A CASE STUDY ON PERFORMANCE EVALUATION OF GRID CONNECTED PV GENERATION SYSTEM IN UAE

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Abstract

Energy is an important aspect in the today's world. Due to the increase in the population and the decrease in oil and other energy resources the power generation using renewable energy has become more popular. The proper paper presents the feasibility analysis of implementing the photovoltaic system for a residential house in UAE using a grid connected system. In this paper real data for a typical residential house with the present electricity cost in UAE is taken in to consideration for the analysis. RET screen software has been used for the economic analysis. The software has also been used to get the climatic conditions like humidity, temperature with the radiations. The effect of these conditions with the efficiency of the solar panels was also analyzed.

Keywords: *Photovoltaic system, RET screen, Feasibility, Energy Analysis.*

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1. INTRODUCTION

Renewable energy today is becoming more and more popular because of the fluctuation in the oil prices. Photovoltaics and Wind mill are today very popular alternate energy sources as it is a clean energy and abundant in supply. The costs of the PV cells are also decreasing day by day. Photovoltaic system mainly uses PV cells which when incident with photons from sun light break the bonds and releases electrons. These electrons flow in the circuit as DC current. The inverters are used to convert the DC to AC for residential power. Today solar technology has developed in many ways ranging from multiple tracking PV system where the sun is tracked by dual axis. Today concentrating solar cells are used in which the sunlight is focused using dish to concentrate the light and when the light falls in to the cells part of the energy is converted to electrical energy. The rest of the energy is either reflected or absorbed. The efficiency of the PV cells range from 15% to 20% and hence more number of panels have to be added to get the required power. There are lots of research going on to bring the efficiency higher. [1,3]]. Some of the other areas of research include thin film cells, flexible panels, building integrated PV systems. Researches are going on in the areas of rectenna called nano anteno to convert sun light to DC directly. Though the efficiency of these type of panels are &0% theoretically practically the NREL has achieved only 1%.

The figure 1 below shows the equivalent circuit for PV cell in which the current source indicates that the current flow when the light falls on the PV cell. The Rs and Rsh are the series and parallel resistance appearing across the cell. These are the resistance by the conductors. The figure 2 shows that the characteristics of PV in which it is seen that the voltage and current varies according to the variation in the incident sunlight and the red indicates the another set of V-I characteristics for different temperature which is 56 degree centigrade.[2] It is seen that as the temperature increases above 25 degree centigrade the performance is reduced. The optimal working condition of PV cell is 25 degree centigrade.

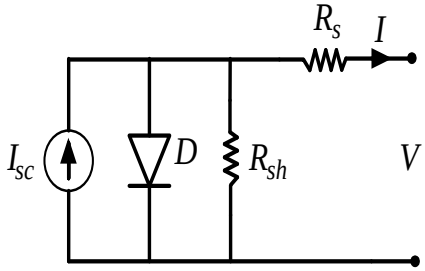

Fig 1: Equivalent circuit of array.

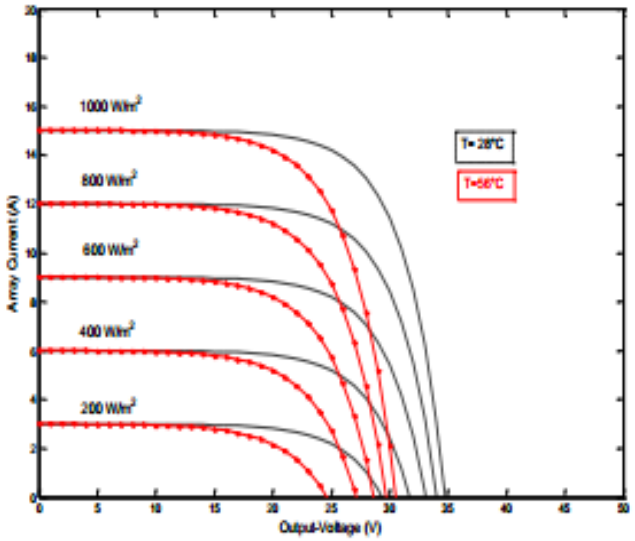

Fig 2: Characterisitics of PV for different irradiance and temperature

2. SOLAR CELL EFFICIENCY

The figure 3 below shows the efficiency of the solar cells. It can be seen from the graph that the efficiency has been reached until 24%. The efficiency of the solar panels mainly depends on open circuit voltage, short circuit current Fill Factor and power input. The formula governing the effificny is given below. Here Voc is the open circuit voltage which is the maximum voltage across the panels when the terminals are open, Isc is the short circuit current which is the current flowing through the terminals when it is shorted. The fill factor is the maximum area that can be fitted inside the curve, k stands for the boltsman constant. Vmp and Imp is the peak values of Voc and and Isc where the power is maximum and q is the elementary charge.[2,5,6]

