TECHNO-ECONOMIC AND PERFORMANCE COMPARISON OF PV INSTALLATION IN DIFFERENT LOCATION IN NOTHERN IRAQ

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ABSTRACT

The research aims to give a better understanding about the potential of photovoltaic plant to solve power shortage problem in Northern Iraq. A detailed investigation, performance and techno-economic analysis of PV plant installations in this region is done in this study. The objective of the study includes; investigating the best location for photovoltaic plant installation in Northern Iraq, checking the feasibility and viability of the proposed PV plants and checking the performance difference between a fixed and a double axis PV plants. RETScreen software is used to determine the possible cost of building a 10 MW PV plant in three different locations in Northern region of Iraq. The results from these locations (Erbil, Kirkurk, As-sulaymaniyah) will be compared. Results of this study shows that installing 10 MW PV plant in all the three locations (As-sulaymaniyah, Erbil, Kirkuk) is feasible. Installing a two-axis 10 MW PV plant in As-sulaymaniyah will save as much as US$1,573,327 per year.

1. INTRODUCTION

The solar energy potential in Kurdistan region is 6318.83 MJ/m^2/yr with an average of 4.81 kWh/m²/day [1]. This data encourages the establishment of PV systems to increase the supply and hence reduce (eliminate) the deficiency in electricity supply. According to the Ministry of Planning there was a shortage in power supply by 579 MW in 2012. Almost 82% of the total power demand in northern Iraq is provided by the government [2]. The demand increases day by day, especially after the displacement of people from other parts of Iraq to Kurdistan region caused by the fights against ISIS after mid of 2014.

The distinct advantages of Solar Photovoltaic technology are: reduction of fossil fuel usage (Coal, Petrol, and Natural gas) to generate power, reduce carbon dioxide emission and therefore reduce global warming effects. The cost of power generation by using solar PV technologies has been greatly reduced, because of the development and increase in efficiency of solar power technologies [3]. The efficiency of most commercial Photovoltaic panel systems is between 15% and 20% [4]. On the other hand, there are disadvantages associated with the use of solar technologies which includes; degradation of lands, affecting the aesthetic value in the buildings through using this technology, and chemical effects of their material, etc. [5].

Certain economic indicators are considered in photovoltaic system applications. These are Payback Period (PBP), Net Present Value (NPV), Levelized Cost of Electricity (LCOE), and Internal Rate of Return (IRR) [6]. PV system components are generally divided into two; the panels, and Balance of System (BOS) components. The major part of the investment cost of a PV system is the procurement of the PV panels. The BOS costs include inverters, mounting, wiring, and power conditioning. Operating and maintaining costs are also considered in economic analysis [7].

Northern Iraq region is one of the most peaceful and developed regions in the country; nevertheless, this region is still facing a power challenge. Currently, this region has inadequate power supply and rural areas have little or no access to electricity. Also, there is no grid connected or standalone huge PV plants in this region now. The aim of this study is to investigate the feasibility of PV plants to meet some of the energy requirements in Kurdistan Region of Iraq. The study attempts to evaluate the use of photovoltaic panels in the region as an alternative to fossil fuel. The research is significant as it evaluates the feasibility of new sustainable and renewable source of energy in this region. The research aims to give a better understanding about the potential of photovoltaic plant as a means of solving power shortage problem at the cities in Northern Iraq. A detailed performance and techno-economic analysis of PV plant installations in this region will be done in this study. The objectives of the study include; Investigation of the best location for photovoltaic plant installation in Northern Iraq, check the feasibility and viability, determine payback period, internal rate of return and other economic indicators of the system. Also, check the performance difference between fixed and double axis PV plants.

2. KURDISTAN REGION OF IRAQ

The Kurdistan Region is part of Federal Republic of Iraq (North-East of Iraq). The region is adjacent to Turkey from the north, to Syria from the west, to Iran from the east, and to rest of Iraq from the south. The region consists of three governorates; Erbil (the capital of the region), Sulaymani, and Duhok. The area of the region is 73,618 km^2 with the disputed area, which represents almost 17% of the total area of the Republic of Iraq [8]. Geographically, the region is located between the coordinates; longitudes 42°25’ E, and 46°15’ E, and between latitudes 34°42’ N and 37°22’ N, as in Fig. 1.

The energy sector is the most crucial cornerstone of the Iraq`s economy. Iraq is a place of large oil reserves as it has the 13th largest gas reserves, and the fifth largest proven oil reserves [10].

