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PHOTOVOLTAIC ECONOMIC POTENTIAL FOR INVESTMENT PORTFOLIO IN SOUTH EAST ASIA

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ABSTRACT

This study is about the economic potential of solar photovoltaic (PV) potential in South East Asia particularly Malaysia that implementing FiT incentive. It is crucial from the perspective of private and individual pv energy provider to evaluate the economic potential of this type of energy investment. The economic indicator to be used is levelized cost of energy in RM/kW and payback period prediction in years. All the data for the determination of this indicator mostly from the authorized body and scientific standpoint. The alternative view of economic profitability is also applied while the capacity factor (CF) fluctuation due to unpredictable amount of solar radiation is determined based on the location. The indicator certainly can assist the energy investor to assess the potential and benefits according to their financial ability, period of investment while knowing the risk involved.

Keywords: photovoltaic, economic indicator, payback period.

1. INTRODUCTION

1.1 Energy demand

Demand for electricity stays flat in western country while marginally increasing in South East Asia. There are several factors that influence the dynamic of the energy market demand. The rise of electricity bills over the past 5 years urge the consumer to reduce energy consumption through managing the usage efficiently. The uncertainty in economic outlook also contributes to the slow energy demand. These situations impose direct impact towards the renewable energy industries.

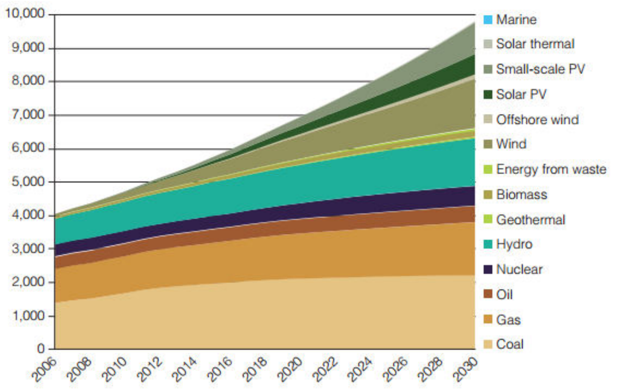

Figure-1. Forecast of the cumulative installed power generation capacity (GW).

1.2 Free and clean: photovoltaic energy

Photovoltaic energy is considered to be the future of the energy industry because it is known to be environmentally friendly and uses free infinite energy source from the sun. Unfortunately the cost of producing energy through photovoltaic is still very high and its power output fluctuates depending on the weather. Even though in the near term, the picture looks bleak for the photovoltaic industry, this is just temporary. One day the fossil fuel may be depleted and as the photovoltaic technology expands, the cost of this energy would also decrease.In this work, we determined the Levelized Cost of Solar PV in Malaysia with justifiable assumption. Other LCOE calculation techniques and external factor are also applied. A range of LCOE is then identified and compared to the FiT (Feed in Taariff) offered by SEDA. The research would give an indication of the economic potential as a developing nation with good infrastructure such as Malaysia to both the PV service provider and the potential PV generation entrepreneur.

1.3 Clean energy demand

The demand towards clean energy is projected to rise from roughly what was 23% in 2010 to around 34% in 2030. Figure-1 shows the forecast cumulative installed power generation capacity from 2006 to 2030. Starting from a lower base, solar PV capacity should grow from 2% in 2012 to16% by 2030.A significant amount of this growth is due to the expectation that solar PV cost will become cost competitive with conventional sources of power in several markets. This is particularly the case in regions with tropical climate such as South East Asia and hot and dry season such as Middle East (World Energy Council, 2013). The levelized cost of energy analysis performed by (Bloomberg, 2016) shows that there is a wide cost spectrum across the renewable energy technologies. The maturity of renewable energy made the energy cost closing down the cost with the conventional energy source. Figure-2 above shows the levelized cost of renewable energy in the second quarter of 2013.

