive regulatory framework.	• Time-of-use tariffs; • Digitalization; • Revision of the distribution system operator methodologies to account for demand-side flexibility.	• Enables policy and regulatory frameworks; • Simplification of administrative processes; • Access to finance; • Capacity building within communities.	• Electrification strategy that accounts for pay-as-you-go (PAYG) and off-grid systems; • Consumer awareness of PAYG models; • Access to finance for local energy service providers.

Peer-to-peer: Prosumers and consumers can trade electricity, without an intermediary, at an agreed price. IRENA [23] showed that Australia, Germany, Japan, Malaysia, Netherlands, the UK, and the US have started trial P2P schemes. Many of the pilot projects used blockchain technology.

Energy as a service: This model provides energy and related services such as energy advice, energy management, and energy asset installation. In 2019, smart meter penetration was 14% globally, 70% in China and the US, and 44% in the EU [24]. EaaS models with time-of-use pricing could reduce peak demand by 3–10%. EaaS models are emerging in many countries, including Australia, China, Finland, Ireland, Italy, Japan, Sweden, the UK, and the US. Jos'e Iria [25] proposed a new business model for the aggregators of prosumers based on the concept of energy as a service. The consumers pay a monthly fee for aggregators to represent and optimize them in multiple wholesale electricity markets, including energy and ancillary service markets. This provides simplicity and predictability to prosumers, as they are offered a guaranteed outcome before the services are delivered.

Community ownership: Users collectively own and manage energy-related assets to share cost and ownership. More than 4000 community-owned projects provide power, mainly in Australia, Europe, and the United States [26]. Innovations emerging with community ownership include aggregators, demand response, mini-grids, energy storage, and electric vehicles. IRENA [26] reported that Eigg Electric, a community-owned company, provides 95% renewable power to all Scottish (UK) island residents.

Pay as you go: The provider offers solar equipment and installation service to users, who pay in a package using mobile payments or mobile credit. Between 2015 and 2020, around 8 million people gained access to energy with PAYG models. About two-thirds of the world's off-grid energy consumers can access mobile networks. Almost 40 million off-grid solar systems were sold globally by 2019 [27].

2.2. Solar Rooftop-as-a-Service Business Model for DSO

Energy companies and manufacturers of energy equipment and parts now use the EaaS business model. Gitelman (2023) [18] mentioned that the EaaS market size is expected to reach USD 220 billion, and that more popular returns on this business model are also possible. Jos'e Iria et al. [25] showed that this new business model builds on the concept of energy as a service, where prosumers pay a monthly fee to the aggregator instead of being subject to a volumetric pricing scheme. In this paper, rooftop-as-a-service (RaaS) is a new business opportunity for DSOs to sell a package of services to consumers. In the energy transition, the RaaS model can bridge the gap between their loss on revenue of distribution operation services and free LSRs. In this paper, the solar rooftop business model is divided into four models, as shown in the details of the business and the financial impact of each business model as follows.

Model 1: Consulting, Design, and Installation (CDI) business

The characteristics of this business are as follows:

1. Designing a solar rooftop installation system requires a standard size, a size according to the customer's request, or one for each home option.
2. The arrangement of sourcing, suppliers, and experts to install solar rooftops for customers by DSOs will be contracted to installers (OEM). DSO can outsource from any company for customer service by designing certain regulations for the outsourced shops.
3. The customer will pay some monthly expenses to the DSO for the middle company to maintain and contact the outsource that the DSO has agreed to (the DSO must make contracts with local companies in each region, that is, the outsourcing company for the DSO).

The process of providing services is to check the electricity usage of each customer's home or building, estimate the installation cost in each home, and visit the home so as to inspect and design the installation by an expert engineer.

How does the DSO convince customers to install solar rooftops?

- They recommend solar PV modules that are efficient and inexpensive for people;
- Solar rooftop systems must have a minimum of a 10-year warranty for customer confidence;
- There are characteristics and criteria for selecting suppliers systematically and with standards. For example, Solar City will select only suppliers whose equipment is two to three times more durable than general ones and are longer than the general industry (in this case, 35 years when compared with the public's approximately 25 years);
- Personnel arrangement for the inspection of systems annually;
- Personnel arrangement for inspection of suppliers to assess systems every month with a randomizing method;
- The design of a solar rooftop must be able to withstand particularly harsh weather conditions.

