The Effectiveness of Indonesia's Feed-in-Tariff Implementation to Improve Business Interest in Renewable Energy Case: The Simulation for Solar Farm in Weh Island (Aceh-Indonesia)

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***Abstract*—The support of the Indonesian government in encouraging the achievement of renewable energy targets is to impose a Feed in Tariff (FiT) rule as a benchmark purchase price through the State Electricity Provider (PLN). The Ministry of Energy and Mineral Resources in 2013 determined that, the FiT for the Aceh region was $ 17 cents, where the highest FiT in Indonesia could reach $ 30 cents. In 2017 a new regulation was issued, in which FiT was set at 85% of regional production costs (BPP). In fact, currently BPP available on Weh Island reach more than Rp. 2,500 / kWh, with an average selling price to the community of Rp. 900, - / kWh. This BPP is more expensive than the price setting by the Government in 2017 of Rp 1,733 / kWh. In measuring the FiT's effectiveness, the evaluation solved based on economic valuation. Simulations were carried out for the capacity of 1 and 5 MW solar farms using 2 different panel components by comparing the prices of FiT BPP determined by the government and BPP in actual conditions. The results showed that, simulations with a capacity of 1 MW, using 85% of the government's BPP, were ineffective and not feasible based on economic calculations. whereas with FiT based on actual BPP, the profit to be achieved is about 42-45% / kwh with return-on-investment capital in the 10th year. The simulation with 5 MW capacity shows an effective and feasible profit if it use the actual BPP condition of the FiT with an effective profit value around 49-56% / kwh.**

***Keywords*—Feed-In-Tariff, Effectiveness, Renewable Energy, Solar Farm.**

I. INTRODUCTION

THE countries gathered in the Association of South East Asian Nations (ASEAN) including Indonesia, have a serious target to increase renewable energy (EBT) as one of the solutions to the energy crisis, where it is expected that the application of the energy mix can increase by 23% in 2025 (IRENA,2016). The study of the use of renewable energy is considered very important, because it is related to future energy needs and also related to environmental issues. Conventional energy such as energy derived from fossils, for example, has a contribution to carbon dioxide (Co2) emissions which greatly affect the earth's environment. Therefore, one of the Indonesian government's support in supporting the renewable energy target is to enact the Feed in Tariff (FiT) regulation as a benchmark for the purchase price of renewable energy (EBT) by the State Electricity Company. (PLN). Feed in tariffs or called "standard offer contract"(Counture et.al, 2010) "advanced renewable tariff"(Paul, 2012) or "renewable energy payments"[4] is related to policies designed to increase investment in renewable energy technologies by offering long-term contracts to renewable energy producers (Conture,2012,2013) Their aim is to provide funding for renewable energy producers, provide certainty and long contracts that help finance renewable energy investments (Conture, 2012).

Table 1.
Cost of production (BPP) for electricity in Aceh (the regulation of the Minister of Energy and Mineral Resources No.1404 in 2017)

Region / Distribution / System / Subsystem	**BPP/kWh (Rp)**	**BPP / kWh (Cent U$/kWh)**
SUMATERA	1.194	8,98
Nort Sumatera		
1. Aceh	1.383	10,40
a. Weh Island	1.733	13,03
b. Simeulue Island	1.817	13,66

Table 2.
The value of *Feed in Tariff* Indonesia

	Rupiah (Rp)	USD ($)
The Regulation in 2013 (in general)	2.329	0,17
	3.425	0,25
	Rupiah (Rp)	USD ($)
	4.110	0,3
The Regulation in 2017 (85% of CoE) (when the CoE of Weh-Aceh = Rp 1.733, -)	1.473	0,11
The Regulation in 2017 (85% of CoE) (real CoE of Weh- Aceh = Rp 2.500,-)	2.100	0,16

In recent years, government regulations related to feed in Tariff have changed twice. The Indonesian Government Regulation on Energy and Mineral Resources in 2013 states, the FiT for the Aceh region is $ 0,17 and can reach $ 0,30 with special conditions set by the government. The next latest regulation in 2017(ESDM regulation,2017), states that the purchase of electricity by the government for renewable energy (EBT), most of the Sun and Wind is 85% of the local BPP. So, to apply renewable energy, subsidies by the government or the tariffs provided by each region will be different. Natural resources available at locations that are used as renewable energy sources, such as potential wind speeds for wind energy systems, solar radiation received by an area for solar energy agriculture, wave power and others.