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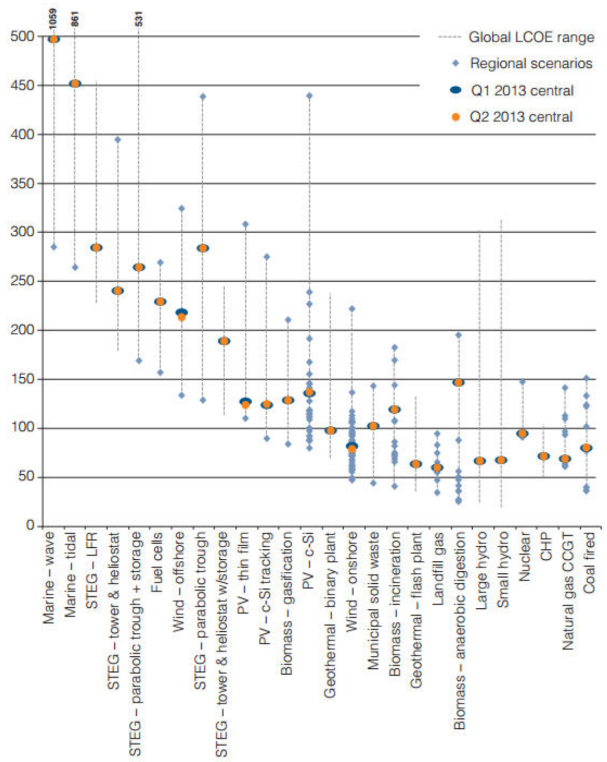

Figure-2. Levelized cost of renewable energy in the second quarter of 2013. (World Energy Council, 2013).

2. METHOD

Based on the previous study made by (Bengt Stridh *et al*, 2014) in Europe, the LCOE calculation requires a lot of assumption due different retail price of energy, self consumption percentage, fees from the energy distributor, energy trading price fluctuation, various fees by the energy authority and many more. The distinct between these two studies is that in Europe the cost of PV is reduced by the government subsidy and the energy is a commodity for trading.

In South East Asia, the renewable energy sector is growing rapidly due to various incentives provided by the government. In Malaysia, Thailand, Indonesia and Philipines the Feed-in tariff was one of the key incentive to promote growth in PV energy sector in the region. This region also does not trade electricity as in Europe. Hence, the LCOE calculation is less complicated and become much more accurate when only single country information, Malaysia is used in the calculation.

2.1 Solar PV cost based on LCOE

The levelized cost of energy, LCOE is an economic indicator used by the power industry to obtain the cost of generating one kilowatt-hour (kWh) of electricity averaged over the lifetime of the power plant. The LCOE is a function of fixed cost and annual cost shown in equation 1.

$$LCOE = \frac{Cost\ Structure}{Electricity\ Output} \qquad (1)$$

For a power plant that uses heat as the source for the prime-mover, the total fixed cost is the sum of initial power plant costs and the product of Heat Rate in (Btu/kWh) and Fuel in (RM/Btu). The levelized annual cost is a product of levelizing factor and the sum of all raw cost annually and the operational and maintenance cost. This equation is applied to to calculate LCOE for PV in Malaysia. Malaysia is chosen for this study since it is the 3rd largest solar module manufacturing hub in the world hence suitable candidates for cost competitiveness study.

2.2 LCOE of PV in Malaysia

In Malaysia, the cost breakdown of a residential PV system is given in Table-1 shown below (Sustainable Energy Development Authority, 2014). The fees for acceptance test and reliability run test supervised by the authorized body is shown in Table 2 (Sustainable Energy Development Authority, 2016). The variable cost of PV can come from annual maintenance. The maintenance cost annually by reputable company can be as high as USD 0.075/kW annually. If the panel is easily accessible, the owner can perform their own maintenance.

Table-1. Cost breakdown of a residential PV system - local currency (RM).

Cost category	Average (local currency/W)	Low (local currency/W)	High (local currency/W)
Hardware			
Module	3,0	Not available	
Inverter	1,2		
Other (racking, wiring...)	1,4		
Soft costs			
Installation	0,70		
Customer Acquisition	0,25		
Profit	1,45		
Other (permitting, contracting, financing...)	0,5		
Subtotal Hardware	5,6		
Subtotal Soft costs	2,9		
Total	8,5		

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Table-2. Fees for acceptance test and reliability run test supervised by SEDA.

Procedure	Capacity	Testing and commissioning to be witnessed by an Authority's representative	Fees (RM)
Systems less than or equal to 12 kWp and systems less than or equal to 12 kWp (use of microinverter in the PV system)	≤ 12 kW	No	
Systems greater than > 12 kW and less than 72 kWp	> 12 kW but < 72 kW	Yes	3,710
Systems equal to or greater than 72 kWp and up to 425 kWp	≥ 72 kW but ≤ 425 kW	Yes	5,300
Systems greater than 425 kWp	> 425 kW	Yes	7,420

Table-3. List of assumption and justification.