Despite the increase in the supply of electricity in Iraq, the demand is still not met. The grid based (transmission) electricity capacity was 8GW as at 2011, while the estimated capacity to meet demands was 15GW, meaning there was a deficit of about 7GW [11]. About 90% of residential places in Iraq supplement their electricity needs with generator devices, and the generation capacity of these devices is estimated at about 3 TWh. The cost implications of this is high as it is estimated that the generator consumers are paying about 10 to 15 times more for electricity obtained from this source than for electricity from the grid [12].

Figure 1: Kurdistan region of Iraq showing Erbil location [9]

There is peak electricity demand during summer seasons, which is about 50% higher than the average demand. This creates a lager gap between the electricity supplied and demand. The gas fired plants used in producing electricity in Iraq is about 31% efficient [4].

The demand on power in Kurdistan region is increasing progressively. A total power demand in the Region based on official data in 2004 was 829 MW (Megawatt). Today the region demand is more than 3000 MW [13].

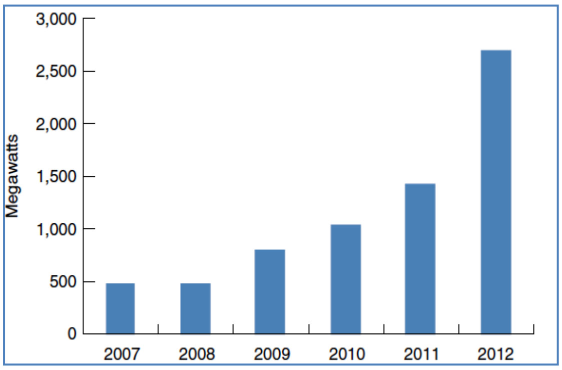

Figure 2: Electricity production in Kurdistan Region of Iraq Source [14]

The production of power in Kurdistan region has also increased. The region was producing less than 500 MW in 2007. Power production jumped to almost double within one year from 2008 to 2009, and finally to 2700 MW in 2012, as in Fig. 2.

The data/chart (Fig. 2) shows that there is a lack of power supply in the region which was more than 500-600 MW in 2012. This has caused almost 15-20 % deficiency in meeting the demand. KRG (Kurdistan Region Government) supply electricity between 12 to 19 hours per day according to the seasons and demands. The remaining hours will be provided through private generators or from neighbour countries [15].

The region produces theoretically 3049 MW if the power stations work ultimately. But the actual production is not more than 2700 MW; hence, the region receives electricity from adjacent countries like Iran and Turkey to compensate the shortage of the supply [15]. The power generation in Kurdistan region mainly depends on natural gas (74%) and on hydropower generation (21%), on diesel generators (3%) and the remaining 2% depends on other types.

3. METHODOLOGY

For this study, RETScreen software is used to determine the possible cost of building a 10 MW PV plant in three different locations in Northern region of Iraq. The results from these locations (Erbil, Kirkurk, As-sulaymaniyah) will be compared. These plants will help to reduce power related problems and increase the electricity accessibility level in the regions considered as well as in the country. RETScreen simulation results would be used to ascertain the Simple Payback Period, Internal Rate of Return and Net Present Value, Energy Production Costs. These will be used to measure the performance, feasibility and viability of installing solar PV plant in three different sites in northern region of Iraq. In addition, annual greenhouse gas abatement is also determined using the RETScreen software.

3.1. Site Selection

The three cities in this research are selected based on data availability on the RETScreen database. These data are extracted from NASA database by the software developer. Figure 1 shows the location of these sites in the Kurdistan region of Iraq. It should also be noted that these cities are also selected because of their high solar radiation [16].

Erbil (also Arbil or Irbil) is the capital city of Kurdistan. It is located on the coordinate 36°11′28″N 44°0′33″E and it is in the northern region of Iraq. Erbil is one of the oldest inhabited areas in the world with settlement dated back to 5000 B.C [16]. This city is blessed with solar resources. When using a fixed system, its annual production can be as high as 1.78 MWh/m^2 and 1.94 MWh/m^2 on horizontal and tilted surface respectively. Also, while using a two-axis tracking system, the yearly production on horizontal surfaces are the same (as fixed axis system) but the annual daily production increases from 5.33 kWh/m^2/d to 7.18 kWh/m^2/d. The slope and the azimuth angle used in this research are 28.0 and 0 degrees respectively.

