Study of Economic Viability of Floating Photovoltaic Electric Power in Indonesia

A A Untoro[1] , T Gunawan[1] , B D Hidayanto[1] , F A Perkasa[1] and A A Wijaya[1]

[1] Pembangkitan Jawa Bali Company (PT. PJB) Unit Pengembangan Usaha dan Pembangunan Bidakara Tower 2,16th Floor Jl Jendral Gatot Subroto Kav. 71 – 73 Pancoran South Jakarta 12870 Indonesia

Abstract. The government has already set target for utilisation of renewable energy to be achieved are at least 23% in 2025 and 31% in 2050. This study assess the feasibility of the implementation utility scale Floating Solar PV in Indonesia based on technical and economic perspective. The analysis focused on the assessment of solar irradiation data, modul efficiency to project electric production, followed by economic analysis on the parameter of the interest rate, debt to equity ratio, electric production, EPC Cost. In Indonesia, there is also incentives which are regulated to promote the infrastructure investment including renewable energy which are tax holiday, import tax exemption which can reduce the tariff. The investigation show that the effect the interest rate, debt to equity ratio, EPC Cost to the tariff and effect the incentive which are the tax holiday, import tax exemption to the tariff. which are evaluated for each area based on on assessment energy yield projection and dam identification to be compared to electrical generation cost (BPP Local and BPP National) where based on the simulation the electricity tariff of Floating Solar PV (4.9 – 5.8 cUSD/kWh) in each province is below the BPP

Key Words: Floating Solar PV, Renewable Energy, BPP Local, BPP National, incentive, EPC, debt to equity ratio, energy yield projection

1. Introduction

The government has already set a regulation at electricity sector, specifically on Law No.30 of 2009, that the primary energy sources either local or abroad should be used optimally as to provide sustainable electricity. Based on government regulation No.79/2014 regarding Nationality Energy Policy that the target for utilisation of renewable energy to be achieved are at least 23% in 2025 and 31% in 2050 which is then implemented in Electric Supply Business Plan 2019 – 2028 of the Indonesian state-owned power utility firm, PT PLN (Persero). For that purpose, PLN with the government support as governed in the Ministry of Energy and Mineral Resources Regulation No. 50 of 2017, is obliged to buy the electricity from power plants that utilize renewable energy sources with the regulated tariff, if electricity generation cost in the local electricity system (BPP Local) is higher than national electricity generation cost (BPP National), then the maximum tariff shall be 85% from BPP Local, but if the BPP Local is same or below BPP National then the price shall be based on an agreement of the parties. This tariff scheme is implemented to avoid the increase of electricity generation cost due to renewable energy implementation [1].

In 2019, the realization of renewable energy only reach 8,55% from the target 23% in 2025. The realization of new power plant from renewable energy is 9.5 Gigawatts (GW) or only 2.15% of the total potential of renewable energy in Indonesia, which is estimated to reach 442 GW where the solar energy is the highest potency in Indonesia. It is estimated to reach 207.8 GWp but only 0.15 GWp which has been installed [2].

Table 1. Renewable Energy Potency

No	Type	Potency	Realization
1	Geothermal	25.4 GW	1.949 GW
2	Bioenergy	32.6 GW	1.859 GW
3	Solar	207.8 GWp	0.15 GWp
4	Hydro	94.3 GW	5.42 GW
5	Wind	60.6 GW	0.076 GW
6	Tidal	17.9 GW	-

The transition from conventional fossil energy to renewable energy is driven not only by economical factor but also several other factors such as rapidly falling renewable energy capital costs, technical suitability, and concerns around the climate change and local pollution. Also, over the last ten years, project finance has become increasingly popular in the renewables energy sector [3]

It is noticed that due to its sustainability and ubiquity, solar photovoltaic is considered to be one of the most promising renewable energy to provide economical and sustainable electricity. In 2019, the implementation of solar PV in Indonesia is majorly dominated by ground – mounted solar PV system which reach 91% and 9% of rooftop PV, but currently there is the development of the Indonesia's first floating PV in Cirata, West Java, with capacity 145 MW, is scheduled to be operated in 2022 [4]. In addition, the implementation of Solar PV show that the Mexico, UEA and Brazil achieve lowest tariff from the utility scale above 100 MW [5].

