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RESEARCH ARTICLE

REDUCTIONS IN CO_2 EMISSIONS FROM ELECTRICITY GENERATION FROM SOLAR ENERGY AT SULAYMANYAH AIRPORT IN KURDISTAN, IRAQ

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ABSTRACT

The gradual increase in the earth's temperature in the last three decades highlights how global warming has become a major concern for the future of our planet. To meet the world's needs for low CO_2 power generation, alternatives to conventional fossil fuels are required. Solar energy is an attractive alternative that represents a vast resource which can be harnessed in all regions of the world. Dependency on fossil fuels to generate electricity in order to match the rapid power demand and increasing populations has resulted in huge pollution and damage to the environment. This paper considers the electricity demand and the amount of CO_2 reductions of Sulymaniah International Airport in Kurdistan, Iraq. The cost of replacing a proportion of the conventional fossil fuel power generation with solar energy is first estimated and then theoretical calculations of possible reductions in CO_2 emissions are presented.

INTRODUCTION

Solar energy is particularly attractive due to the abundance of solar irradiation [1], which if harnessed appropriately has the potential to supply all the global energy requirements. It is environmentally friendly and does not require extensive and expensive infrastructure to implement since solar systems are installed and generate electricity on-site compared to power stations many kilometres away from the point of use. Solar cells efficiencies [2] are also rapidly improving and reliability increasing with the use of new materials and technologies and hence these trends will enhance the implementation of solar solutions [3]. Solar energy is modelled as packets of energy called photons. The photons that impact on a material are absorbed and this energy is transformed to excite electrons within the material. The change of energy can be captured and converted into electrical power. In solar photovoltaic (PV) modules, sunlight is absorbed by the solar panels producing electrical changes within them which are used to generate electrical power for output use. Energy generation and the impact it has on the climate can be characterised by its carbon emission intensity i.e. a measure of the CO_2 or other greenhouse gases such as methane CH_4 or nitrous oxide N_2O which are released into the environment. Figure 1 shows how emissions have been increasing over time.

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MATERIALS AND METHODS

Global warming due to the rise in the earth's temperature has been gradually rising as seen in Figure 2. A comparison of the amount of carbon emission intensity produced from different technologies is shown in Figure 3 below [4]. It can be seen from the above figure that renewable technologies produce little or no emissions during operation but can produce some emissions during the manufacturing phase. The majority of CO_2 comes from coal and gas as expected and the use of these to generate electrical power needs to be reduced. Nuclear energy does not generate much CO_2 but has issues related to disposal of waste whilst wind energy requires the use of space steady flow of wind across the blades and wind turbines. Hence, PV seems like the most attractive and user friendly alternative. Therefore this option has been explored further in this study. We consider the operation and electricity demand of Sulymaniah international airport in Kurdistan, Iraq. A solar energy plant which can supply approximately 7.3% of the airports electricity demand will be considered with its estimated set up costs. Cost analysis of such a plant in the region has been carried out previously [5]. Analysis of the cost benefits and CO_2 emission reductions using the solar plant can

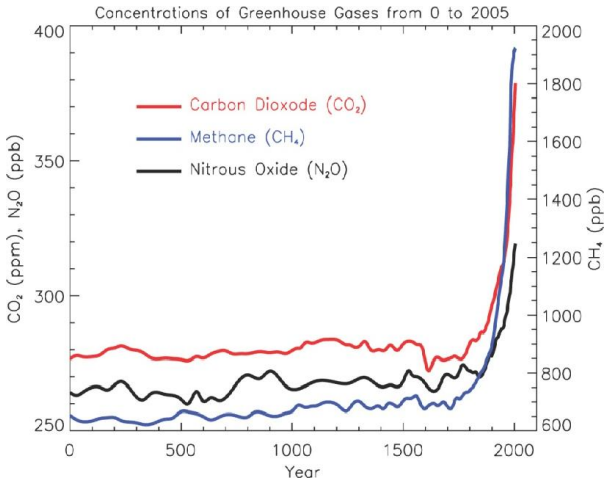

Figure 1. Concentration of Greenhouse Gases [6]