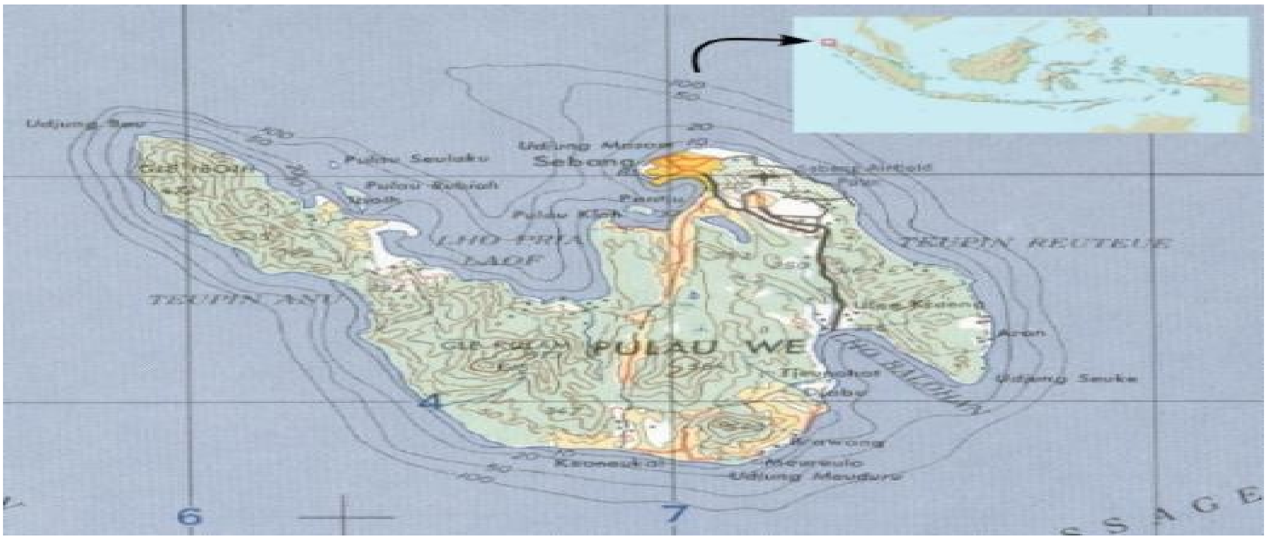

Figure 1. Map of Weh-Aceh Island Location for Solar Farm Planning.

Table 3.
Investment feasibility and% profit effectiveness by implementing FiT for 1 MW solar farm simulations

Decision variabel	Eligibility Indicators	1 MW Mono			1 MW Poly		
E output MWh		1625.2			1581.5		
Investment (Rp)		32,676,529,000			29,495,929,000		
FiT (Rp)		85% of CoE (based of the ministry regulation)	85% of real CoE condition in pulau Weh	General FiT umum applied in Indonesia	85% of CoE (based of the ministry regulation)	85% of real CoE condition in pulau Weh	General FiT umum applied in Indonesia
		1,473	2,100	2,329	1,473	2,100	2,329
CoE (Rp)		273	877	1,097	335	939	1,159
LCoE (Rp)	900	1,200	1,223	1,232	1,138	1,161	1,170
Effectiveness (%)		0.19	0.42	0.47	0.23	0.45	0.50
Present Cost (Rp)		10,447,850,000	31,090,150,000	38,629,360,000	12,282,280,000	32,351,560,000	39,681,510,000
Annual Cost		504,521,800	1,501,329,000	1,865,394,000	593,105,500	1,562,242,000	1,916,201,000
ROI (%)		2.4	5.4	6.5	2.8	6.1	7.3
IRR (%)	5.70%	4	8.1	9.5	4.6	9	10.4
Simple PBP	25 thn	16.48	10.34	9.27	15.47	9.61	8.62
Discounted PBP	25 thn	18.71	11.32	10.06	17.37	10.46	9.3