Since, utility scale ground – mounted solar PV system require large area and land acquisition has been a major obstacle to the economic development in Indonesia, cause the delay of the infrastructure projects for years [6]. Therefore, the Floating Solar PV system could be an alternative solution to increase the utilization of utility scale of solar energy as it is not dependent on the land availability, because it is installed on the water surface. As the Floating Solar PV cover the water surface, it will reduce the sunlight which lead to reduction of water operation losses and algae growth [7] [8].

In addition, the ambient temperature in open water surface tend to be lower and the wind speed is higher than in the land, those could reduce the operating temperature of the PV cell which lead to improvement of Floating Solar PV systems efficiency to 10% compared to ground-mounted solar PV systems [9]. Also, the Floating Solar PV are less dust compared to ground – mounted solar PV since the wind in the water surface contain less dust [10]. It is also noticed that, between floating solar PV and hydroelectric power plants could be a complementary operation [11].

2. Data and Method

Based on economic analysis conducted conducted by A P and Kyung Nam Kim on floating solar PV system with capacity 1 MW that the tariff on floating PV in Indonesia is 12,374 cUSD/kWh with an IRR value of 14% and 9.986 cUSD/kWh with an IRR value of 8% [14]. Considering the lower tarif could be achieved by the development of the utility scale Floating Solar PV system above 100 MW and incentive the government could be granted, then this paper focused on the economic analysis based on the recent financial parameter and recent PPA of Floating Solar PV System in Indonesia, include the fiscal facility from Indonesia's related government stakeholder.

2.1. Dam dan Solar Energy Potential in Indonesia

Indonesia is an archipelago country. This fact is supported with the majority area in Indonesia is mainly water surface, since sea took up larger portion than the land on this country. Indonesia also has many fresh water sources located in the lands, that can be used as hydroelectric reservoir, the lakes

and irrigation ponds and irrigation. This water surface became potential factors that can be used as a media for Floating Solar PV. As found on database from Ministry of Public Work and Public Housing, Water Resources Directorate there are 65 operating and under construction dams and there is also a potential in reaching up to 220 dams.

Based on the Indonesia Solar Energy Potential Map from Ministry of Energy and Mineral Resources, the solar radiation in Indonesia is ranging from 2.81 to 5.27 kWh/m2/day with energy potency applies to Indonesia land cover areas reach 3,550 GW. As to optimise the utilisation of dam in Indonesia by introducing the floating solar PV, the solar energy potential assessment is conducted from NASA Database for each dam which has surface area more than 100 ha to implement floating photovoltaic power plant with capacity more than 100 MW, where there are 12 dam which has been operated and its surface area is more than 100 ha, which is grouped into province as shown in Table 2. However, the assessment could also to be conducted in hydroelectric reservoir, lake of coal mine, etc.

Table 2. Solar Irradiation Potency

No	Province	Irradiation (kWh/m2/day)
1	East Java	5,26-5,37
2	West Java	4,76
3	Central Java	4,6-4,8
4	South Sulawesi	5,87
5	East Nusa Tenggara	5,76-5,92
6	Bali	5,37

2.2. Incentives

Ministry of Finance issued tax holiday regulation No 150/PMK.010/2018 to promote the infrastructure investment in Indonesia, where tax payer which categorized as pionner industries that have broad link, provide added value and high externalities, introduce new technologies and have strategic value for the national economy, thus the tax payer could be given a facility for reducing Corporate Income Tax. This regulation govern the category for the facility with minimum new investment shall be at least one hundred billion rupiah, as stipulated from the Table 3.

