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RESEARCH ARTICLE

SOLAR PHOTOVOLTAIC GENERATION POTENTIAL AND PLANT CAPACITY IN NORTHERN IRAQ

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ABSTRACT

Energy is an essential requirement globally, a reliable supply of energy is vital for our modern life; nowadays the majority of the energy supply comes from non-renewable energy sources such as fossil fuel. In the last three decades "Global Warming" has increasingly become a major concern for the future of our planet. More dependency and the use of fossil fuel to generate electricity in order to match the rapid power demand due to development of technology and increasing populations have resulted in huge pollution and damage of the environment. The reliance on fossil fuel sources needs to be reduced by efficient energy management and replacement with renewable energy sources. Solar energy photovoltaic cells (PV) have emerged as promising candidates. This study aims to introduce the feasibility and potential of solar electricity generation on the basis of solar radiation data gained from Agro-Meteorological-sub-sector [1], in the Erbil-Northern Iraq region. Analysis using linear regression and insolation data available for the region suggests that significant electricity output can be generated using solar power from available fixed plant areas. The results and the measurement calculations used justify and support clearly the method been utilised in the study.

INTRODUCTION

Energy has transformed the way in which humans live, travel and work. Energy is essential in economic development (Mohammedi *et al*., 2014); without a reliable energy supply it is difficult to achieve and sustain economic growth. Modern technology is reliant on a reliable supply of energy and directly influences our lifestyles. Currently, the majority of the energy supply comes from non-renewable energy sources. It causes substantial damage to our environment (Suresh Kumar and Manoharan, 2014), therefore, the renewable energy alternative can play an essential role in replacing non-renewable energy sources mainly fossil fuels including coal, oil and gas (Ouattara *et al*., 2013). Most of solar (PV) panels are mainly used for off-grid purposes; therefore, there is no large long construction power lines needed to cover all areas. The off-grid PV system's storage device is via a battery used to store excess electricity which helps the cell to run for some time whilst there is limited or no sunlight (Trapani and Millar, 2013). Solar energy from the sun can be produced in a variety of ways, especially with the rapid development of technology including silicon solar cells, flexible organic solar cells (Hamad and Alsaad, 2010). Currently, although increasing in trend, there is little research on developing solar cells on graphene, a two dimensional carbon sheet, which has a thickness of a single layer of carbon atoms (Wang *et al*., 2008). New applications will emerge and the potential to place graphene based solar cells on wide range of surfaces. This will expand applications considerably (Patlitzianas *et al*., 2013) even though numerous applications have been developed since early civilisation. Using Photovoltaic Geographic Information System (PVGIS) (Šúri, 2004) or radiation databases, this system needs data on solar radiation to provide estimations of PV system performance. Variations in climates provide different solar radiation levels make the accuracy of the data not exact, therefore, hence the need to understand the strength and weakness of the data sources. Two types of solar radiation sources of data at the earth's surface are ground measurements and calculations based on satellite data. A pyranometer is used for solar radiation, at ground measurement level, to measures radiation from the sun (Ashhab *et al*., 2013). This device is an actinometer, which measures broadband solar irradiation on a planer surface employing a sensor especially designed for measuring solar flux density at 180°. Ground measurements generally provide the best results. Solar radiation estimation (Huld and Gambardella, 2012) from satellites use a number of

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different methods to calculate and estimate solar radiation for ground measurement using data from satellites. For solar calculations, measurements need to account for reflected radiation from the atmosphere and clouds. In addition, there are different types of satellites measurements to estimate solar radiation levels (Šúri and Dunlop, 2005). Security and stability issues along with rich reserves of oil and gas in Northern Iraq has led to rapid economic development and large increases in the population due to large immigration from the rural areas and from the outside regions, such as southern Iraq and North Eastern Syria. The area has thus experienced a rapid increase in electricity demand. In addition, the electricity production needed significant rehabilitation and technological development in order to supply reliable power to meet increased demand for electricity. Statistics in Northern Iraq shows that the total demand in 2004 was 829 MW which has reached 3279 MW in 2012, almost 4 times higher over a decade with its highest jump of around 100% in one year (Meurs, 2008). The region was only producing 482 MW in 2007 and more recently has reached to a level of 2700 MW in 2012 (kurdishglobe.net, 2013). Carbon dioxide (CO_2) level in Kurdistan between 2003- 2008 was 25-30 million tons, indicating an increase in the air pollution. Evidence shows that environment pollution is occurring such as black cloud. Large numbers of generators also produce huge CO_2 emission into the atmosphere.