In a previous study (Rahmawati, et al, 2019) it was found that electrical energy used today in the Weh-Aceh Island region, came from a Diesel Power Plant (PLTD) where the cost of production reached Rp. 2,550 / kWh, with an average selling price to the community is Rp. 900 / kWh. The lowest payment was made by the Household type 1 (R1-subsidized) sector in the amount of Rp.423 / kWh. Thus, this explains that the cost of electricity production on Weh Island is currently more expensive compared to the provisions determined by the Government of the Minister of Energy and Mineral Resources No.1404 of 2017 which states that for the Weh island region, the price of electricity production is Rp 1,733 / kWh. Cost of production (BPP) for electricity in Aceh and value of feed in tariff Indonesia can see Table 1 and 2.

The discrepancy in the actual cost of electricity production in Weh-Aceh Island with the cost of production determined by the government will produce a different value on the application of feed in tariffs to the proposed renewable energy applications. Therefore, some simulated models will be tested with a number of Feed in Tariff schemes which are also based on the cost of electricity production at the location both in real terms and based on central government regulations. Thus, information on the effectiveness of the provisions of feed in tariffs will be obtained by the government for renewable energy developers in Indonesia which also serves to support increasing the energy mix.

With this consideration, it is expected that renewable energy developers, especially for private developers, can

Table 4.
Investment feasibility and% profit effectiveness by implementing FiT for 5 MW solar farm simulations

Decision variabel	Eligibility Indicators	5 MW Mono			5 MW Poly		
E output MWh		7991			7852		
Investment (Rp)		149,023,925,000			133,189,325,000		
FiT (Rp)		85% of CoE (based of the ministry regulation)	85% of real CoE condition in pulau Weh	General FiT umum applied in Indonesia	85% of CoE (based of the ministry regulation)	85% of real CoE condition in pulau Weh	General FiT umum applied in Indonesia
CoE (Rp)		1,473	2,100	2,329	1,473	2,100	2,329
LCoE (Rp)		412	1,035	1,262	555	1,177	1,404
Effectiveness (%)	Rp. 900,-	1.061	1.065	1.067	918	923	925
Present Cost (Rp)		0.28	0.49	0.54	0.38	0.56	0.60
Annual Cost		69,567,030,000	172,866,400,000	210,594,700,000	91,658,940,000	193,146,600,000	230,213,000,000
ROI (%)		3,359,359,000	8,347,640,000	10,169,520,000	4,426,168,000	9,326,958,000	11,116,880,000
IRR (%)		3.1	6.4	77	4.2	7.9	9.2
Simple PBP	5.70%	5	9.8	10.8	6.5	11	12.6
Discounted PBP	25 thn	14.3	9.63	8.15	11.81	8.32	7.41
Discounted PBP	25 thn	15.99	10.73	8.77	13.1	8.85	7.91

assess whether the projects carried out can be profitable or can be properly realized.

II. METHOD

In this study, the location under study is one of the islands in the Aceh region – Indonesia named Weh Island, where this island is a location that has excellent solar radiation for solar energy planning (Rahmawati, et al, 2019); (PVsyst, 2018). Map of Weh-Aceh Island location for solar farm planning can see Figure 1.