Kirkuk (also known as karkuk) is a northern Iraq town that is 86 kilometres south of the capital of Kurdistan. It is located on the coordinate 35°28′0″N 44°119′0″E with huge diverse population (speaking different languages). The city is the site for the ancient mid-3rd millennium B.C. (John Boardman). The slope and the azimuth angle that gives the highest annual yields are 30.0 and 0 degrees respectively. When using a fixed system, its annual production can be as high as 1.82

MWh/m^2 and 2.01 MWh/m^2 on horizontal and tilted surface respectively. Also, while using a two-axis tracking system, the yearly production on horizontal surfaces are the same (as fixed axis system) but the annual daily production increases on tilted surfaces from 5.50 kWh/m^2/d to 7.42 kWh/m^2/d.

As-sulaymaniyah (also called sulamani or slemani) is a modern city is Northern Iraq (Kurdistan). It is located on the coordinate 35°33′26″N 45°26′08″E with a typical semi-arid climate. The city is characterized with wet cold winter and dry hot summer. The slope and the azimuth angle that gives the highest annual yield are 28.0 and 0 degrees respectively. When using a fixed system, its annual production can be as high as 1.81 MWh/m^2 and 1.98 MWh/m^2 on horizontal and tilted surface respectively. A two-axis tracking system will produce 5.44 kWh/m^2/d to 7.33 kWh/m^2/d.

3.2. PV Selection

Varieties of PV-modules panels are available in today's PV market with different characteristics. However, performing a survey of the various characteristics of PVs from different manufacturers and considering mostly the ones that are available, China Sunergy mono-Si - CSUN200-48M (available on the database of RetScreen) which has a peak capacity of 200W is selected.

Table 1: PV module specifications [20]

Item	**Specification**	**Item**	**Specification**
Manufacturer	China Sunergy	Short circuit current	8.83 A
PV module type/ model	Mono-Si - CSUN200-48M	Frame	Anodized aluminum profile
Practical Efficiency	17.12%	Mounting dimensions and thickness	50mm
Module Efficiency	15.7 %	Width and Length	990mm×1956 mm
PV Module Rating/ Rated Power	200 W	Weight	23.8 kg
Voltage [@Peak Power]	35.80 V	Standard operating conditions (SOC)	1000 W/m2, AM 1.5, 25 °C
Current[@PeakPower]	8.37 A	Operating Temperature	-40 °C to +85 °C
Open circuit Voltage.	44.5 V	Operating Relative Humidity.	40% to 95 %

This module is economical and durable with lots of application in different locations in the world. It has a practical efficiency is 17.2 % and a module efficiency of 15%. The full specifications of the PV-module are given in Table 1. The inverters used for this study has an efficiency of 95% and the capacity is 13,000kW [17]–[19].

3.3. Financial and Cost Parameters

To carry-out the economic analysis for the PV plant project, the initial costs of the installation, which consists of PV and inverter costs, balance of system components cost, feasibility studies cost, development cost, engineering costs, periodic costs, and financial parameters are all required to be inputted into RETScreen for two-axis tracking system and fixed system. Table 2 and 3 gives full details of all the financial parameters used in this research. The initial cost that comprised of feasibility study, development/engineering is US$15,006,000 and US$19,561,500 for fixed and two-axis respectively. Additionally, the periodic costs, and operation and maintenance cost are US$77,000 and US$98,000 [17]. 3.2% miscellaneous loss is also used in this calculation [21]. The energy export rate is 130 $/MWh in Iraq currently [22]. It should be noted that for this research, subsidy and other related PV plant policy are not considered as none of these incentives exist in Northern Iraq.

Table 2: Initial and Periodic Costs PV plant

Cost Item Description		
Initial Cost Item.	Fixed	Two-Axis
Feasibility Study.	US$1,500	US$1,500
Development.	US$2,000	US$4,000
Engineering.	US$10,000	US$10,000
Transmission line	US$1,000	US$1,000
Power system and other components	US$15,169,500	US$19,561,500
Periodic Cost Item.	Fixed	Two-Axis

Annual O&M Cost (Annual).	75,000$	96,000$

Table 3: Other parameters [22]

Parameters Description	Values
Inflation Rate	1%
Project Life	25yrs
Corporate income tax	15%
Interest rate	4%

4. RESULTS AND DISCUSSIONS

This section presents the results gotten from analyzing the installation of 10 MW PV plant in three different cities (As-sulaymaniyah, Erbil, Kirkuk) in Northern Iraq. In checking the feasibility, techno-economic parameters are used as discussed earlier. RETScreen software is used for the analysis done in this study and the results are discussed. The discussion is done in two sub-sections: Discussing the feasibility of doing the installation in each location; A comparative discussion of the viability of this PV plant in different location and using different tracking system and Emission reduction achieved.