Model 2: Operation and Maintenance (O&M) business

The characteristics of this business are as follows:

1. Designing a solar rooftop installation system requires a standard size, a size according to the customer's request, or one for each home option;
2. The installation of solar rooftops for customers;
3. After-sales service for the solar rooftops of customers;
4. Products must be guaranteed to customers;
5. Customers must be worth their investment. However, currently, customers prefer to invest themselves because the cost of PV modules has come down rapidly.

The process of providing services is to estimate the usage of each house or building, to estimate the cost of usage in each home, to visit the home so as to inspect and design the installation by an expert engineer, to install solar rooftop systems, and to provide after-sales services.

How can customers be interested in installation?

- Recommend solar PV modules that are efficient and inexpensive;
- Solar rooftop systems must have a minimum of a 10-year warranty for customer confidence;
- There are characteristics and criteria for selecting suppliers systematically and with standards. For example, Solar City will select only suppliers whose equipment is two to three times more durable than general ones and is longer than the general industry (in this case, 35 years when compared with the public's approximately 25 years);
- Personnel arrangement for inspections of the system annually;
- Personnel arrangement for inspection of suppliers every month to assess systems with a randomizing method;
- The design of a solar rooftop must be able to withstand particularly harsh weather conditions.

Model 3: Energy Service Company (ESCO)

The characteristics of this business are as follows:

1. This is the same business as Business model 1 or 2, but it adds the DSO's investment;
2. The DSO will invest wholly into solar rooftop systems by renting the roof space of private buildings and managing the electricity by selling it to the public;
3. The homeowner or building owner will receive a rental fee from the DSO and will manage the electricity;
4. There are three forms of rent available:
    4.1. Rental Model: Customers agree to the installation and receive an initial rental fee from the DSO.
    4.2. Shared Model (70% and 30%): Customers and the DSO will share a portion of their income.
    4.3. Guaranteed Saving: Customers and DSOs will share a portion of their income but receive unique options that can guarantee the selling price of electricity, such as in the form of Solar City (a subsidiary company of Tesla).

The steps of the operation are as follows: the DSO provides consultation on design and installation on site, the customer agrees and signs the DSO's electricity purchase, the company designs the appropriate installation and size for the customer, the DSO arranges all of the systems for generating electricity, and the customers receive a discount on the electricity price or a share of the income. When the contract expires, customers can remove the system without cost or can extend to a long-term contract.

Model 4: Power Purchase Agreement (PPA)

The characteristics of this business are as follows:

1. This is the same business as Business model 1 or 2 but adds the DSO's investment.
2. The DSO will invest wholly into solar rooftop systems by renting the roof space of private buildings and managing the electricity by selling it to the public, or the DSO will offer a lower electricity rate.

3. The homeowner or building owner will receive a rental fee from the DSO, and the DSO will manage the electricity for them.
4. There are two forms of business activities available:
    4.1. Shared Model (70% and 30%): Customers and the DSO will share a portion of their income.
    4.2. Guaranteed Saving: Customers and DSOs will share a portion of their income but receive unique options that can guarantee the selling price of electricity and the amount of electricity generation from solar rooftops.

The operation steps work for different installation sizes and customers, such as private businesses, real estate factories, etc.

2.3. RaaS Customer Sector

In this study, we start by analyzing the trustworthiness of the installation of a solar rooftop investment for each type of energy user for the purposes of assessing the motivation to invest. This is achieved by analyzing four groups of electricity users, similar to the study of Okur et al., in the residential and commercial sectors [28]:

Residential installations use the electricity in residential homes, including temples, monasteries, the religious establishments of all religions, and related areas, by connecting through a single electrical meter.

Small business (S) installations consume electricity from small businesses such as businesses combined with residential homes, industries, government agencies, any offices, any government agencies, local government organizations, state enterprises, embassies, offices of foreign government agencies, and offices of international organizations or others. This also includes related areas that have a maximum average power demand in 15 min, which is less than 30 kilowatts (kW) when connected through a single electricity meter.