Indonesia is a region that is located right on the equator. This condition makes Indonesia only has 2 seasons in a year, summer and rainy season. In summer, Indonesia receives high enough solar radiation, while in the rainy season, solar radiation will decrease. Data from NASA shows that the average annual radiation on Weh-Aceh Island is about 5.1 kwh / m2 / day. The highest solar radiation occurs in February-April where in the order of solar radiation values are 5.75 - 5.79 - 5.64 kwh / m2 / day. The lowest radiation occurred in October and November, where the radiation was in the numbers 4.66 - 4.67 kwh / m2 / day (PVsyst, 2018).

A. Data collection

The data used in this study are secondary data, where the data obtained comes from official institutions related to solar farm planning.

1. State Electricity Provider (PLN)
2. Statistics central agency (BPS)
3. Meteorology Climatology and Geophysics Agency (BMKG)
4. NASA
5. Solar farm planning consultant

B. Economic analysis

Economic studies on a project, especially solar farm, aim to be able to produce the information needed as a reference for investors to determine the feasibility of an investment. (Sugiarianta, et al, 2016; M. Pauzi, et al, 2015) There are several factors that can guide investors to assess the feasibility of an investment, as follows:

C. Life Cycle Cost (LCC)

Life-cycle costs refer to the sum of all recurring and non-recurring costs associated with a product, structure, system, or service during its lifetime.

$$LCC = C_{capital} + C_{O\&M} + C_{replacement} - C_{salvage} \quad (1)$$

D. Cost of energy (CoE)

CoE is the total price of electricity generated from energy sources, so in the PV system in this study, the source of energy generated comes from simulated solar PV panels.

$$CoE = \frac{LCC}{\sum_1^n Epv} \quad (2)$$

Where :

LCC = Life Cycle Cost
$\sum^n$Epv (L) = The total energy generated by PV

E. Levelize Cost of Energy (LCoE)

LCoE is the price at which electrical energy is generated from certain energy sources and can reach a break even during a certain period of time. Usually, the time period is determined based on the usage time (lifetime) of the generating system. Levelized Cost is equal to the net cost to install a renewable energy system divided by the expected lifetime energy output

$$LCoE = \frac{1+\sum_{t=1}^{n}\frac{LCC}{(1+r)^t}}{\sum_{t=1}^{n}\frac{LCC}{(1+r)^t}} \quad (3)$$

Where:
It : Investment cost in t-year periode
LCC: Life Cycle Cost for the t-year period
r : The value of the applicable interest rates
Et : Electricity generation generated (in kWh) in the t-year
n : Umur pakai pembangkit

F. Net Present Value

NPV shows a lump-sum with a certain discontent current giving a figure of how much the current business value (Rp) is. In this method, NPV incorporates a time value factor, considers all project cash flows, measures the absolute amount so that it is easy to follow its contribution to efforts to increase the company's wealth [32]. Net Present Value shows below:

$$NPV = \frac{TAC}{CRF} \quad (4)$$

Where:
TAC= *Total Annualized Cost*
CRF= *Capital Recovery Factor*

G. Pay Back Period (PBP)

Pay Back Period (PBP) is a certain period of time that shows the occurrence of cash inflows which is cumulatively equal to the amount of investment in the form of present value.

$$NPV = \frac{Initial\ Investment}{Cash\ in\ Flow\ Per\ Period} \quad (5)$$

H. Internal Rate of Return (IRR)

(M.Pauzi et al, 2015) IRR is a parameter used to obtain an interest rate that equates the total present value of the expected cash flow recipient with the total present value required for investment. IRR decision criteria is if the IRR value is greater than the general interest rate in effect, then the value of the project can be accepted, otherwise, the project is rejected. The general interest rate applicable in Indonesia, based on Bank Indonesia in lase 3 year was 5.7% (BI rate, 2020). The formula used to calculate IRR values is as follows:

$$IRR = i + \left(\frac{NPV}{NPV^1 - NPV^2}\,(i^1 - i^2)\right) \quad (6)$$

Where:
I = Interest rate
i^1 = Interest rates that can produce a positive NPV value
i^2 = Interest rates that can produce a negative NPV value
NPV^1 = Positif value of *net present value*
NPV^2 = Negatif value of *net present value*

III. RESULTS AND DISCUSSION

Effectiveness analysis of economic valuation based on 3 Feed in Tariff schemes on solar farm system simulation.