The proposed PV plant nominal capacity for all the three locations are the same, hence the land requirement. However, the land requirements for the fixed panels is less compared to the panels with two axis tracking system; 65,317m^2 and 70,621m^2 respectively.

4.1. Economic Feasibility

4.1.1. As-Sulaymaniyah

Installing a 10 MW PV plant with fixed panels or panels with two-axis tracking system will export as much as 16,978.3 MWh and 22,777 MWh of electricity annually in As-sulaymaniyah to the grid respectively. The capacity factors of the two systems are estimated as 19.4% for the fixed panels and 26% for the panels with two axis tracking mechanism. The total electricity that will be exported to the grid over the period of 25 years is 424,457.5 MWh and 569,425 MWh for fixed and two-axis systems respectively. The annual revenue generated after considering the discount rate, the inflation rate and other parameters are 2,961,003 US$/yr and 2,207,178 US$/yr for the two-axis and the fixed PV plant respectively. The cumulative cash flow (for As-sulaymaniyah) indicating the payback period for each of the proposed PV plants are shown in fig. 3 and fig. 4.

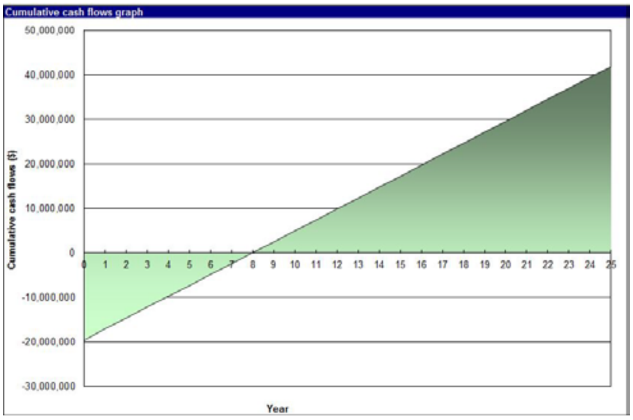

Figure 3: Cumulative cash flow diagram showing the equity payback period for two-axis 10 MW PV plant in As-sulaymaniyah

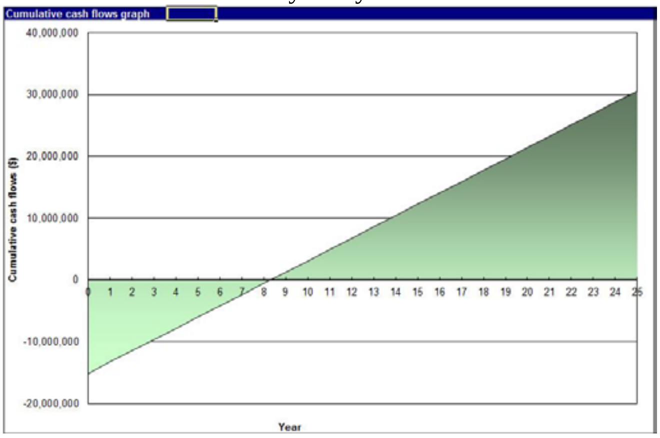

Figure 4: Cumulative cash flow diagram showing the equity payback period for fixed 10MW PV plant in As-sulaymaniyah

4.1.2. Erbil

The result shows that the annual electricity exported to the grid is 16,726.8 MWh and 22,454 MWh for fixed and two-axis systems respectively. The electricity exportation to the grid over the 25 years' life span of the project is estimated as 418,170 MWh and 561,350 MWh for fixed and two-axis systems respectively.

The annual revenue generated after considering the discount rate, the inflation rate and other parameters are 2,174,487 US$/yr and 2,919,002 US$/yr for the fixed and for the two-axis PV plant respectively. The yearly cash flow (for Erbil) for each of the proposed PV plants is shown in Table 4 and 5. Other economic feasibility parameters (NPV, IRR, Payback period) are discussed in detail in the following section while making the comparison of all the locations.