Table 3. Summary Tax Holiday Incentive

No	Item	Description
1	The deduction of Corporate Income Tax	a. In the amount of 100% of total corporate income tax owed for new investment with a value of at least five hundred bullion rupiah. b. In the amount of 50% of total corporate income tax owed for new investment with a value of at least one hundred bullion rupiah and at most less than five hundred billion rupiah
2	The period for reducing Corporate Income Tax	a. For five tax years for investment with and investment plan at least five hundred billion rupiah and less than one trillion rupiah b. For seven tax years for investment with and investment plan at least one trillion rupiah rupiah and less than five trillion rupiah c. For ten tax years for investment with and investment plan at least five trillion rupiah rupiah and less than fifteen trillion rupiah d. For fifteen tax years for investment with and investment plan at least fifteen trillion rupiah rupiah and less than thirty trillion rupiah e. For twenty tax years for investment with and investment plan at least thirty trillion rupiah rupiah

In addition to tax holiday incentives, the Indonesia government also grant import duty and tax exemption, the importation of good relating to electricity equipment will generally be subject to import duty at the rate range between 5% to 15%, import VAT of 10% and Income Tax Article 22 ("PPh 22") of 2,5%. The exemption facilities for the duty and taxes may be available but subject to approval of related government stakeholder.

2.3. Method

This paper focused on the economic viability of floating photovoltaic with capacity more than 100 MW. The economic analysis consider three aspect, firstly, technical aspect, related to the solar potency to produce electricity which mainly affected by the site due to geographic condition. Second, the economic parameter which establish tariff such as EPC Cost, Interest rate and Debt to Equity Ratio. Lastly, the incentive that government grant such as tax holiday, tax and import duty exemption. The result of tariff from the calculation to be compared with BPP in every province as already stated in Ministry of Energy and Mineral Resources Decree.

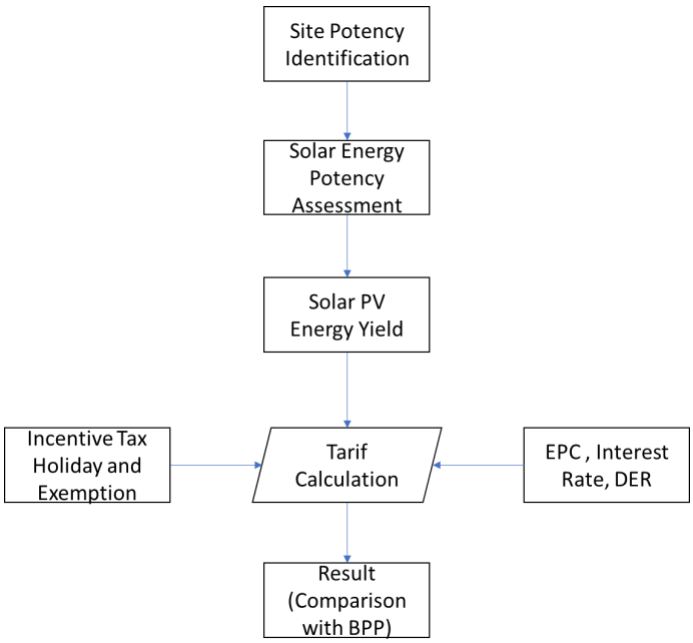

Figure 1. Method

3. Result and Discussion

3.1. Assessment of Financial Parameter

There are two type of PV systems which are ground-mounted or floating system where the difference between both are the structure which are highly site specific, specifically the Floating Solar PV which has the floater and anchoring and mooring system. In addition, the insulation and shielding properties of DC cables is provided to avoid moisture degradation, therefore capital expenditure will increase compared to the ground-mounted PV. In 2018, the capital expenditure for large scale Floating PV systems ranged between $0.7 and $0.8 per watt-peak, it will depend on the location, depth, variation, and size [11]. Furthermore, In India, referring to the tender conducted in 2018 of the first large scale Floating PV plant, Kayamkulam phase II, with capacity 70 MW, the cost reach $ 0,499 and $ 0,55 per watt-peak with the assumption of 1 USD is INR 70.09 [12]. At present, this cost could be the lowest tariff in the world. The low costs in India may be caused by some factors, for instance the decrease of floaters cost because manufacturing process improvement, the reduction of material cost and thickness of floater. It also noticed that competitive bidding by project developers also affect the low cost. In