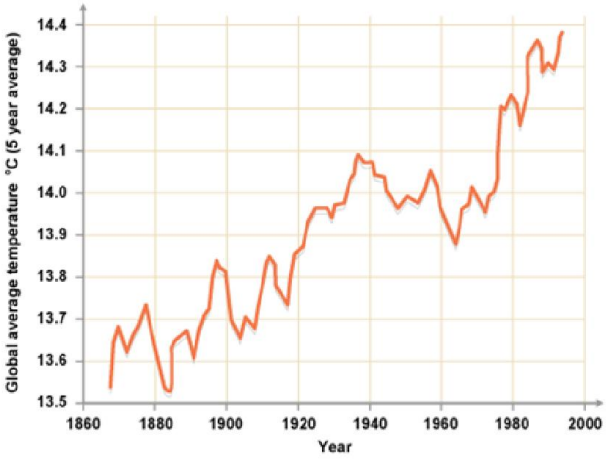

Figure 2. Global average temperature of the earth [6]

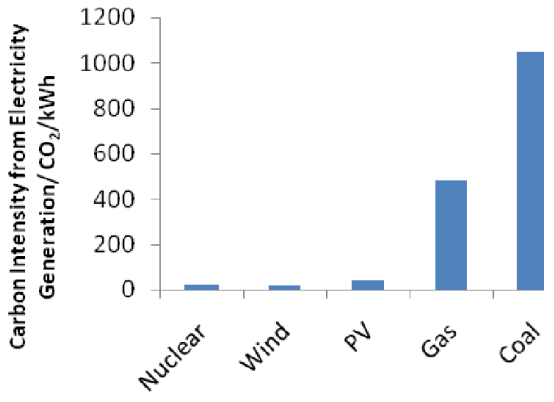

Figure 3 Types of Electricity Generation

now be considered. The reduction CO_2 emissions is a function of the amount of conventional power being displaced, its carbon intensity and the amount and type of energy consumed in the manufacturing and set up of solar energy plant.

RESULTS AND DISCUSSION

Insolation and energy output

Solar insolation for the Kurdistan, Iraq region varies throughout the year and the total energy output for an available area to generate a 315 KW solar plant shown in Table1 [5]. Figure 4 shows the total energy output for the plant. Clearly the peaks in energy outputs occur in the months of summer June, July and August. The international airport electricity consumption demand and costs are shown in table 2.

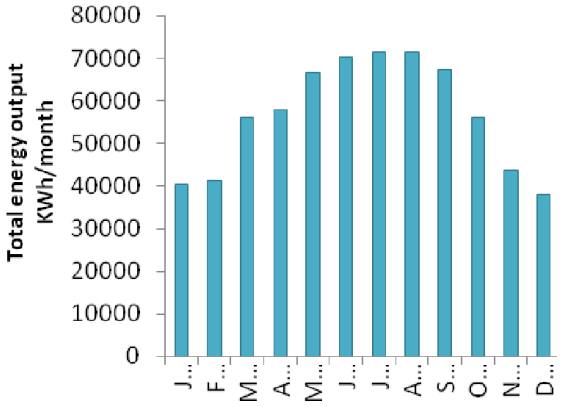

Figure 4. Total energy output for available area

Table 1. Monthly energy output and total energy output using available area for the plant in Northern Iraq [7]

Month	Unit (kWh)	Cost (£)
Jan	745158	11400.92
Feb	800428	12246.55
Mar	619136	9472.78
Apr	561406	8589.51
May	650623	9954.53
Jun	915408	14005.74
July	936244	14324.53
Aug	1036399	15856.90
Sep	916440	14021.53
Oct	705736	10797.76
Nov	771288	11800.71
Dec	717955	10984.71
Total	9376221	143456.17

Table 2. Monthly energy consumption and its costsfor Sulaymanyah International Airport near Erbil [7]

Month	Energy output (KWh/month)
Jan	40574
Feb	41314
Mar	56298
Apr	58100
May	66634
Jun	70444
July	71691
Aug	71581
Sep	67252
Oct	56298
Nov	43734
Dec	38155
Total	682075

Figure 5 and 6 show the energy demand and cost of the energy at Sulaymanyah International Airport respectively.