Table 4: Yearly cash flow for fixed 10MW PV plant in Erbil

Yearly cash flows			
Year	Pre-tax	After-tax	Cumulative
#	$	$	$
0	-15,169,500	-15,169,500	-15,169,500
1	2,101,287	1,786,094	-13,383,406
2	2,103,087	1,787,624	-11,595,783
3	2,104,887	1,789,154	-9,806,629
4	2,106,687	1,790,684	-8,015,945
5	2,108,488	1,792,215	-6,223,730
6	2,110,289	1,793,745	-4,429,985
7	2,112,090	1,795,276	-2,634,709
8	2,113,891	1,796,808	-837,901
9	2,115,693	1,798,339	960,438
10	2,117,495	1,799,871	2,760,308
11	2,119,297	1,801,402	4,561,711
12	2,121,099	1,802,934	6,364,645
13	2,122,902	1,804,467	8,169,112
14	2,124,705	1,805,999	9,975,111
15	2,126,508	1,807,532	11,782,642
16	2,128,311	1,809,064	13,591,707
17	2,130,114	1,810,597	15,402,304
18	2,131,918	1,812,130	17,214,434
19	2,133,722	1,813,663	19,028,097
20	2,135,526	1,815,197	20,843,294
21	2,137,330	1,816,730	22,660,024
22	2,139,134	1,818,264	24,478,288
23	2,140,938	1,819,797	26,298,085
24	2,142,743	1,821,331	28,119,417
25	2,142,282	1,820,939	29,940,356

Table 5: Yearly cash flow for two-axis 10MW PV plant in Erbil

Yearly cash flows			
Year	Pre-tax	After-tax	Cumulative
#	$	$	$
0	-19,561,500	-19,561,500	-19,561,500
1	2,825,441	2,401,625	-17,159,875
2	2,827,880	2,403,698	-14,756,177
3	2,830,320	2,405,772	-12,350,405
4	2,832,761	2,407,847	-9,942,558
5	2,835,202	2,409,922	-7,532,637
6	2,837,643	2,411,997	-5,120,640
7	2,840,085	2,414,072	-2,706,568
8	2,842,528	2,416,149	-290,419
9	2,844,971	2,418,225	2,127,806
10	2,847,414	2,420,302	4,548,108
11	2,849,858	2,422,379	6,970,487
12	2,852,302	2,424,457	9,394,943
13	2,854,747	2,426,535	11,821,478
14	2,857,192	2,428,613	14,250,091
15	2,859,637	2,430,691	16,680,782
16	2,862,083	2,432,770	19,113,553
17	2,864,529	2,434,850	21,548,402
18	2,866,976	2,436,929	23,985,332
19	2,869,422	2,439,009	26,424,341
20	2,871,870	2,441,089	28,865,430
21	2,874,317	2,443,170	31,308,599
22	2,876,765	2,445,250	33,753,850
23	2,879,213	2,447,331	36,201,181
24	2,881,662	2,449,413	38,650,594
25	2,881,845	2,449,568	41,100,162

4.1.2. Kirkuk

Installing a 10 MW PV plant will export as much as 16,948 MWh and 22,758 MWh of electricity annually for fixed and two-axis systems to the grid respectively. These electricity export rates result in different capacity factors of the two different tracking systems (19.3% for fixed and 26% for two axis). The electricity that will be exported to the grid over the period of 25 years is 423,700 MWh and 568,950 MWh for fixed and two-axis systems respectively. The annual revenue generated after considering the discount rate, the inflation rate and other parameters are 2,958,558 US$/yr and 2,203,299 US$/yr for the two-axis and the fixed PV plant respectively. The cumulative cash flow indicating the PBP are shown in fig. 5 & 6.

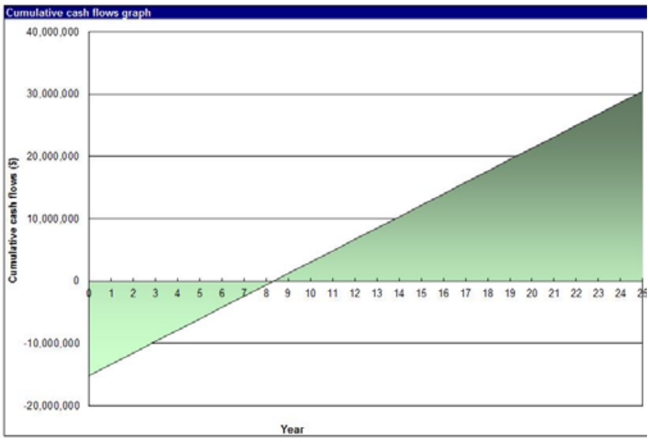

Figure 5: Cumulative cash flow diagram showing the equity payback period for fixed-axis 10 MW PV plant in Kirkuk