$$V_{MP} = V_{OC} - \frac{nkT}{q}\ln\left(\frac{V_{mp}}{nkT/q} + 1\right)$$

$$FF = \frac{V_{OC} - \ln(V_{OC} + 0.72)}{V_{OC} + 1}$$

$$V_{OC} = \frac{q}{nkT} V_{OC}$$

$$FF = \frac{V_{MP} I_{MP}}{V_{OC} I_{SC}}$$

$$\eta = \frac{V_{OC} I_{SC} FF}{P_{in}}$$

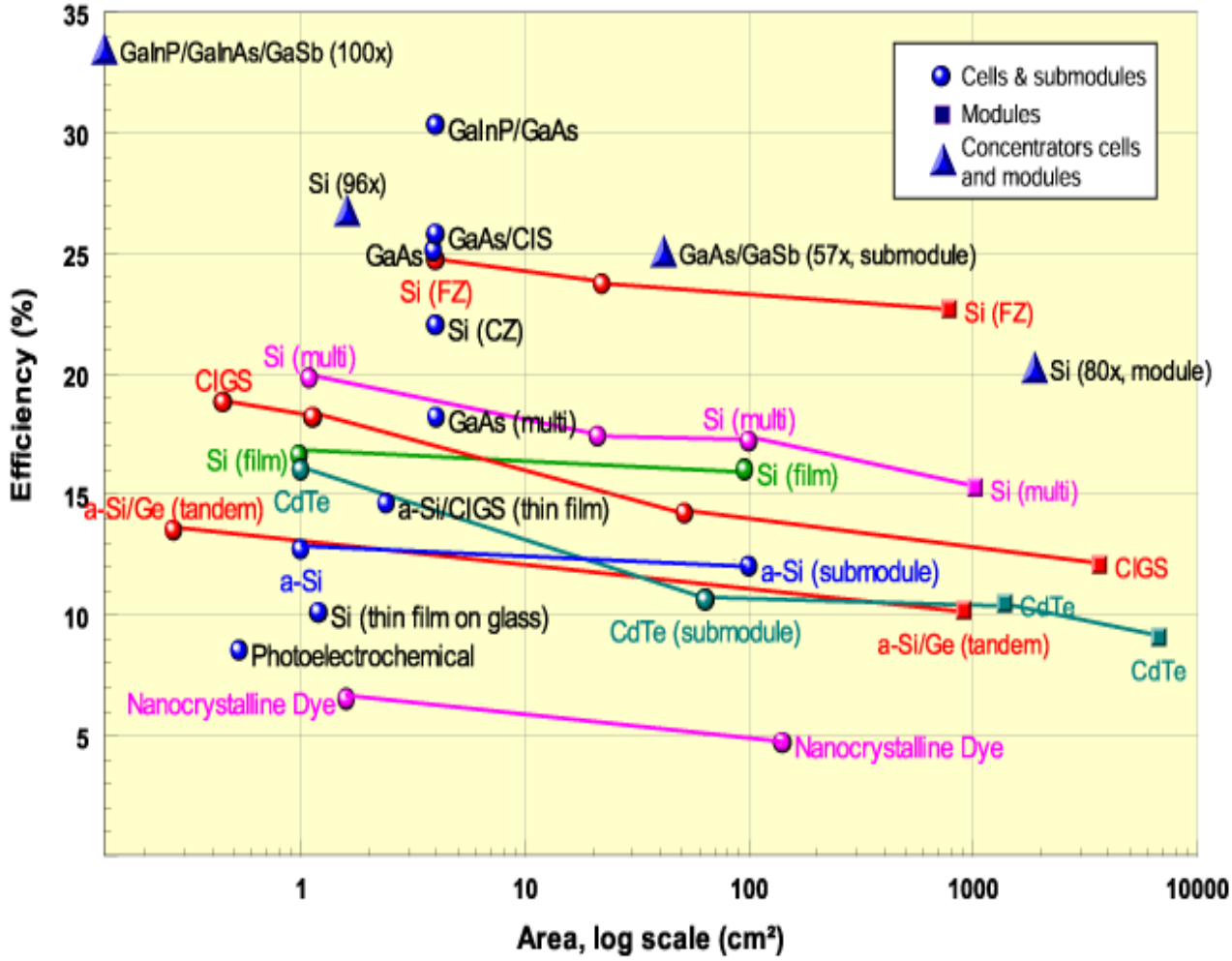

Fig 3: Efficiency of various types of solar cells

3. DESIGN OF PHOTOVOLTAIC SYSTEM

The figure 4 shows the variation of average earth and air temperature every month. It can be seen that the temperature rises in the month of June July and august. The temperature