Medium business (M) installations use the electricity from more significant businesses, such as in industry, government agencies, offices or any other government agencies, local government organizations, state enterprises, embassies, offices of foreign government agencies, and offices of international organizations. This also includes related areas that have an average power demand for electricity at any given time from 30 kW to 1000 kW in 15 min, and which have an average electric power consumption that does not exceed 250,000 kWh per month over the last 3 months by connecting through a single electrical meter.

Large business (L) installations use the electricity from large companies such as in industry, government agencies, offices or any other government agencies, local government organizations, state enterprises, embassies, offices of foreign government agencies, and offices of international organizations. This also includes related areas that have a maximum average power demand at any time of 1000 kW in 15 min, or at least have an average electrical energy consumption of 250,000 kWh per month over the last 3 months by connecting through a single electrical meter.

3. Business Perspective Analysis

We analyze the RaaS business perspective in order to provide a perspective for DSOs to proceed with concrete operations. We use different analytical methods, starting with SWOT—strengths, weaknesses, opportunities, and threats—to create a broader perspective of corporate executives. Then, we conduct the Five Forces analysis of business pressures followed by a marketing analysis of products, prices, customers, and promotions. Finally, an economic analysis is performed to determine the impact of competition in the current market.

3.1. SWOT Analysis

SWOT analysis is a tool for evaluating situations for business operations. This helps the management to know the strengths and weaknesses of the internal environment and see opportunities and obstacles from the external environment—the impact on all types of business operations. The way through which to conduct business is to run a SWOT analysis. Table 2 presents the results for all four types of business models and emphasizes (as per the view of DSO) each business in parentheses.

Table 2. SWOT analysis for other business models.

Issues	Strength	Weakness	Opportunity	Threat
Stakeholders /services	• The DSO should have existing customers with electricity usage data. They can then use this information to help further competitors in quickly introducing customers to new services. • The DSO has a database of electricity customers that is useful for selecting customers quickly, and it can help with rapidly taking care of after services with customers. • The DSO has a good relationship with government agencies and state enterprises. Therefore, the process of requesting and approval of installation by the agency may be more convenient. • (Model 3) Customers do not waste time and resources with solar rooftop systems but, instead, obtain more rent for increased revenue in rental model systems.	• Customers can directly contact this consulting company (if the government does not require only the DSO to operate the business). The DSO must run the business to focus on service, and the price must be able to compete with competitors. • The DSO may compete directly with companies like this. However, it may not be compelling enough to compete with private companies due to many legal limitations. • Larger organizations will cause the work to be delayed. The adjustment strategies may be postponed because they must undergo many consideration steps. • Internal political problems may occur, such as the overall procurement cost being more than the private sector's.	• The government and the Ministry of Energy can make more connections and obtain a greater understanding of people and entrepreneurs for business growth. • To ease the burden of importing energy in other forms from abroad, customers can use the energy generated as a carbon credit through which to reduce tax payments or future income that the government or the DSO may wish to support. • Models 2, 3, and 4 are capable of being implemented in the same format. They can be connected to the parallel wires of many buildings, and they all involve installing a separate meter. This model can be applied to shops or other government offices. • Model 3 customers have more installation demand because they do not have to invest alone and do not have enough funds to install alone.	• Currently, many service providers in this field in Thailand can enter the competition at any time. • Electrical outlets across the country in several areas can join together to form a solar cell management company, and they would then be able to compete with the DSO. • Model 3 customers can contact the consulting firm directly. Therefore, the DSO must focus on a service-oriented approach, where the price must be able to compete with competitors. This would include paying attention to more sensitive services.
Finance and accounting	• The DSO has relatively high yearly profits and can support this business quickly. • The loan of the DSO is a state enterprise; as such, it has a lower cost of capital than its competitors. • For Models 3 and 4, the DSO has the capital advantage and the profits from selling electricity each year; as such, it can quickly bring this part forward for investment. • For Model 4, the DSO does not need to invest much money because the landlord or business owner will be involved. • For Model 4, the DSO can negotiate investments from various financial institutions instead of spending the investments from the DSO unilaterally in a large number of arrangements. In addition, as it is a state enterprise, it will also receive lower investment loans than other companies.	• The DSO cannot set up the installation price but the outsourcing company still has to compete on price with other companies. The DSO will open for annual procurement for the price of customer service. • For Models 3 and 4, the DSO requires a significant investment; therefore, the organization must have good liquidity management. However, the DSO still has experience in liquidity management each year, mainly in the form of collecting electricity bills. • For Model 4, the DSO requires a certain amount of investment from the homeowner or business owner; the DSO should control good liquidity management in the organization and use this benefit for other investments with higher returns.	• Governments can support the initiative by encouraging people and private sectors to install solar PV rooftops, such as, for example, through incentive tax, etc. • For Models 3 and 4, the DSO should negotiate investments with various financial institutions instead of investing the money from the DSO itself. A large number of investments might be accepted as a better investment option. • For Model 4, the DSO can contact more customers because there is no need to invest 100% in each investment. This makes it possible to expand the installation to many places. • For Model 3, those with a guaranteed income will favor customers that are afraid of risk and have a low income.	• The price of installation equipment and tools is falling rapidly, including the lower price of batteries; as such, even more companies will provide this service than ever before. Still, this will affect the sales and profit of the company.