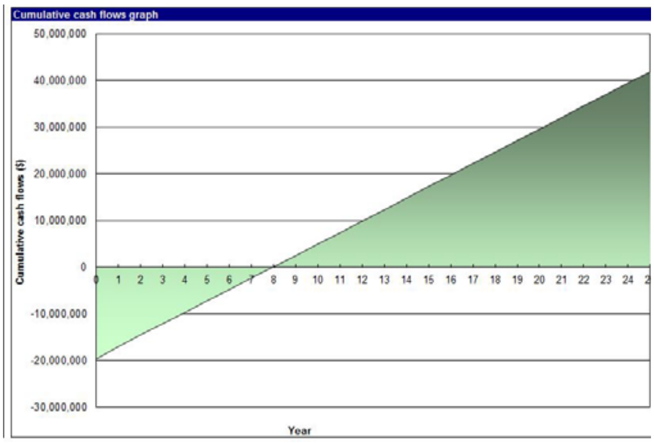

Figure 6: Cumulative cash flow diagram showing the equity payback period for two-axis 10 MW PV plant in Kirkuk

4.2. Comparative Economic Feasibility

4.2.1. Electricity Exported to Grid

One of the main of objectives of this research is to determine the city that has the highest viability considering the economic and other characteristics. As seen in table 1-6, As-Sulaymaniyah has the highest solar energy potential of all the three cities considered in this research. This is also evident on the electricity exported into the grid on both the fixed and two-axis PV system for this city. While As-sulaymaniyah has the highest electricity exportation to the grid, Erbil has the lowest (fig. 7).

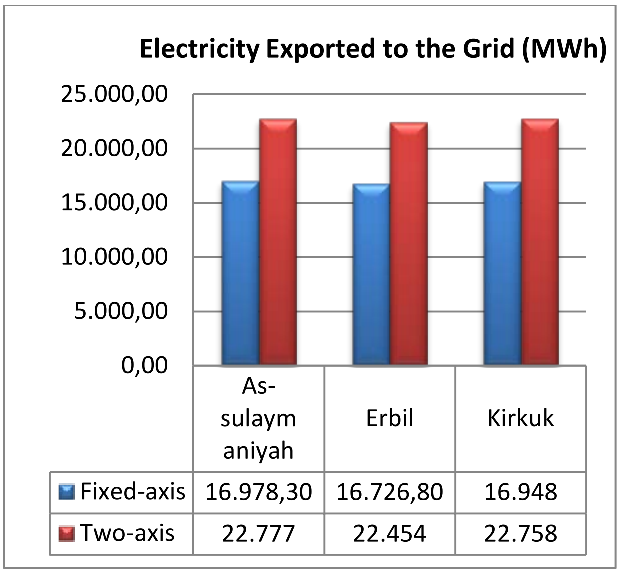

Figure 7: Comparative chat of electricity exportation

4.2.2. Payback Period

Payback period indicates the duration for the project to recoup the initial investment. It utilizes the cash receipts it generates which is calculated using the total initial costs, total annual savings and the total annual costs (but excluding all debt payments). The basic criteria for concluding on payback period is that the smaller the payback period, the more desirable the project for investors. [17]. In this research both the equity payback and simple payback period are considered.

