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# Design and Simulation of Hybrid System for Generation Electricity in Iraq

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**Abstract**

An economical possibility study and a whole design procedure of a hybrid ( Solar – Diesel) system consists of pho-tovoltaic panels and a diesel generator as a backup system has been implemented in this paper. The proposed system was designed in Iraq at a rural site. It is found that providing small amount of electricity for a home using this proposed system is very useful and viable with other types of conventional energy sources as it decreases both operation costs and air pollution.

***Keywords:*** Solar Energy, Diesel generator, Off grid

## 1. Introduction

Two types of technologies are widely used in the generation of power, the first and the oldest one was the classical power generation using fossil fuel, whereas the second one is the renewable energy technologies where they have rapidly improved due to the increasing the efficiency of power generation and to reducing in their costs. The other factor that make the using of the renewable technologies very important is the fact that the how to transmit and distribute of energy generated from fossil fuels in remote areas was very difficult and expensive, while generating renewable energy for these areas can offer a suitable source [1]. The solar power is infinite, site-dependent, non-polluting, and high potential source for backup energy production, it's widely used nowadays [2].

The main suitable option for supplying electrical energy for remote areas is the diesel generator (DG) because of their compact design and high specific power, but the major drawback of using this system is the cost of operation which is influenced by load profiles which are affected by the economic condition [3].

The photovoltaic system can be install and customize in a very short period, as well as the diesel generators, that are not cost effectual systems, mainly in rural areas. [4] This is so called hybrid power system which combines between the high primary cost of PV system with the low primary cost of DG. [5] This combination of photovoltaic – diesel system has feasible economic in a lot of applications used for supplying power energy in remote area that there is no grid energy. Taking into account that Photovoltaic – DG is better than stand alone PV system or stand alone DG system. [6]

The main advantages of renewable energy technologies are, produce sustainable and clean power energy source in addition to low maintenance cost and low operating power cost [7].

The photovoltaic systems can be installed in rural areas independent of electricity network. Many systems are built in Cambodia, Latin America, Iran, Kyrgyzstan and Maltese islands as well as China, Bangladesh , South Africa, and Brazil [8].

The main reason of using hybrid system or the combined of different energy resources are to allow the improvement of the whole system reliability, efficiency of the supplied power and to reduce storage power energy [9].

The hybrid renewable energy system such as PV-DG power system presents some properties that includes decrease in operating cost by made the operating time of the generator low, also lead to low pollution of the environment and low costs of maintenance [9].

There are some researches that illustrate the importance of using hybrid (solar-diesel) in order to support the grid power and minimize the cost of power. Such as, Wei Zhou [ 11] established by making a comparison between the prediction and the measured data of the field.

Yousif El Tous [12] represented a universal and flexible model for sizing and selecting hybrid off grid Photovoltaic and Wind system, the main aim of their research is develop a comprehensive model with the automatic sizing and selection of the optimum size of Wind PV and battery banks, the system depends on the electrical load to be supplied, the wind and PV resources and the needed backup time.

As shown at the previous studies Wei Zhou deals with photovoltaic power only, where it will be weak source for supplying power to loads, Yousif El Tous using photovoltaic – wind energy sources that wind energy is not useful energy source for this region while wind speed is almost low.

In this research, electric energy was supplied using photovoltaic- diesel energy sources to a remote area in Iraq, since the solar radiation is good and the fuel was available. Modeling studies in the previous papers fulfilled that hybrid PV-DG system has an obvious advantage more predictable stand-alone DG system for a rural area electric energy. It was verified to reduce the fuel consumption, operating cost and maintenance cost. Using essential input data, the PV and the generator output powers and the consumption of fuel were perfectly predicted and validated using the data of experimental.