Parameters	Assumption values	Source/ Justification
Plant cost	RM 8.5/W	SEDA
Annual Cost	Nil 0.5% - 1% of installation cost	Ideal case Maintenance, monitoring cost
Lifetime of the PV system,	21 years	SEDA
Plant Capacity	4kW	SEDA
Discount rate, d	8%	Highest deposit rate among Malaysia bank.
Escalation Rate	2.4%	Inflation rate in from National Bank Malaysia
Sunlight hours/day	0.25 hours/day	Malaysia Meteorology Service
Tax and Fees	Nil	4kW capacity-zero fees

LCOE range can be very broad. A number of assumptions have to be made to simplify the calculation. Table 3 listed all the parameters required to calculate LCOE and the justification or source of the data(Energy Market Authority and Building and Construction Authority Handbook, 2016).

If the ideal case is considered, the LCOE values yield RM 3.88/kW for 4kW rated solar system. The LCOE values for the non - ideal case is presented graphically below.

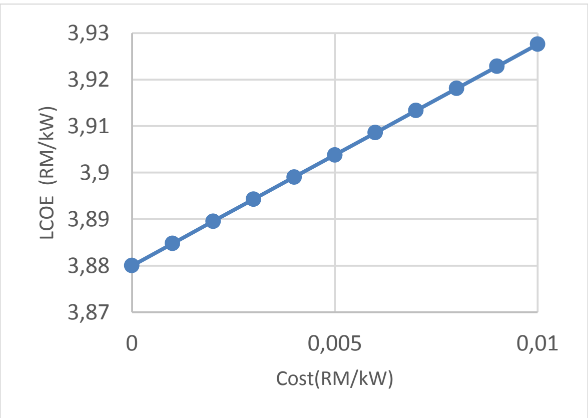

Figure-3. LCOE vs Annual cost.

2.3 Payback period based on NPV

It is unusual to use Net present value (NPV) as an indicator for an investment in energy industry. NPV can be used if the initial investment and annual profit are known. Equation (2) shows the general equation of NPV.

$$NPV = \Delta A \times PVF(d, n) - \Delta P \quad (2)$$

Where PVF is the present value function of d, discount rate and n, the number of years of the investment period. ΔP is the initial investment of the project. NPV by taking the same discount rate and investment period in Table 4(Sustainable Energy Development Authority, 2016) with Feed in Tariff (FiT) of RM 0.8249/kW and 8,760 hours of full sunlight a year yield RM 54969.48.

VOL. 11, NO. 19, OCTOBER 2016 ISSN 1819-6608
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Table-4. Feed in Taarif in Malaysia.

Description of Qualifying Renewable Energy Installation	FiT Rates (RM per kWh)
(a) Basic FiT rates having installed capacity of:	01-JAN-2016
(i) up to and including 4kW	0.8249
(ii) above 4kW and up to and including 24kW	0.8048
(iii) above 24kW and up to and including 72kW	0.6139
(b) Bonus FiT rates having the following criteria (one or more):	
(i) use as installation in buildings or building structures	+0.1550
(ii) use as building materials	+0.1325
(iii) use of locally manufactured or assembled solar PV modules	+0.0500
(iv) use of locally manufactured or assembled solar inverters	+0.0500

Based on NPV rules, the positive value shows that the investing in this project is profitable. Simple Payback Period (SPP) is 4.7 years. The Internal Rate of Return (IRR) from the precalculated present value function in Table-5 is 19%-21%.(Masters and Gilbert M, 2013).

Table-5. Present value function to help estimate the internal rate of return.