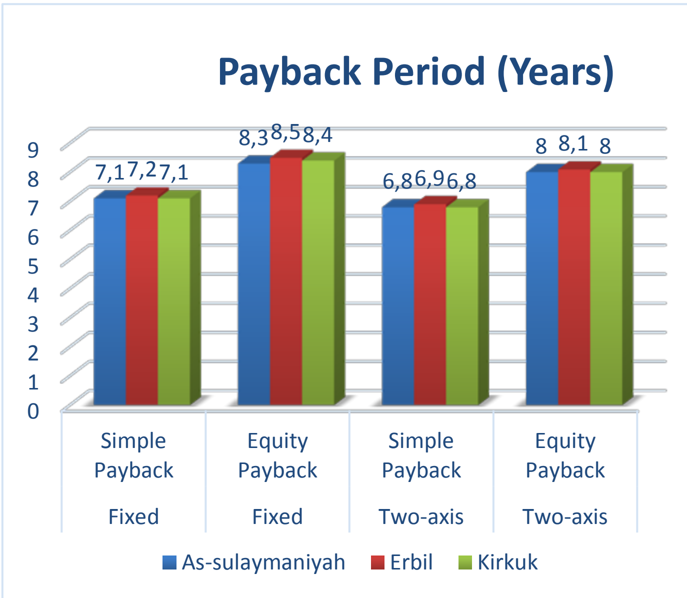

Figure 8: Comparative chat of Payback Periods

The simple payback for this research for the three locations is between 6.8 and 6.9 years for the two-axis system while that of the fixed system is between 7.1 and 7.2 years (fig. 8). Thus, the installation of the project is highly encouraged. The equity payback period is between 8 and 8.1 years for two-axis and between 8.3 and 8.5 for fixed axis PV system.

4.2.3. Net Present Value

NPV present worth of a project considering all the future cash flows that is discounted at the discount rate is calculated. When the net present value of a project is positive, it's an indication that such project will be viable. However, a project is deemed to be profitable or economically viable, if the NPV is a high positive value. For all the cities considered in this study, the NPV is greater than zero and this is an indication that the project is viable for all the locations. Although the difference between As-sulaymaniyah and Kirkuk is not that much in terms of NPV, As-slaymaniyah still has the greatest NPV and Erbil has the lowest (fig. 9).

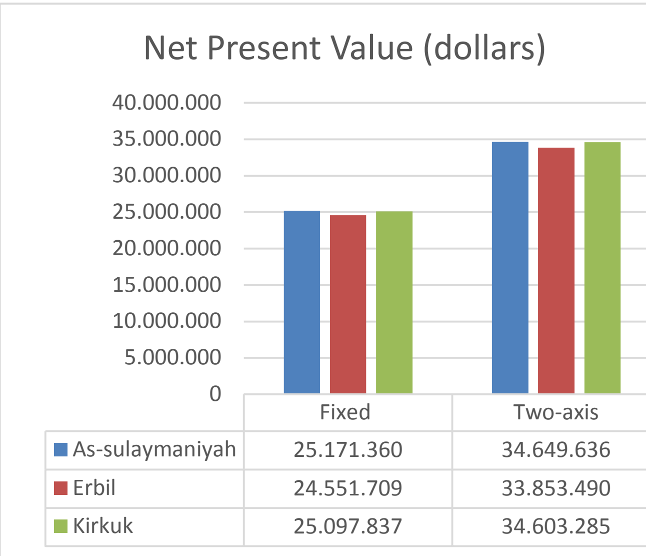

Figure 91: Comparative chat for the Net Present Values

4.2.4. Internal Rate Return

IRR is the time adjusted rate of return i.e. the true interest yield generated by the Project equity over the life of the project. It can be calculated manually by checking for the discount rate that would make the net present value of the intended project to amount to zero. A project is said to be worthwhile if the IRR is greater or equal to the discount rate. Solar PV plant installation for all the cities are viable (fig. 10) based on the pre-tax and after-tax IRR values for fixed or two axis systems.

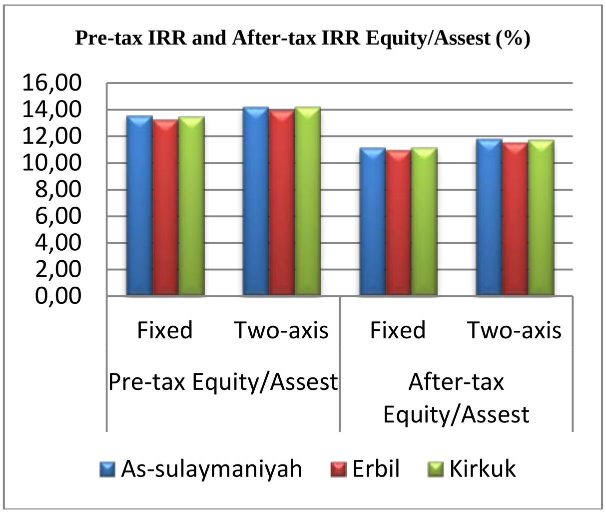

Figure 10: Pre-tax IRR and After-tax IRR Equity/Assets

4.2.5. Other Financial Parameters

Other financial parameters like benefit-cost ratio, energy production cost and annual life cycle saving are considered for this study. Benefit-cost Ratio (B-C) is an economical ratio that consists of the net benefits to costs of the project. B-C is over 1 for all cities (Table 6), which indicates that the investment of 10 MW PV plant (fixed or two axis) is viable.