## 2. **Problem Modelling**

### *A. Photovoltaic System*

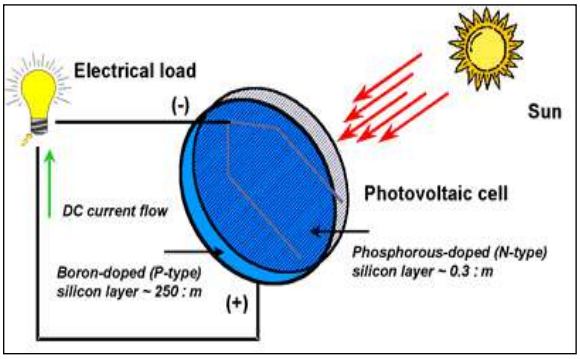


Figure 1: electricity generation from solar cell

Figure1 shows the electrical generation from solar cell. Photovoltaic array is build up by combining series/parallel combination of PV cells, that is generally can be represented by an equivalent circuit form as shown in Figure 2.

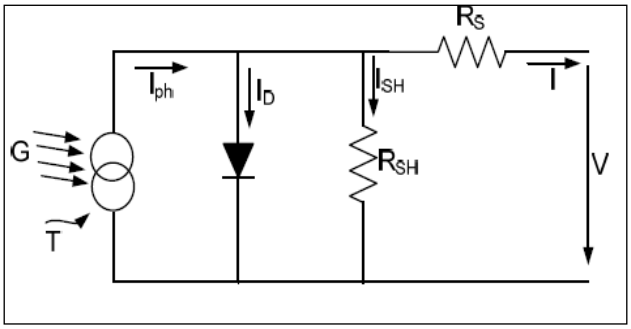


Figure 2: the equivalent circuit of photovoltaic cell.

Iph is represent the photo current which proportion directly to solar radiation G. Bothe T which represent the temperature and photo current Iph have a linear relationship [11].

The output power of the Photovoltaic array be able to obtain by using the following equation:

$$P_{pv}(t) = I_{ns}(t) \times A \times E_{ff}(pv) \qquad (1)$$

Where$I_{ns}(t)$ is isolation value at t time (kW/ $m^2$), A represents the single Photovoltaic panel area ($m^2$), $E_{ff}(pv)$is the overall efficiency of the Photovoltaic panels and dc/dc converters.

### *B. Diesel Generation Structure*

The DG shown in Figure 3 is commonly assemblage of a synchronous generator connected to a diesel engine. The frequency of an alternating current output is kept by a regulator speed. The regulator operates by regulating the fuel flow of in order to remain the speed of the generator speed and the engine constant. [9].

The consumption of fuel of DG unit has a relationship with the rated power and generated power. The cost of fuel consumption can be calculated for an annum as the following equation:[9]

$$\mathrm{AFC} = \mathrm{C_f} \sum_{t=1}^{\mathrm{Tend}} \mathrm{F(t)}$$

Where AFC represents is the annual cost of fuel of DG , F(t) represents the consumption of fuel per hour (I.D. /hour) [10].This factor can be calculated using the following equation:

$$\mathrm{F(t)} = (\ 0.246 \times \mathrm{P_{DG}(t)} + \ 0.08415 \times \mathrm{P_R})$$

Where PR represents the rated power of DG in kW, PDG(t) represents the generated power by DG in kW ,$C_f$represents the fuel cost per liter for example1.28 I. D.

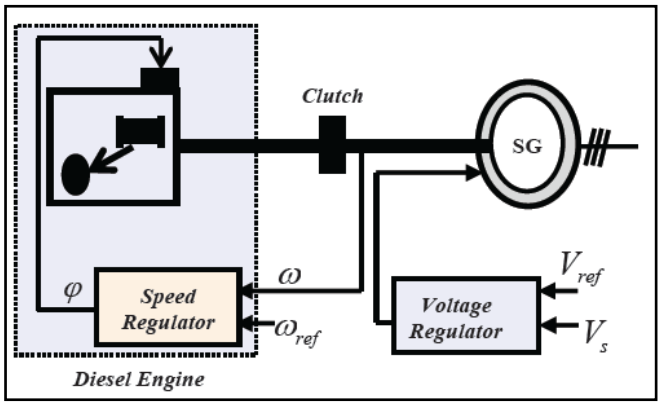


Figure 3: The structure of diesel generator

### *C. Modeling of Solar-Diesel Scheme*

The configuration model of PV - DG system that used in this research is shown in Figure 4. PV model follows I-V characteristic. The variables that are used as an input data of this proposed model are the radiation of solar and cell temperature of PV panels shown in Figure 5.