affects the performance of photovoltaic as the ambient temperature to get the maximum efficiency is 25 degree centigrade.

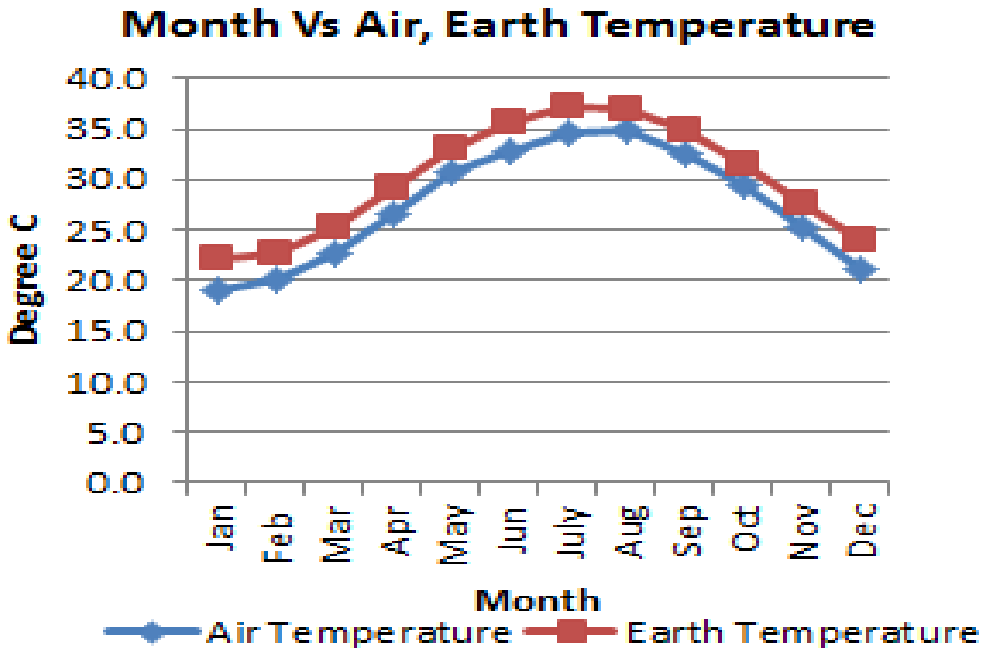

Fig 4: Month Vs Air temperature

The figure 5 shows the variation of solar radiation and wind speed for every month and it can be observed that the solar radiation is high in UAE and also the wind speed is almost constant. The wind speed also affects the performance of the panels. The sand storm due to wind deposits the sand dust in panels which also highly reduce the performance of the PV panels.