Indonesia, based on the proposal for the floating solar PV Project with capacity 145 MW in 2019, the capital expenditure reach 0,6 per watt-peak

Table 4. Assumption of Financial Parameter

No	Item	Value	Unit
1	PPA Term	25	years
2	Interest Rate	LIBOR + 2.7	%
3	Tenor	16	years
4	DER	80:20	%
5	Discount Rate	10	%

Based on the tariff simulation, with the assumption as shown in Table 4, it concluded that the tariff, referring to the recent EPC Cost Price for Floating Solar PV Power Plant, is almost at 5.1 – 7.3 cUSD/kWh

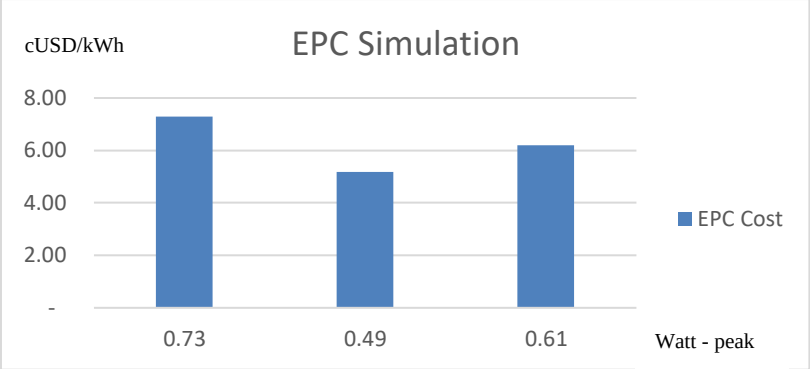

Figure 2. Tariff Simulation EPC Cost

Beside the EPC Cost, in financing sector, it is noticed that the risk perception which has been reduced along with maturing market, will improve availability and project debt finance pricing as the share debt increase for solar PV, with more 75 : 25 structures and even the ratios 80 : 20 could be achieved [13]. As shown in Figure 3 below, it is notice that due to more debt to finance the Project could lead to tariff reduction as the cost of debt is less than cost of equity where the tarif can reduce up to 0.5 cUSD/kWh when the debt portion raise from 70 to 80, with the assumption of capital expenditure 0,6 per watt-peak.

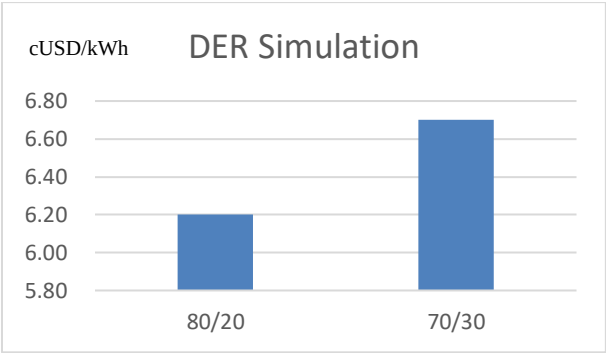

Figure 3. Tariff Simulation on DER

3.2. Incentives

Based on regulation in the Table 3 regarding the implementation of tax holiday, the investment cost of floating PV with capacity is more than 100 MW is categorized as investment with and investment plan at least one trillion rupiah rupiah and less than five trillion rupiah then it could get facility to reduce

the period of corporate income tax for seven years in the amount of 100% of total corporate income tax owed because it is categorized as new investment. The reduced of corporate tax cost cause the tariff reduction. As shown in the Picture 4 below, if the project developers is granted the facility by the government, then it reduce the tariff 0.18 cUSD/kWh