Table 2. *Cont.*

Issues	Strength	Weakness	Opportunity	Threat
Technical/ tools/ equipment/ location	• Setting up this business as an intermediary so that the DSO does not have to bear the burden of various assets will allow the DSO to focus on its service and acquiring customers by issuing incentive programs. • The DSO already has branches that accept electricity bills and services, which is an advantage over its competitors in making contact with customers easier. • For Models 2, 3, and 4, the DSO has an advantage in transportation and logistics for handling equipment.	• The limitation of state enterprise is that it cannot improve research and development, nor can it truly compete with the private sector. • For Model 2, the DSO has to bear the burden of too many technical personnel. It may even run out of personnel if there are technicians in various fields and there is good management. • For Models 2, 3, and 4, the DSO bears the burden of acquiring the assets required for solar rooftop installation.	• Opening a consulting business is to make the company's internal personnel know and understand solar energy and its installation. • Instead of the DSO installing cables and networks far away, the DSO can apply a solar rooftop system that is mixed with batteries to reduce the budget.	• In the case of industry saturation, data and information will have reached a standard point. As a result, installation instructions may no longer be required, and various electrical companies or department stores nationwide may take care of it directly. • For Model 2, the cost of equipment and installation tools will reduce rapidly, including lower prices for batteries. More companies provide this service. Therefore, it can affect the sales and profit of each company. • There are new technologies that will have a significant impact on businesses.
Others	• The DSO will have an economy of scale advantage.	• (Model 3,4) The DSO is a disadvantaged state enterprise due to legal restrictions on business operations, capital allocation, and fundraising.	• This is a source for building good relationships between the organization and the public and private sectors to preserve the environment, which is an approach to CSR.	

Stakeholders/Services: DSOs have a good relationship with government agencies and state enterprises. Therefore, the process of requesting and obtaining approval for installations from the agency may be more convenient.

Finance and Accounting: The loans from the DSO are a state enterprise; as such, they have a lower capital cost than their competitors. The DSO can negotiate investments from various financial institutions instead of spending the investment from the DSO unilaterally in a large number of arrangements. In addition, it is also a state enterprise that will receive lower investment loans than other companies.

Technical/Tools/Equipment/Location: Instead of the DSO installing cables and networks far away, the DSO can apply a solar rooftop system that is mixed with batteries to reduce the budget. The DSO has an advantage in transportation and logistics for handling equipment.

The RaaS approach for prosumers or self-consumption residential consumers initially shows the business possibility of a valuable public benefit with a regulatory and an operational framework. Customers are confident in the standards, and they trust in the organization of a state enterprise. Models 3 and 4 represent the high value of the DSO in terms of strength and opportunities. It is necessary to make adjustments with the stakeholders involved to have confidence in the potential of self-consumption as a total advantage.