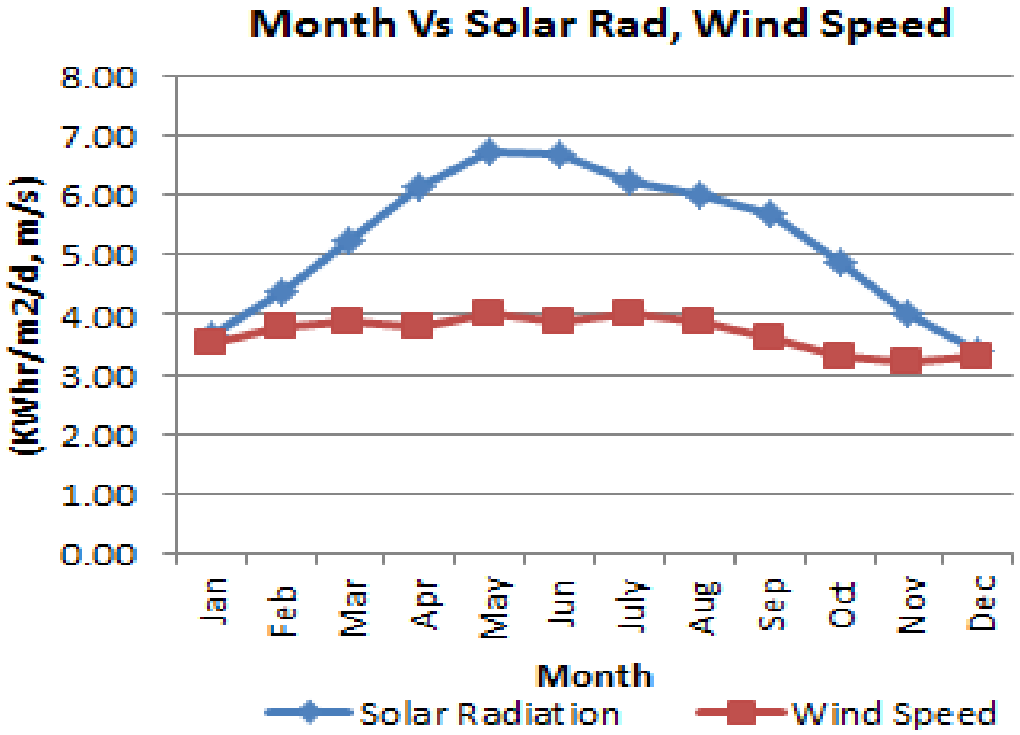

Fig 5: Month Vs Solar radiation

The wind between the panels and roof creates pressure on the panels which creates force and finally damage the panels. The effect of snow is not considered in this paper but the snow also significantly affects the panel performance one is the deposit and the other is the weight of snow deposited in the panels. The figure 6 shows the load for every month to be connected to the PV system. The average load is approximately 4KW. The load varies as per the climatic situations. The typical load from the month of May to September is high due to summer and it shows low in august as most of the residents in UAE will be on vacation.

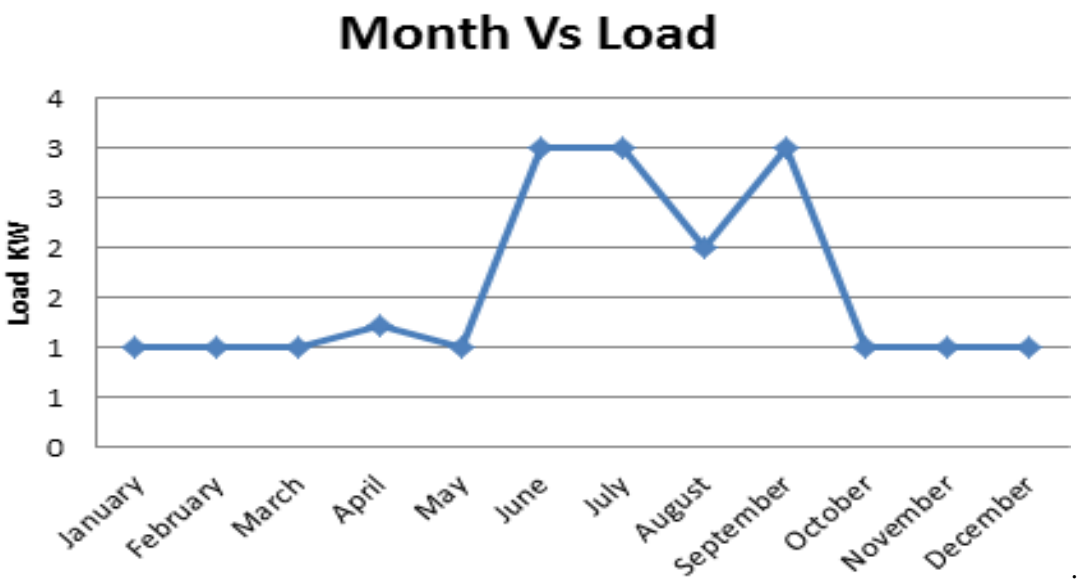

Fig 6: Month Vs Load

3. DESIGN USING RET SCREEN SOFTWARE

The following table shows the amount of solar radiation incident every month and how much electricity can be exported to the grid. The angle of tilt is kept at 25 which is approximately equal to latitude and the azimuth angle is set as 25 degree.