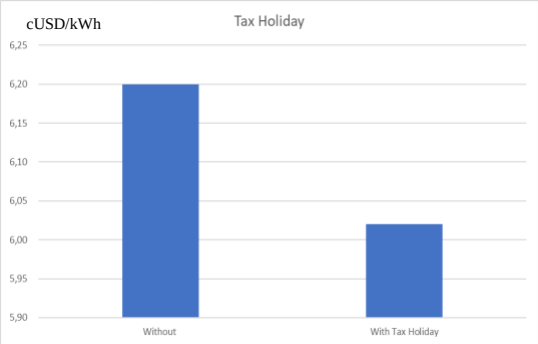

Figure 4. Tax Holiday

In addition, the project developers also could be granted the tax exemption facility for certain freight on board equipment which already governed by the relevant stakeholder of government. Based on the simulation, the exemption facility could reduce the tarif from 6.2 cUSD/kWh to 6.01 cUSD/kWh as shown in the Figure 5, then if the both facility implemented then it could reduce the tariff from 6.2 c USD/kWh to 5.8 c USD/kWh as shown in the Figure 6.

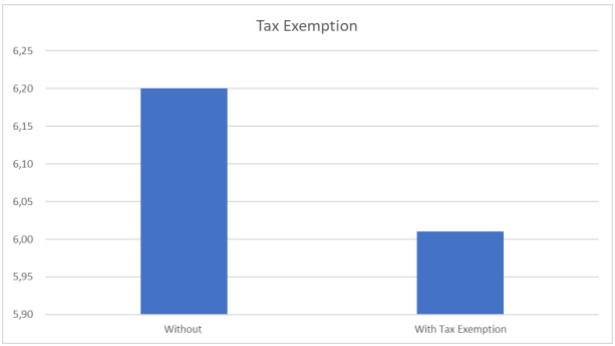

Figure 5. Tax Exemption

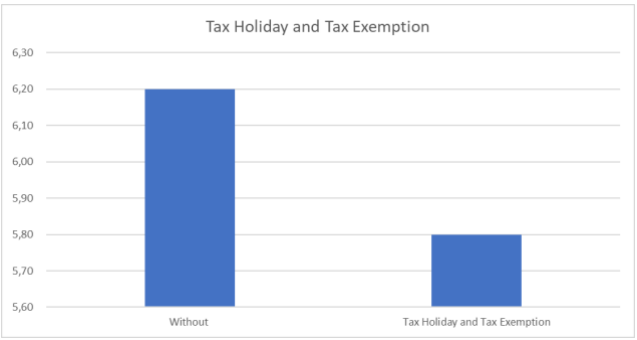

Figure 6. Tax Holiday and Tax Exemption

3.3. Energy Yield Projection

Based on the solar irradiation data provided in Table 1, the calculation is conducted to estimate the yearly total electric production of floating photovoltaic power plant for each location. It is notice that location which has higher solar irradiation will produce more energy, where the yearly total electric

production in Sulawesi Selatan, Nusa Tenggara Timur dan Bali has higher total electric production than yearly total electric production in Jawa as shown in Figure 5.

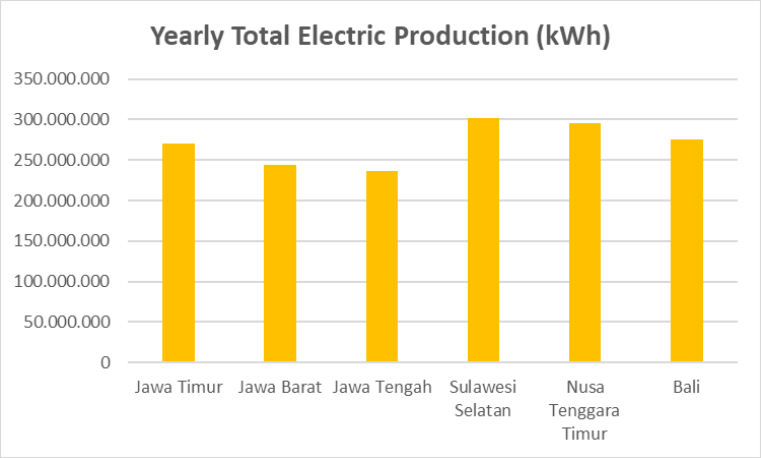

Figure 7. Yearly Total Electric Production

Furthermore, the electricity tariff would be different related to solar irradiation in each location. The cheaper tarif is obtained for the location which has higher yearly total electric production, mainly Sulawesi Selatan, Nusa Tenggara Timur and Bali. In addition, based on simulation in Jawa Barat, the tarif could achieved 5.8 cUSD/kWh but in the area which has highest energy yield projection the tariff could reach 4.9 cUSD/kWh