Life (years)	9%	11%	13%	15%	17%	19%	21%	23%	25%	27%	29%	31%	33%	35%	37%	39%
1	0.92	0.90	0.88	0.87	0.85	0.84	0.83	0.81	0.80	0.79	0.78	0.76	0.75	0.74	0.73	0.72
2	1.76	1.71	1.67	1.63	1.59	1.55	1.51	1.47	1.44	1.41	1.38	1.35	1.32	1.29	1.26	1.24
3	2.53	2.44	2.36	2.28	2.21	2.14	2.07	2.01	1.95	1.90	1.84	1.79	1.74	1.70	1.65	1.61
4	3.24	3.10	2.97	2.85	2.74	2.64	2.54	2.45	2.36	2.28	2.20	2.13	2.06	2.00	1.94	1.88
5	3.89	3.70	3.52	3.35	3.20	3.06	2.93	2.80	2.69	2.58	2.48	2.39	2.30	2.22	2.14	2.07
6	4.49	4.23	4.00	3.78	3.59	3.41	3.24	3.09	2.95	2.82	2.70	2.59	2.48	2.39	2.29	2.21
7	5.03	4.71	4.42	4.16	3.92	3.71	3.51	3.33	3.16	3.01	2.87	2.74	2.62	2.51	2.40	2.31
8	5.53	5.15	4.80	4.49	4.21	3.95	3.73	3.52	3.33	3.16	3.00	2.85	2.72	2.60	2.48	2.38
9	6.00	5.54	5.13	4.77	4.45	4.16	3.91	3.67	3.46	3.27	3.10	2.94	2.80	2.67	2.54	2.43
10	6.42	5.89	5.43	5.02	4.66	4.34	4.05	3.80	3.57	3.36	3.18	3.01	2.86	2.72	2.59	2.47
15	8.06	7.19	6.46	5.85	5.32	4.88	4.49	4.15	3.86	3.60	3.37	3.17	2.99	2.83	2.68	2.55
20	9.13	7.96	7.02	6.26	5.63	5.10	4.66	4.28	3.95	3.67	3.43	3.21	3.02	2.85	2.70	2.56
25	9.82	8.42	7.33	6.46	5.77	5.20	4.72	4.32	3.98	3.69	3.44	3.22	3.03	2.86	2.70	2.56
30	10.27	8.69	7.50	6.57	5.83	5.23	4.75	4.34	4.00	3.70	3.45	3.22	3.03	2.86	2.70	2.56

2.4 Payback period based derived from LCOE

In the other hand, the payback period that can be derived from LCOE is given by the formula below.

$$I - \sum_{i=1}^{p} \left(\frac{v^i x y^i (1-d)^{i-1}}{(1+rate)^i} - a_i \right) = 0 \quad (3)$$

Where

I = initial investment cost,
P = payback period in years
V = electricity feed in tariff, first year output (8,760 hours,
d = degradation rate (0.5%/year),
a = annual cost, I is year and rate is discount rate of 6%.

2.5 Result from payback period based derived from LCOE

Figure-4 graphically shows the accumulation of income after n years of investment in PV energy for 4kW PV capacity. The colors represent the different Feed in Tariff based on bonus level in Table-4. From this graph, the energy investor can easily predict how long their investment in PV energy can come to fruition. The range of the initial cost for 4kW PV system is between RM 34,000 to 50,000. Based on the graph, the payback period for this case is 5 -6 years. This method of calculation in much more accurate compared to the NPV method just because it includes the PV energy degradation rate in the calculation. According to (Dirk C. Jordan and Sarah R. Kurtz, 2013), the mean degradation rate of PV system over 40 years of the data is 0.8% and median of 0.5%.

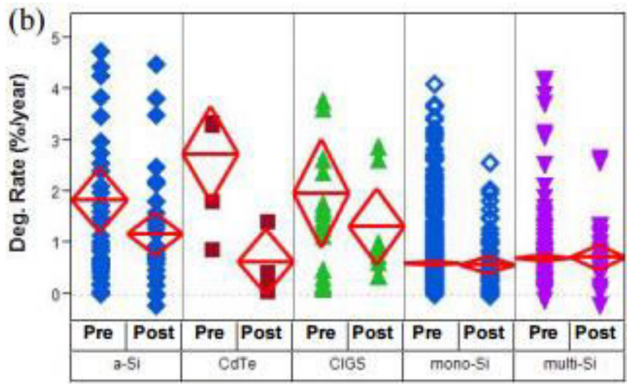

Figure-4. degradation rate by technology (Dirk C. Jordan and Sarah R. Kurtz, 2013).

Figure-5 shows the degradation rate of by all known module technology. Nevertheless the difference is very minimal. The calculation so far only applicable for a PV capacity of 12 kW and below. As the capacity increase, the PV cost is decreased. The income based on FiT also decreases while the tax and fees increase.