3.2. Five Forces Analysis

The Five Forces from factors affecting all five areas will help entrepreneurs decide how to plan their business strategies. For new businesses, it can be used to help decide whether it is worth entering that market or not. The analysis of the Five Forces of each business is detailed in Table 3, in which the forces that affect these four types of business operations is expanded on. These Five Forces are the threats of new competitors, new entrants, replacing products and substitutes, the bargaining power of customers, and the bargaining power of suppliers in industry rivalries.

Table 3. Five Forces analysis for the four business perspectives.

Detail	Model 1	Model 2	Model 3	Model 4
The threat of new entrants	High Low investment, easy to apply	Medium Many people accept installation, but there are still reliability issues.	Low Requirement of investment and reliability	Low Requirement of investment and reliability
Threat of substitutes	High Able to study by yourself on the Internet, such as on YouTube	High Homeowners could hire a mechanic to install the system, or they could install it themselves.	Medium Able to combine two platforms for bank loans to invest	Medium Able to combine two platforms for bank loans to invest
Bargaining power of customers	Low Many customers	Low Many customers	High Some large customers can invest by themselves because there is enough capital.	High Some large customers can invest by themselves because there is enough capital.
Bargaining power of suppliers	Medium There are not many panel vendors from abroad, but, equally, there are not too few.	Medium There are not many panel vendors from abroad, but, equally, there not too few.	Low A few panel vendors are from abroad, but they can buy in significant numbers.	Low A few panel vendors are from abroad, but they can buy in significant numbers.
Industry rivalry	Medium/High Currently, there are many competitors in the consultation and installation business.	Medium Currently, there are many competitors in the consultation and installation business.	Low There are many competitors in the consultation and installation business, as well as little investment.	Low There are many competitors in the consultation and installation business, as well as little investment.

In Business Model 1, there are various worrying forces such as businesses with low investment, various new competitors that can easily enter the market, and customers that can obtain knowledge from mixed media on the Internet. Competition from current competitors is also essential due to the large number of consulting firms in Thailand, of which electrical companies can advise on installing solar PV panels.

In Business Model 2, the most worrying factor is the customer's ability to hire technicians to install the system independently without using DSO services, which may be cheaper and more efficient. Several companies can represent this business and bargain with the supplier to force the DSO into cheaper costs; however, most of the suppliers are abroad, and there is only a small degree of bargaining that is possible with the DSO.

In Business Models 3 and 4, there will be a strong customer bargaining power, as ascertained from the calculation. Large-scale customers are important customers who will invest in installing solar PV panels. They can install the panels themselves without investment from the DSO, which makes the customer's bargaining relatively high.

3.3. 4P Marketing Analysis

The goal of 4P is for businesses to know more about their products and what customers need. Is the price set appropriate for the customer group? Which type of marketing channel is the most effective when compared to the target group, or can it compete with other players more or less? As a business operation, the triumphant factor in marketing consists of integrating the product, price, place, and promotion. With respect to this, all four business models have a 4P marketing strategy at every step. Table 4 shows the analysis that the 4Ps applied to all four types of RaaS models, and they are highlighted for each in parentheses. The DSO, for example, requires efficient and inexpensive solar PV modules. Regarding the stimulation market, the agency should present to people the feasibility of installing solar PV systems. Regarding cost, the DSO can add on a premium as a government organization, and charging this is possible by positioning the business to focus on high-quality installation and service, as well as being more reliable than other companies.

Table 4. The 4P analysis for the different types of businesses.