3.4. Comparison with BPP

PLN as a buyer to electricity, produced by project developers, intend to do efficiency by reducing the Cost of Electricity Supply (BPP). Furthermore, Ministry Energy and Mineral Resources already issue the Decree every year to update the Cost of Electricity Supply (BPP). In terms of economic perspective, the electricity tariff below BPP could be considered by PLN to implement the Floating PV as it will achieved the target energy mix as introduced by the Government and at the same time to reduce BPP.

Based on the simulation the electricity tarif of Floating PV (4.9 – 5.8 cUSD/kWh) is below the BPP. It is noticed that the development of Floating PV in utility scale shall be considered as part of effort to accelerate the achievement of the energy mix and to reduce the investment cost.

4. Conclusions

Based on the simulation tariff of Floating Solar PV, it is noticed that the tariff could reach (4.9 – 5.8 cUSD/kWh) consider the recent EPC price, DER and incentive that could be granted by the Government where the incentive from government could reduce tariff 0.4 c USD/kWh. It it noticed that the resulted tariff is below the BPP, then by implementing utility scale of Floating Solar PV, it will achieve the energy mix target and also to reduce the investment cost of Floating Solar PV. It is recommended to do further studies related to the demand, the electricity system in each area to make prioritization Floating Solar PV development not only in economic perspective but also technical perspective.

5. References

[1] Electric Supply Business Plan 2019 – 2028 (Indonesia: PT PLN (Persero))
[2] National Energy Policy of Renewable Energy and Energy Conservation 2019 (Indonesia: Ministry Energy and Mineral Resources))

[3] Joel K Rahmatallah P Danny H 2018 Renewable Eletricity Finance in resources rich countries of the Middle East and North Africa : A case study on the Gulf Cooperation Council (Energy)
[4] Policy Regulation and Initiative of the Solar Energy Development in Indonesia 2019 (Indonesia: Ministry Energy and Mineral Resources))
[5] Pamela S Fabby T 2019 Briefing Paper: Apa yang Membuat Biaya Pembangkitan PLTS Skala Utilitas Bertambah Murah (Indonesia: IESR)
[6] James G 2019 Land Acquisition in Indonesia and Law No. 2 of 2012 Asian Development Bank Institute
[7] Yadav N Gupta M and Sudhakar K 2016 Energy assessment of floating photovoltaic system in 2016 International Conference on Electrical Power and Energy Systems (ICEPES)
[8] Sahu A Yadav and K Sudhakar 2016 Floating photovoltaic power plant: a review. Renew Sustain Energy Rev. 66 (Supplement C): 815–824
[9] Ferrer G Ferrán G Redón S Ferrer G, P Sánchez R Torregrosa S 2013 A New Photovoltaic Floating Cover System for Water Reservoirs Renewable Energy 60:63−70.
[10] Mohit A Sarvesh D 2019 Floating Solar Photovoltaic (FSPV): A Third Pillar to Solar PV Sector (India: The Energy and Resources Institute)
[11] Mohit A Sarvesh D 2019 Floating Solar Photovoltaic (FSPV): A Third Pillar to Solar PV Sector (India: The Energy and Resources Institute)
[12] World Bank Group ESMAP and SERIS 2019 Where Sun Meets Water: Floating Solar Market Report Washington DC: World Bank.
[13] Dutt A, Lucila A and Barath M 2019 *Clean Energy Investment Trends: Evolving Risk Perceptions for India's Grid-Connected Renewable Energy Projects* New Delhi Paris: Council on Energy, Environment and Water International Energy Agency
[14] A P Sukarso K N Kim 2020 Cooling Effect on the Floating Solar PV : Performance and Economic Analysis on the Case of West Java Province in Indonesia (Energies)