They supply the local population with electricity because government cannot supply all of the electricity demand. These problems are causing serious health concerns for the region's population. Currently, there is no effective environmental policy or legislation to help to reduce the use of fossil fuels and at the same time encouraging the use of alternative renewable energies for generating electricity and thus preventing further pollution (kurdishglobe.net, 2013). Figure 1 shows that only a small percentage of renewable energy currently being used in the region.

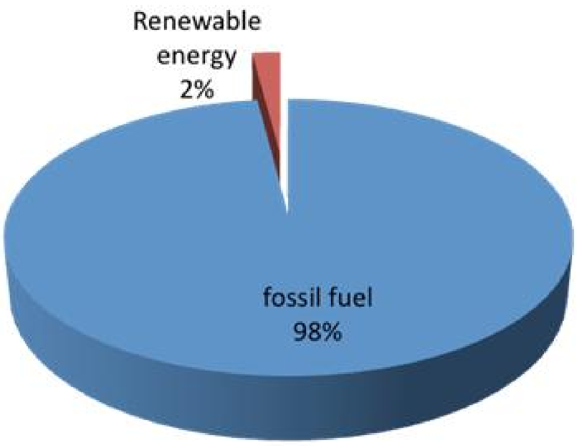

Figure 1. Renewable energy and fossil fuel use in Northern Iraq

Clearly reliance on fossil fuels needs to reduced and replace with renewable energy from solar sources. Some work on research and development activities of solar energy and its various aspects in the Kurdistan region of Northern Iraq have been carried out over the last decade. Work related to energy output of photovoltaic (PV) module in different regions of Iraq (Ganguli and Singh, 2010) and approaches for formulating the amount of solar radiation at ground levels. This paper first develops the relationship between the input solar radiation onto a photovoltaic cell and the corresponding output power using statistical linear regression analysis from available experimental data. This input-output relationship is then used in the formulation of an estimate of the total available yearly output energy from a hundred square metre available solar area.

MATERIALS AND METHODS

The sunlight impinging on the panels, i.e. irradiance or insulation (incoming solar radiation), is measured in units of Watts per square meter (W/m^2). Using this data the available power output (W) from the photovoltaic module (PV) given the input solar radiation can be calculated using data from (Ganguli and Singh, 2010) with statistical analysis based on linear regression. The goal of linear regression is to produce a best line (mathematical expression) that fits observations made; this is done by minimising the squared deviations of the observed points from that of the best line.

i.e. $$S = \sum_{i=1}^{n} d_i^2$$

where d_i is the i^{th} residual associated with the n data points and S is the total error to be minimized. When a regression line has been found, it can be used to predict a value of the dependent variable. Fundamental assumptions in linear regression analysis are needed in order to execute the analysis properly: there needs to be a linear relationship between the independent and dependent variables; the residuals have to be normally distributed and that the calculated values are consistent with observed values.

RESULTS AND DISCUSSION

To calculate a relationship for the solar radiation available on the titled surface and the energy output of the PV generator, data from a photovoltaic module BP SX PV was used (Ganguli and Singh, 2010), see Table 1 below: Figure2 shows the line of best fit for the above data from which the following relationship is obtained;

$$P = 0.151\,SR - 2.568$$

This equation gives an effective power output for a photovoltaic module given solar radiation input and used in subsequent sections enabling for calculations of power outputs to be made. Understanding PV system design is very important to obtain availability of the amount of sunlight at particular location at a given time. Two common methods generally characterise the radiation and they are solar radiance (radiation) and solar insolation. Solar radiance is a direct power density with units of kW/m^2, which varies during the day from 0 kW/m^2 at night to highest, reaching 1kW/m^2, and is dependent on local temperatures and whether conditions at the location. To take measurement of solar radiance instruments such as a pyranometer (measuring global radiation) or pyrheliometer (measuring direct radiation) are generally used. Whilst the most commonly measured radiation is solar irradiance, however, the more common radiation data that is useful and used in the system design methods is the solar insolation. Solar insolation is the total solar energy amount received at a particular location throughout a specified period of time, usually measured in kWh/m^2/day units. Solar insolation is the direct solar irradiance average over a period of time, and the data for solar insolation is used for simple system designs of PV while solar radiance can be used for much more complicated system design of PV performance.