Table 1- Electricity exported to grid and the solar radiation

Month	Daily solar radiation - horizontal kWh/m²/d	Daily solar radiation - tilted kWh/m²/d	Electricity export rate AED/MWh	Electricity exported t grid MWh
January	3.65	4.53	230.0	0.913
February	4.37	5.06	230.0	0.912
March	5.21	5.56	230.0	1.096
April	6.15	6.07	230.0	1.136
May	6.71	6.24	230.0	1.186
June	6.69	6.05	230.0	1.105
July	6.22	5.71	230.0	1.073
August	6.02	5.79	230.0	1.082
September	5.67	5.87	230.0	1.068
October	4.88	5.53	230.0	1.057
November	4.00	4.91	230.0	0.929
December	3.39	4.29	230.0	0.859
Annual	**5.25**	**5.47**	**230.00**	**12.416**

Table 2: PV details

Photovoltaic			
Type		mono-Si	
Power capacity	kW	14.72	
Manufacturer		Sunpower	
Model		mono-Si - SPR-320E-WHT	46 unit(s)
Efficiency	%	19.6%	
Nominal operating cell temperature	°C	45	
Temperature coefficient	% / °C	0.40%	
Solar collector area	m²	75	

The table 2 shown above shows that the mono silicon PV is used due to its high efficiency and cost. Here 46 units of PV panels each with 320W are used making it to 14.7KW. Though the average power required is around 4KW the PV system is designed for 14KW as the efficiency of panels is around 20% and any extra power generated is connected to grid. In this case inverter with a capacity of 15KW is used to convert the obtained DC to AC voltage.

Base case GHG emission tCO2	Proposed case GHG emission tCO2	Gross annual GHG emission reduction tCO2
5.3	0.1	5.2

Electricity contributes 38% of C02 emission compared with the industry which is 32% and Industry which is 14%. The figure 7 shown below shows that the emission increases every year significantly. The green line indicates that the status of CO2 emission in the Middle East. The base case which is the load connected would produce 5.2 tons of carbon dioxide as per the RET screen software which can be eliminated by implementing PV system.