Product	Price	Place	Promotion
• As people are aware of saving money, they should choose solar PV modules that are efficient and inexpensive. • There are characteristics and criteria for selecting suppliers systematically and in a standardized fashion; for example, Solar City will only select suppliers with more durable equipment, i.e., 2–3 times more than the general standard (i.e., a lifetime of 35 years compared to the general standard of about 25 years). • Personnel must be allocated to inspect the system every year. • Personnel must be allocated to inspect the supplier monthly based on random inspection methods. • Solar rooftop designs must be able to withstand extreme weather conditions.	• Due to the customer's confidence in the DSO, we can charge the market price plus the DSO premium. • There is a dynamic pricing management system that adjusts to the prices of the various equipment.	• For Models 1 and 2, the DSO branches for bill payments should be able to provide services and increase the responsibility of each branch to contact customers for prospective solar PV rooftop installations. • For Models 3 and 4, there will be special training to develop the staff to find customers instead of having customers come into contact with the DSO of their own accord. • Utilizing various social media for public relations and Q&A, such as a Facebook page, Instagram profile, a website, and customer service, which may use artificial-intelligence Q&A systems to help save employees time in the future. • Using the existing database to contact customers now.	• Solar rooftop systems must be guaranteed for at least 10 years to build customer confidence. • The sales promotion with current electricity, such as the more you pay for your electricity bill, the more you will receive in terms of a discount on installation. • Publicize various promotions through government media such as government offices, brochures, and websites, or through requesting an official letter. • As per the ESCO model, an aggressive style will be used to approach large-scale customers regarding installation, investment, and payment methods. • As the solar PV rooftop is environmentally protected, the government should set promotions for tax incentives for customers in another way.
Positioning Setting up a company that offers consulting services, installation, and maintenance for solar PV rooftops with a higher expertise and more reliability than competitors.			

As an example of a service location, the DSO can use the current billing branch to provide services for installing solar PV modules by allowing employees in each branch to have more responsibilities. In this way, they can save on the budget and the building branches' investments so as to provide new services. As for the promotion example, the DSO should have a warranty for customers to use solar PV modules for 10 years in order to give customers the confidence to invest in electricity generation from solar PV energy.

3.4. Economic Analysis and Impacts on Society

An economic analysis using game theory for RaaS operations is conducted. Currently, 5–10 large competing companies are operating in the solar energy business. Therefore, a competitive financial analysis is performed using game theory. This is appropriate due to the assumptions that each company has to compete to make the most profit from business operations and that they must be able to estimate the number of customers who will use their service (Q), as well as the appropriate price (P). In this analysis, the Cournot Competition format is used with the following requirements:

The profit function for each company contains each company's revenue subtracted by the cost of each company, which will give the exact marginal cost.

$$\Pi_i = P(Q) * q_i - c_i(q_i) \forall i \tag{1}$$

Here, Π_i is the profit of company i, P is the price paid by the recipient of services, q_i is the number of services provided by company i, and $c_i(q_i)$ is the production cost of company i (which depends on the company's production). The cost function for this is as follows:

$$c_i(q_i) = cq_i \ \forall i \tag{2}$$

The demand function can be written as:

$$P(Q) = a - bQ \tag{3}$$

where aggregate production comes from the supply of each company, for a total of N companies.

$$Q = \Sigma_{i=1}^{N} q_i \tag{4}$$

The first-order condition of each company is to find the q_i that will make the highest profit:

$$\begin{array}{c} \frac{\partial \Pi_i}{\partial q_i} = \frac{\delta\left\{\left(a - b\Sigma_{j=1}^{N} q_j\right) * q_i - c_i q_i\right\}}{\delta q_i} = 0 \ \forall i \\ a - b\Sigma_{j=1}^{N} q_j - bq_i = 0 \ \forall i \end{array} \tag{5}$$

Then, the N equations can be solved for every i. Thus, the number of services that each company will provide is obtained as follows:

$$q_i = \frac{a - c}{b(N+1)} \ \forall i, \tag{6}$$

where we can change the variables a, b, c, and N, and we will be able to know by how much the average number of electricity users changes. As such, the price can be summarized as

$$p = \frac{a + Nc}{N+1} \tag{7}$$

The profit of each company is

$$\Pi_i = \left(\frac{a - c}{N+1}\right)^2 \left(\frac{1}{b}\right) \forall i \tag{8}$$

The total number of electricity users is expressed as follows:

$$Q = q_i N = \frac{(a - c)N}{b(N+1)} \tag{9}$$

This can be performed roughly for every section using this model, or we can use it separately for each market share. The conditions of demand and supply for each market share may vary. We can find each market's price and usage volumes using the Cournot