Table 1. Solar radiation and power output

Solar Radiation (W/m^2)	Power (W)
0	0
400	55
600	85
800	120
1000	150

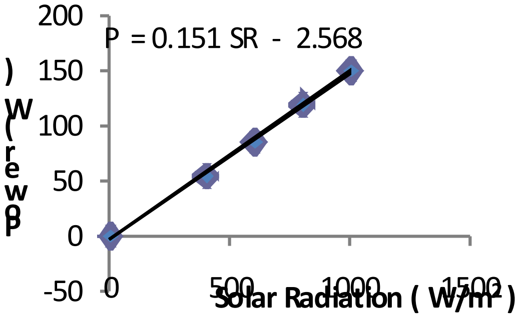

Figure 2. Relationship between solar radiation against power output

$$\frac{3\times10^7}{3\times10^9} \times 100 = 1\%$$

Table 3. Solar Insulation average for each month and the possible output

Month	kWh/m^2/day insulation	Wh/m^2/day insulation	Daily PV Output Wh/m^2(15.1%)
Jan	3.69	3690	557.19
Feb	4.16	4160	628.16
Mar	5.12	5120	773.12
Apr	5.46	5460	824.46
May	6.06	6060	915.06
Jun	6.62	6620	999.62
July	6.52	6520	984.52
Aug	6.51	6510	983.01
Sep	6.32	6320	954.32
Oct	5.12	5120	773.12
Nov	4.11	4110	620.61
Dec	3.47	3470	523.97
Total	63.16	63160	9537.16

Using an area of 100m^2 of solar panels approximately 1% electricity generation is possible for this region. Obviously, this can make a significant contribution for the electricity needs of the local population. Evidently, with larger areas even higher outputs can be achieved and with the new generations of flexible solar cells being developed this offers possibilities of replacing a significant percentage of electricity generated by fossil fuels with renewable solar energy.

Table 2. Time and direct normal irradiance (W/m^2) in Erbil

Time:	6:07	7:07	8:07	9:07	10:07	11:07	12:07	13:07	14:07	15:07	16:07	17:07	17:52
DNI:	410	587	697	766	809	831	837	827	800	752	674	551	410

Table 2 shows for a typical day in June the direct normal irradiance at different times of the day. Figure 3 shows this output graphically. As seen this irradiance fluctuates and varies throughout the day from a minimum to maximum value.

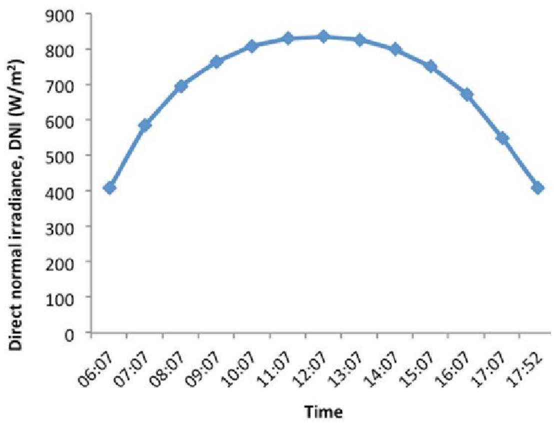

Figure 3. Variation of solar radiation in a typical day in June

Data was obtained from solar radiation database PVGIS-CMSAF. Using our relationship for solar radiation and power output, calculations for the output from the PV module can be made and are shown graphically in Figure 5 above. Using the data from Table 3, calculations can be made to estimate the possible plant output for Erbil in Northern Iraq. Since the total year electricity demand in Northern Iraq (Kurdistan) is approximately 3000MW a year (kurdishglobe.net, 2013). A solar plant with a 100m^2 area can generate around