2.6 PV energy output

The PV technology is improving each year. Despite the increase in system efficiency, the research thus far pays less attention at the effect of the climate change in the PV energy output. The climate nowadays is dynamic. The length of sunlight last year in many parts of the world is not the same as this year so thus the output of PV. The good news is that the variation is less than 5%. (Green Rhino Energy, 2013). The average sunlight in a day in Kuala Lumpur is 6 hours at the altitude of 75^0. The strength of the sunlight received by the PV is known as solar radiation. It is a measurement of power per unit area or Wm^{-2}or MJm^{-2}. In earlier calculation, roughly 6 hours of sunlight per day are received in Malaysia. Table-6 summarized the solar radiation data between October 2015 to March 2016 taken from (Ministry of Science and Technology, 2016).

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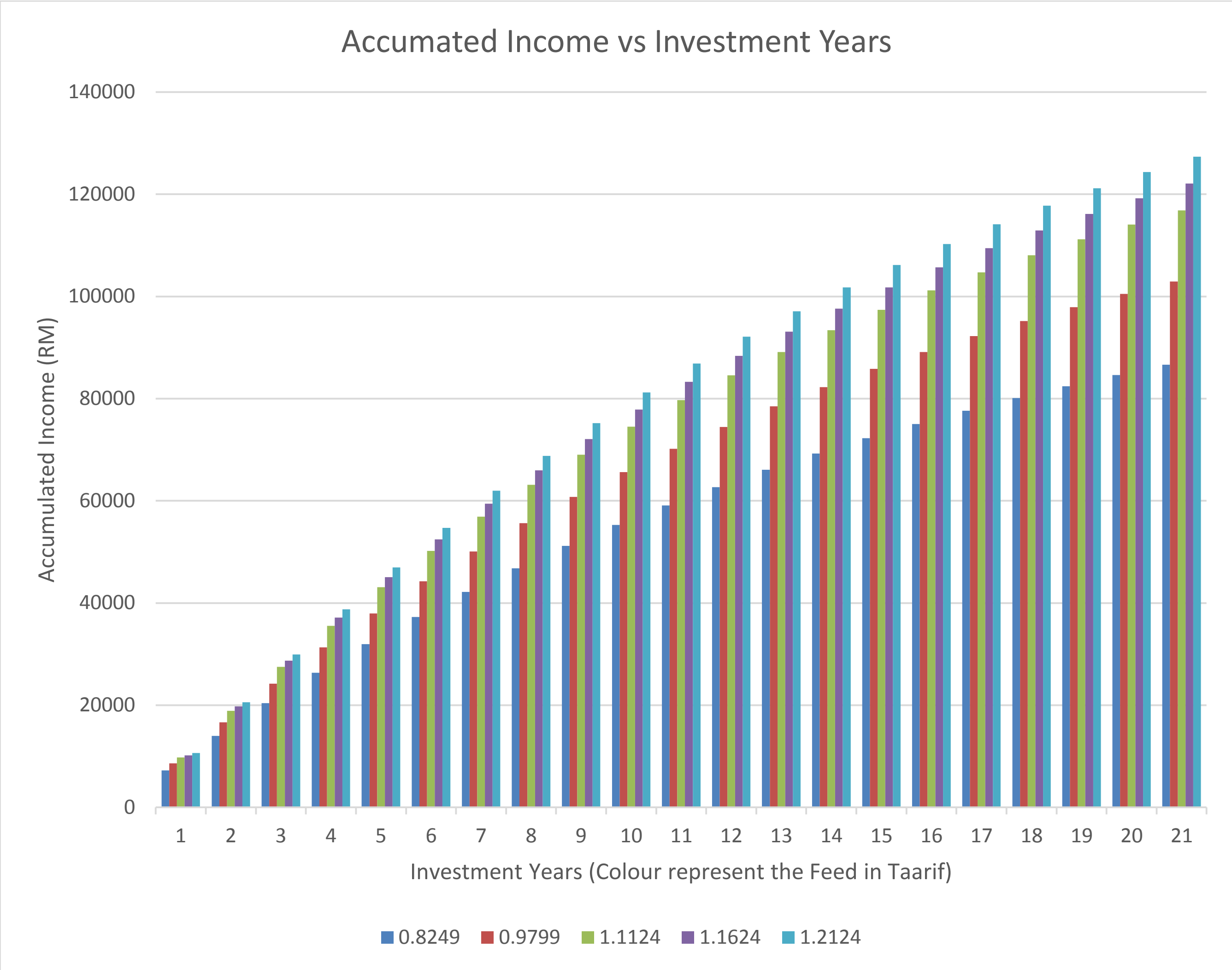

Figure-5. Accumulation of income after n years of investment in PV energy for 4kW PV capacity.