A. Solar Farm 1000 kWp using si-Monocrystalline and si-Polycrystalline technologies

Solar farm simulation with an installed capacity of 1 MW using 2 different technologies with 3 FiT schemes, showing different results. For simulations using mono-crystalline and poly- crystalline technology, using a 85% FiT scheme from the BPP set by the government, the effective profit generated is 19-23%. Supported by an explanation using the IRR eligibility value parameter, this effective value indicates investment ineligibility. This is because the IRR value generated is smaller than the IRR value prevailing in Indonesia. Whereas the FiT scheme adapted to BPP in actual conditions, shows the feasibility with an effective value of 42% using monocrystalline technology and 45% using poly-crystalline technology. Where, using the general FiT price in Indonesia, which is U $ 17 cent / kWh, the effectiveness will reach 47-50% for business developers.

From the results of the calculation, it can be concluded that, in terms of economic feasibility parameters and seeing the effective value produced, the feasible FiT to be used as a reference is the FiT based on the actual BPP condition or FiT that is applied generally to all locations in Indonesia. and the technology that provides the most favorable feasibility value is polycrystalline technology. Data showing the effective value and feasibility parameters of solar farm investment calculated with a capacity of 1 Mw using mono technology and poly crystalline can be seen in table 3.

B. Solar Farm 5000 kWp using si-Monocrystalline and si-Polycrystalline tchnologies

The results of calculations with an installed capacity of 5 MW using 2 different technologies with 3 FiT schemes are as follows.

Using mono-crystalline technology with a FiT scheme of 85% of the BPP determined by the government, the effective profit generated / kWh is 28%. This value does not indicate investment feasibility, where this is explained through the IRR feasibility value parameter. The resulting IRR is 5% which is smaller than the IRR applicable in Indonesia which is 5.7%. While using polycrystalline technology, the effectiveness obtained was 38% with an IRR value of 6.5%. The simulation with the FiT scheme adjusted to the BPP in actual conditions, shows the feasibility with an effectiveness value of 49% using monocrystalline technology and 56% using poly-crystalline technology.

Using the general FiT in Indonesia of U $ 17 cent / kWh, the results show that its effectiveness will reach 54-60% / kWh for business developers. Based on the return of capital as one of the parameters considered in the economic feasibility, it is estimated that the return on capital for the 5 MW simulation will range 8-9 years earlier than the solar farm that has been applied in Malaysia-Malaysia where the return on capital is simulated to occur in the year 10-11. This is closely related to the potential radiation received at the location especially in the Aceh region. Data showing the effective value and feasibility parameters of solar farm investment calculated with a capacity of 5 Mw using mono technology and poly crystalline shown in table 4.

IV. CONCLUSION

The results showed that, simulations with a capacity of 1 MW, using 85% of the government's BPP, were ineffective and not feasible based on economic calculations. whereas with FiT based on actual BPP, the profit to be achieved is about 42-45% / kwh with return-on-investment capital in the 10th year. The simulation with 5 MW capacity shows an effective and feasible profit if it uses the actual BPP condition of the FiT with an effective profit value around 49-56% / kwh. Whereas, using FiT in general for all locations in Indonesia, amounting to $ 0.17, will result in better profits.

Thus, this shows that the FiT determined by the government especially in the Weh-Aceh Island region still needs to be reassessed. Provisions or policies that apply should be able to provide benefits for businesses as a driver for the use of renewable energy in developing countries such as Indonesia.

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