Table 6: Other economic analysis results

Annual life cycle savings (US$/yr)			
Locations	As-slaymaniyah	Erbil	Kirkuk
Fixed	1,142,950	1,114,813	1,139,611
Two-axis	1,573,327	1,537,177	1,571,223
Energy Production cost (US$/MWh)			
Locations	As-slaymaniyah	Erbil	Kirkuk
Fixed	51.679	52.56	51.88
Two-axis	49.74	50.6	49.49
Benefit-Cost Ratio (%)			
Locations	As-slaymaniyah	Erbil	Kirkuk
Fixed	2.66	2.62	2.65
Two-axis	2.77	2.73	2.77

The lower the energy production cost of a system, the more feasible the project. The energy production cost for the three locations ranges from 49.74 US$/MWh and 52.56 US$/MWh for both two-axis and fixed systems.

4.3 Fuels/Greenhouse Gas Emission Saving

Green House Gases (GHG) are gases that affect the environment directly and indirectly. This includes; carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3) and several classes of halo carbons. One of the main advantages of every renewable energy power project is the direct and indirect reduction of GHG emission. Greenhouse gases that are most relevant to energy projects' analysis are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide N_2O; these gases were considered in greenhouse gases emission reduction analysis. When the installation is done in three different locations in Kurdistan (Nothern Iraq), the yearly GHG emission savings (in tCO_2) for fixed systems for As-sulaymaniyah, Erbil and Kirkuk are 17,027, 16,774 and 16,997 respectively. Using a two-axis tracking system increases these values (Table 7).

Table 7: Other economic analysis results

Locations	**GHG Savings**		**Fossil fuel savings**	
	GHG savings per yr (tCO_2)	GHG saving over 25 years (tCO_2)	Fuel oil savings (litres)	Equivalent of cars & light trucks not used yearly
As-sulaymaniyah (fixed)	17,027	425,661	1,520,508	3,118
As-sulaymaniyah (two-axis)	22,842	571,039	2,039,852	4,184
Erbil (fixed)	16,774	419,357	1,498,029	3,072
Erbil (two-axis)	22,518	562,939	2,010,925	4,124
Kirkuk (fixed)	16,997	424,913	1,517,821	3,113
Kirkuk (two-axis)	22,823	570,567	2,038,150	4,180

The fuel oil saving for each of the locations and tracking systems are well over 1,000,000 litres annually (Table 7). This fuel saving is also calculated in terms of the equivalent cars and light trucks that will not be used yearly and the result is shown in table 7.

5. CONCLUSIONS

Installing a 10 MW PV plant in all the three locations (As-sulaymaniyah, Erbil, Kirkuk) considered is generally feasible. The simple payback period for this installation in all the locations considered ranges from 6.8 years to 7.2 year (Fig. 9). The payback period is quite high in comparison to similar installations in developed countries that are achieving simple payback periods of 3 years or less. One of the main reason for the relatively high payback period is the low electricity tariff for Iraq (130 $/MWh). Installing a PV plant with two-axis tracking system gave the lowest simple payback period (6.8 years).

Considering other economic indicators; IRR, NPV, annual life cycle savings and BCR, the project is highly feasible. The NPV for all the cases considered indicates that the project (s) are viable. Installing a two-axis 10 MW PV plant in As-sulaymaniyah will save as much as **US$**1,573,327 per year. In terms of benefit cost ratio, Kirkuk and As-sulaymaniyah gives the best result (2.77%) among the three sites considered.

Using a two-axis tracking system is generally economically better than a fixed system. According to the weather data, As-sulaymaniyah has the highest solar potential hence the best economic analysis results. Although PV plant at Erbil has the lowest viability among the three, this location may have potential of encouraging investors since it's a capital city. Also, it should be noted that the difference in economic viability among the three sites is small, one may easily conclude that all three sites may be considered for investment.

The research targeted at providing an alternative way to meet the energy requirement in Northern Iraq, installing 10 to 20MWp of two-axis system in northern Iraq will solve the existing power problems currently faced in some part of Kurdistan.

Considering Iraq as a country that emits sizeable amount of greenhouse gases, implementing this project abate some considerable emissions into the atmosphere. Reduction of GHG emission is currently a global issue and all nations are trying to achieve. Installing a 10 MW PV plant in any of the three locations considered will save at least 419,357 tonnes of CO_2 equivalence emission from the atmosphere. This project will also increase energy security, sustainability and equity of the country thereby increasing its political status in global energy ranking.

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