Table-6. Daily mean solar radiation reading at low lands and Cameron Highland.

	Low land area (MJm^{-2})	**Cameron** (MJm^{-2})
October	14.25	13.24
November	14.81	12.38
December	11.31	15.82
January	17.36	16.86
Februari	10.93	18.64
March	11.91	20.07

The conversion from Wm^{-2} to MJm^{-2} by simple approximation is Wm^{-2} = 11.57 MJm^{-2} (J.A. Engel-Cox1, N.L. Nair and J.L. Ford, 2012). Assuming that the PV energy contractor uses this data to rate their PV module capacity, it is safe to use the maximum mean daily as the value that generates the rated power for PV module. Thus, we can determine the CF and its effect on the LCOE. Since the insolation data is half a year, we make an assumption that it repeats for the next half year. Figure 6 and 7 shows the predicted annual income versus investment years in two locations.

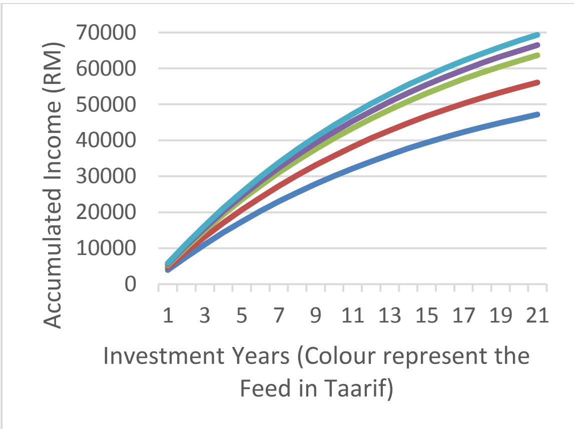

Figure-6. Accumulated Income over 21 years with CF of 0.554 (mean lowland).

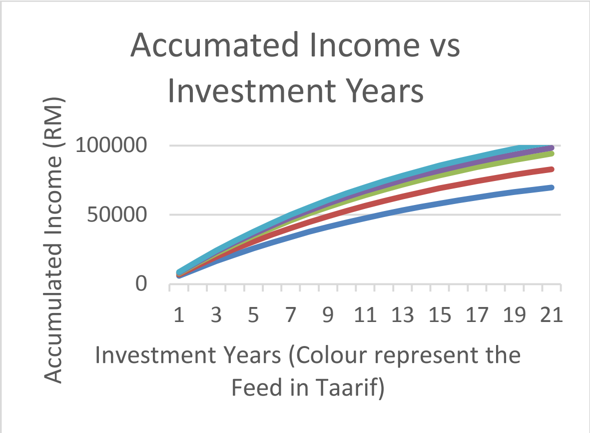

Figure-7. Accumulated Income over 21 years with CF of 0.805 (Cameron).

The summary of the payback period for all the consideration discussed earlier is shown in Table-7.

Table-7. Payback period summary.

	Payback period			
Degradation	0	0.005/y	0.005/y	0.005/y
Capacity factor (CF)	1	1	0.554	0.805
LCOE without degradation	4.7 years	5-6 years	8-21 years	5-12 years

3. CONCLUSIONS

This study evaluates the economical benefits of PV energy in the eyes of investor. The determination of the economic indicator requires a lot of literature on previous work and data from the authorized body. Degradation rates and climate change shows a direct impact towards the profit and pay back period. This study deliver justified information and conclusion that the energy investor should look into before dive into the energy market. Nevertheless, the economic impact should not be the sole reason for the energy investor to invest. In Europe, the trend of green energy is growing rapidly because most of the citizen feel the responsibility of creating the world a greener place to live but if the profit is there, then it should be considered as bonus to them.

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