Competition analysis technique. According to this analysis, there will be three significant competitors to the DSO. The details are presented in Table 5. The results of the analysis show that the profits earned in each customer group will significantly differ and affect the business' income if there are insufficient customers. The analysis results also show gaps and opportunities for the business if it can reduce costs and increase service formats. Customers in the large commercial sector should be potential target groups based on the market size of over a million systems. The difference between the average cost per kW, price system cost, and market price is a gap in which the electricity utility can add different services and incentives by charging reasonable service fees as an option. Teng Zhong et al. [29] showed the potential of city-scale rooftops, which reduce the labor cost through deep learning with the proposed spatial optimization sampling strategy. Dong's [30] research showed that machine learning can reduce customer acquisition costs by 15% (USD 0.07/Watt), and they identified new market opportunities for solar companies to expand and diversify their customer bases. Soft costs and customer acquisition costs are notoriously difficult to reduce due to the challenges in predicting forthcoming events.

Table 5. The price and quantity of solar rooftop installations.

	Residential	S	M	L	Description
N	3	3	3	3	
A	45,000.00	40,000.00	35,000.00	45,000.00	A price where no one installs PV at all (THB/kW)
Max. #	2,500,000.00	2,500,000.00	7,500,000.00	6,500,000.00	Maximum number of PV cus-tomers required to install
B	0.01800	0.01600	0.00467	0.00692	The maximum number of PV installations
C	29,387.42	25,000.00	32,201.99	31,705.30	Average cost per kW
Profit	846,363,684.40	878,906,250.00	104,851,046.24	1,595,651,605.50	Total benefit of each company (THB)
Price	33,290.56	28,750.00	32,901.49	35,028.97	Price in equilibrium (THB/kW)
Quantity	216,841.43	234,375.00	149,893.57	480,086.46	Quantity that each company will install
Total Q	650,524.28	703,125.00	449,680.70	1,440,259.38	Number of systems for the entire market

The exchange rate is about USD 1 = 35.69 THB.

4. Conclusions

The investment price per unit for solar PV rooftop systems is cheaper than using electricity from the grid. This represents a crisis for electricity utility companies if their customers rely on their energy, thereby resulting in the company losing income. Thailand's residential and commercial solar rooftops continue to increase in number. The DSO's adaptation to the RaaS perspective will create strategic business opportunities. Electricity utility companies must adapt by implementing RaaS businesses to customers with confidence against the DSO. The SWOT analysis reveals that ESCO and PPA are strengths in the DSO's performance characteristics and existing customer data. In the electricity industry, both models offer enormous customer bargaining power in terms of a Five Forces analysis. This is because there has begun to be intense competition in the installation of these systems. In addition, the Five Forces analysis and economic analysis also show that competition is starting to increase. The best Five Forces analysis results are those of the ESCO and PPA models. In the 4P analysis, the price per unit is found to be significantly lower than in residential scenarios. Therefore, there is a format for presenting promotions with an advantage over competitors. The DSO should deploy an after-sale service that provides convenience to all customer segments. The DSO should apply technology such as machine learning to

reduce costs. Finally, the economic analysis conducted using Cournot Competition game theory shows a significant differential in the M and L customer sectors' competition due to lower technology prices. Business competitors have increased; therefore, the average installation price should not exceed 30,000 THB/kW (USD 840/kW), where there is over a million customers.

In summary, from a business perspective, it can be seen that only the ESCO and PPA models have had a net positive impact on DSO revenue. However, both forms require a large amount of investment every year. Therefore, deciding on the appropriate business model for the DSO should be considered from several perspectives simultaneously, and this includes net income (which is expected to increase). The amount of money required to invest, the possibility of financing, and the ability to control management efficiency will also be key parameters to assess.

Further studies should focus on new energy technology supply services such as battery energy storage add-ons with solar PV rooftops and electric vehicle charging for residential and commercial sectors. A bundle service package may increase the DSO's competitiveness and income. With this new business perspective, DSOs can maintain their status in the power market and play a significant role in the country's clean energy ecosystem.

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