A 315 KW solar energy plant could make available.

$$\frac{682075 \ kWh}{9376221 \ kWh} \times 100 = 7.3\ \%$$

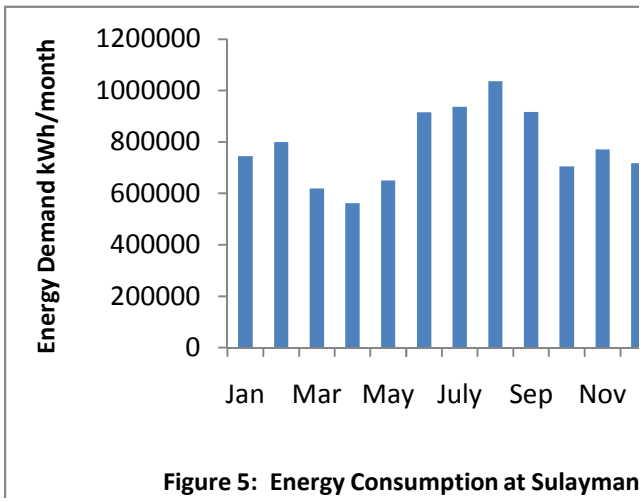

Figure 5: Energy Consumption at Sulayman

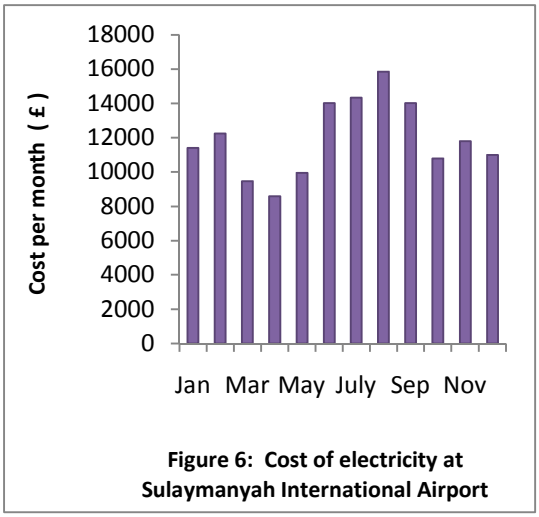

Figure 6: Cost of electricity at Sulaymanyah International Airport

This amount of conventional fossil fuel energy for the airport could be replaced by solar energy using photovoltaic cells and hence corresponding reductions on CO_2 emissions can be estimated for this region. Determining the carbon footprint of one kilowatt-hour of electricity produced by the different methods is not exact, using as many life-cycle analyses, an average value for the different methods can be obtained as shown in table 3 below [7]. Taking the average values for the CO_2 emissions for Coal gives 0.909 kg CO_2 /kWh and for Solar (PV) gives 0.105kg CO_2/KWh. Using these values an estimate of the reduction in CO_2 emissions can be made.

Table 3. CO_2 released for one kilowatt-hour produced by some power generation methods grams CO_2 /kWh

Source	Coal	Natural Gas	Oil and Diesel	Solar / PV
ADEME Carbon Inventory, low	800	430	-	60
ADEME Carbon Inventory, high	1,000	-	-	150
PLC, Inc	889	517	894	-
Oak Ridge National Labs	948	449	748	-
AVERAGE	909	465	821	105

Energy Production	Carbon Dioxide emissions (kg CO_2)
Fossil Fuel	682075 x 0.909 = 620006.18 kg
Solar Photovoltaic	682075 x 0.105 = 71617.88 kg
Total Reduction in CO_2 emissions	548388.3 kg

Conclusions

Regions such as Sulaymanyahin Kurdistan, Iraq have a good number of sunshine hours a day throughout the whole year and are ideal places to utilise and harness the solar energy available from the sun. A solar plant with a capacity to generate around 7.3% of the airport's yearly demand was found to have a potential to reduce the carbon dioxide emissions by 0.55 million kilograms a year. Considering this over a period of the average life span of a solar photovoltaic system of twenty years, gives rise to huge savings in CO_2 emissions in the region of eleven million kilograms. These reductions will only occur if initial investment costs of setting up such a plant are incurred, however over the average life span of the solar plant almost half of the initial costs would be recovered. This shows that if reductions in harmful greenhouse gases are a serious target for the future of the world's population then making use of renewable energy such as solar energy has huge potential. Use of multiple solar plants throughout the country would have a significant impact on CO_2 emissions. Although other renewable energy sources have very low CO_2 emissions, the use of solar energy is a more viable option in certain remote regions since these systems can be set up as stand-alone operations without a national grid structure. There is a urgent need to use alternative sources of energy that do not have adverse effects on the earth's atmosphere. With continuous reduction in costs and increasing efficiencies in solar PV technology this method of energy generation has huge potential both for being environmentally friendly and as an attractive alternative to fossil fuels.

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