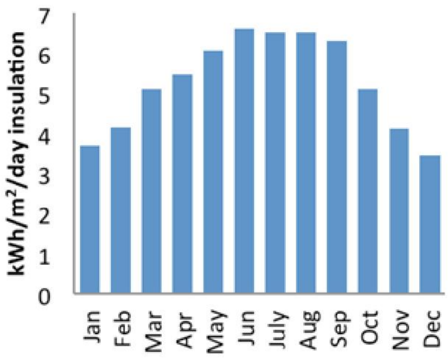

Figure 4. Daily solar insulationfor each month

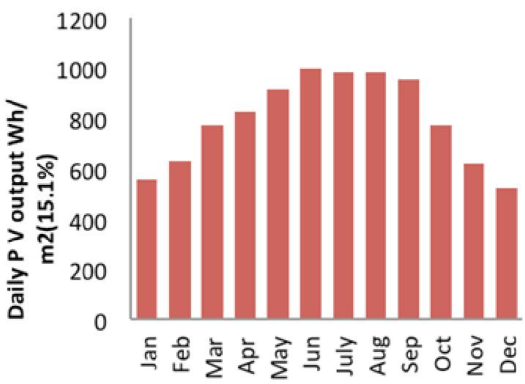

Figure 5. Daily PV outputfor each month

Conclusions

Northern Iraq has a natural potential for developing renewable energy via solar power generation contributing to the domestic supply of electricity needs. Calculations using $100m^2$ of solar panels show potential to generate an output equivalent to 1% of the region's needs. A much greater area capacity future plant could generate much higher outputs. This outcome calculation and average output do not reflect the actual scenario of solar power generation output potential of the entire region of Kurdistan in Northern Iraq. Maximum power calculations need to be done from the readings that would provide much higher results. With improvements in solar panel technology and ever increasing efficiency outputs higher possible output will be obtained in the future. Currently, in the region only 2% of renewable energy has been utilized, generally this study suggests a potential for improving this percentage to a much higher level. While only 1% of the region's electricity demand can be offered from a project of $100m^2$ solar power plant, if three such solar power plants each of $100m^2$ area are established in three major cities for the region then this could provide a 9% output of the electricity demand making a significant contribution in the region.

REFERENCES

Mohammedi, A., N. Mezzai, D. Rekioua, and T. Rekioua, "Impact of shadow on the performances of a domestic photovoltaic pumping system incorporating an MPPT control: A case study in Bejaia, North Algeria," *Energy Conversion and Management,* vol. 84, pp. 20-29, 8// 2014.

Suresh Kumar, U. and P. S. Manoharan, "Economic analysis of hybrid power systems (PV/diesel) in different climatic zones of Tamil Nadu," *Energy Conversion and Management,* vol. 80, pp. 469-476, 4// 2014.

Ouattara, A., L. Pibouleau, C. Azzaro-Pantel, and S. Domenech, "Economic and environmental impacts of the energy source for the utility production system in the HDA process," *Energy Conversion and Management,* vol. 74, pp. 129-139, 10// 2013.

Trapani, K. and D. L. Millar, "Proposing offshore photovoltaic (PV) technology to the energy mix of the Maltese islands," *Energy Conversion and Management,* vol. 67, pp. 18-26, 3// 2013.

Hamad, A. A. and M. A. Alsaad, "A software application for energy flow simulation of a grid connected photovoltaic system," *Energy Conversion and Management,* vol. 51, pp. 1684-1689, 8// 2010.

Wang, X., L. Zhi, and K. Müllen, "Transparent, conductive graphene electrodes for dye-sensitized solar cells," *Nano letters,* vol. 8, pp. 323-327, 2008.

Patlitzianas, K. D., G. K. Skylogiannis, and D. Papastefanakis, "Assessing the PV business opportunities in Greece," *Energy Conversion and Management,* vol. 75, pp. 651-657, 11// 2013.

Šúri M., H. J. "A New GIS-based Solar Radiation Model and Its Application for Photovoltaic Assessments. ," *Transactions in GIS,* vol. 8, 2, 175-190 2004.

Ashhab, M. d. S. S., H. Kaylani, and A. Abdallah, "PV solar system feasibility study," *Energy Conversion and Management,* vol. 65, pp. 777-782, 1// 2013.

Huld T., M. R. Gambardella A, "A new solar radiation database for estimating PV performance in Europe and Africa.," *Solar Energy,* vol. 86, 6, , 2012.

Šúri M., H. T. A., Dunlop E.D, "PVGIS: a web-based solar radiation database for the calculation of PV potential in Europe. ," *International Journal of Sustainable Energy,* vol. 24, 2, 55-67, 2005.

Meurs, P. v. *Comparative Analysis of the Fiscal Terms of Iraqi Ministry of Oil and Kurdistand Region Model Contracts*. London: Clifford Chance LLP, 2008.

kurdishglobe.net. (2013, 14/02). *Power production to double in three years*.

Ganguli, S. and J. Singh, "Estimating the Solar Photovoltaic generation potential and possible plant capacity in Patiala," *International Journal of Applied Engineering Research, Dindigul,* vol. 1, pp. 253-260, 2010.

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