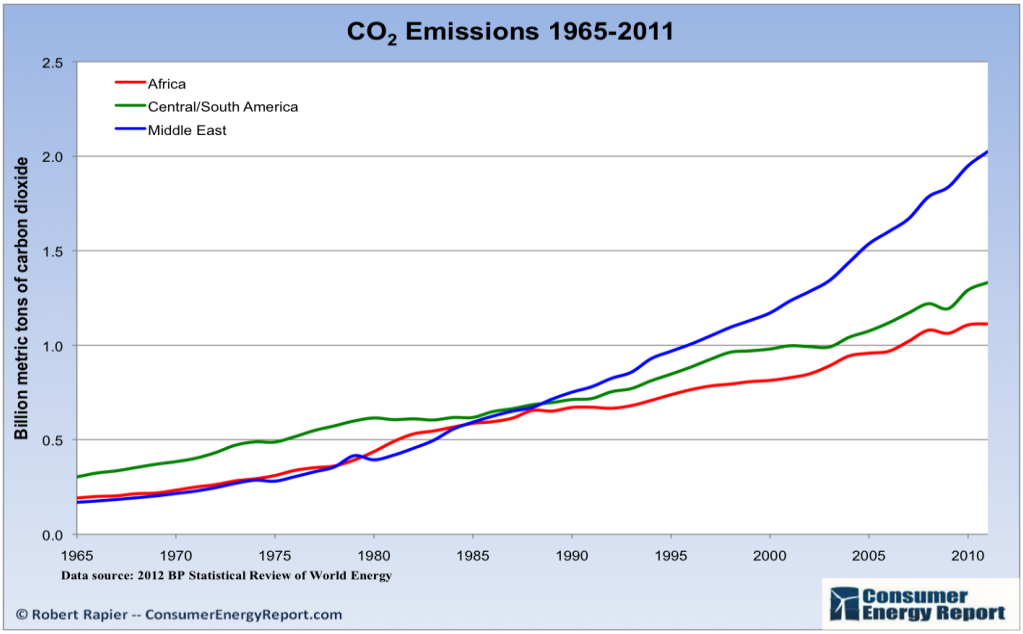

Fig 7: CO2 emission Analysis

Table 3: Engineering Operation and Maintenance

Engineering							
Engineering	cost	1	AED	9,000	AED	9,000	
Subtotal:					**AED**	**9,000**	7.1%
Power system							
Base load - Photovoltaic	kW	14.72	AED	3,000	AED	44,160	
Peak load - Grid electricity	kW	4.86	AED	-	AED	-	
Road construction	km	0	AED	-	AED	-	
Transmission line	km	0	AED	180,000	AED	-	
Substation	project	0			AED	-	
Energy efficiency measures	project	1	AED	3,000	AED	3,000	
User-defined	cost	3	AED	10,000	AED	30,000	
		1	AED	4,000	AED	4,000	
Subtotal:					**AED**	**81,160**	64.4%
Balance of system & miscellaneous							
Spare parts	%	100.0%	AED	300	AED	300	
Transportation	project	1	AED	3,000	AED	3,000	
Training & commissioning	p-d	2	AED	1,000	AED	2,000	
User-defined	cost	1	AED	18,000	AED	18,000	
Contingencies	%	10.0%	AED	114,460	AED	11,446	
Interest during construction	2.25%	1 month(s)	AED	125,906	AED	118	
Subtotal:					**AED**	**34,864**	27.7%
otal initial costs					**AED**	**126,024**	100.0%

The table 3 shows that cost analysis for engineering work to be carried out the power system part which includes the solar panels, construction costs, spare parts, transportation costs were all taken in to account.

4. CONCLUSION

In this paper the design of photovoltaic system for an green house is implemented. Optimum numbers of panels, inverters are selected. The cost analysis, risk analysis were also done using the RET Screen software. The figure8 shown below shows the cash flow analysis. The x-axis shows the year and the y-axis shows the cash flow. It has been observed that the break-even point is reached after sixteen years. It can be seen that the initial cost is around 100000 AED and the profit is shown until 25 years. The analysis is made for 25 years since the life span of the PV system is approximately 25 years.

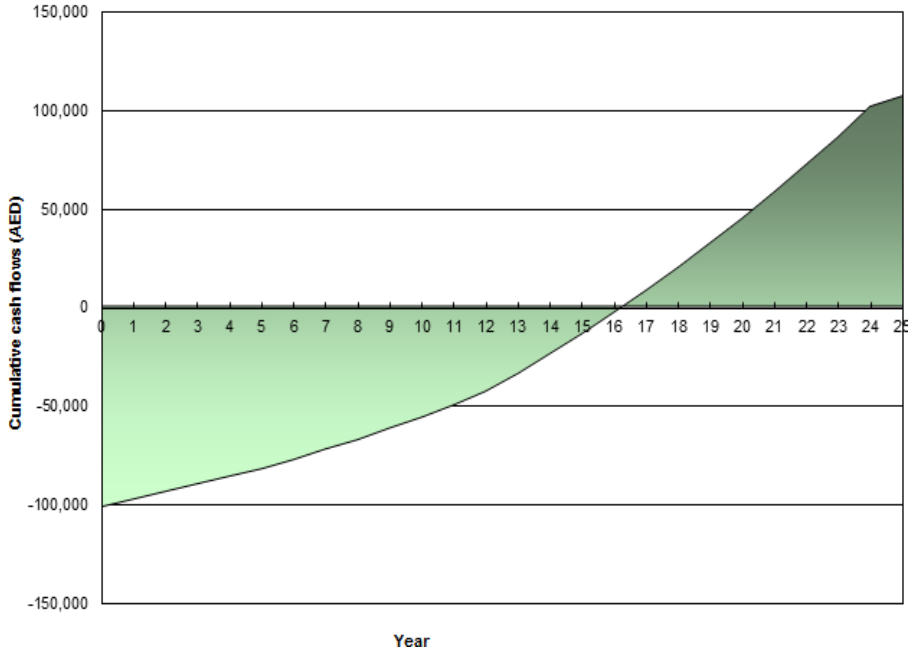

Fig 8: Cash Flow Analysis

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BIOGRAPHY

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