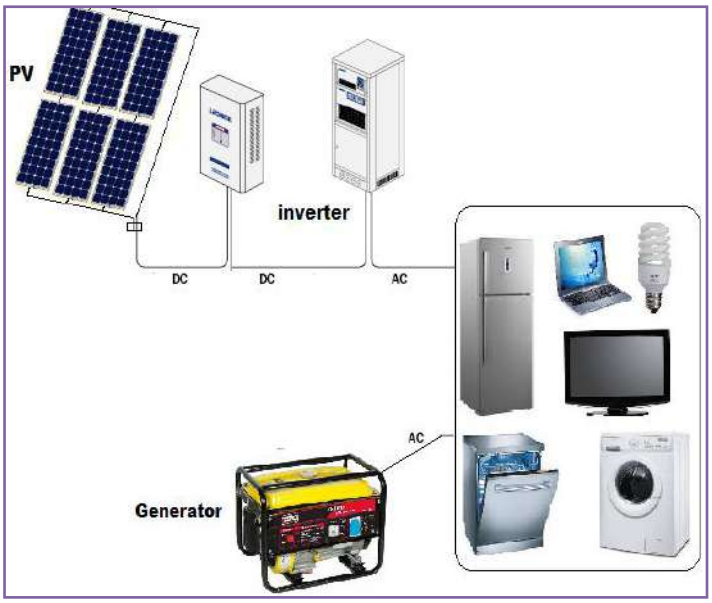


Figure 4: Scheme of Hybrid power system

## 3. Control Strategies

The solar radiation for a week in Iraq are measured in January as shown in Figure 5.The proposed loads maintained in this research listed in table 1. The control strategy that has been applied for this research is shown in the flowchart that shown in Figure 6 which explain the steps that must be taken in order to turn-on the loads with the solar radiation availability, and in maximum demand of load it should be supported the system by turn-on the diesel engine .

According to the real data that calculated for week at a region Iraq , Figure 5 shows the solar radiation that will used to generate power from PV system.

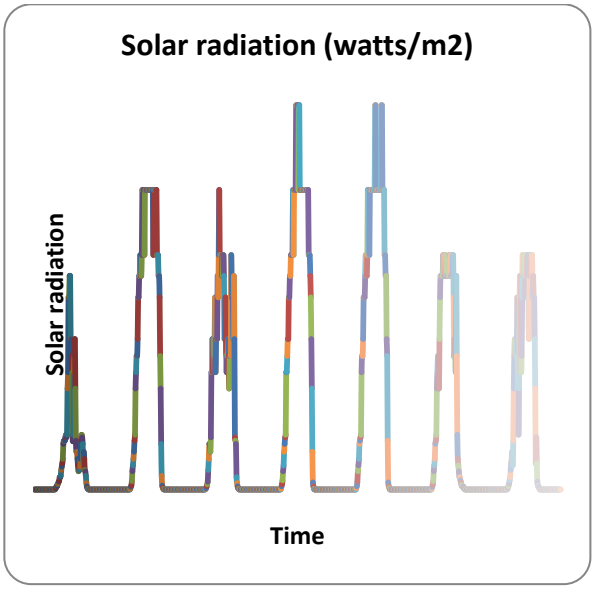


Figure 5: Weekly solar radiation data

Table 1: The Proposed Loads with Their Power

| Load name | Load power (w) |
|---|---|
| Electric Iron | 1000 |
| 100 Incandescent Lamp | 60 |
| Air Conditioner | 2500 |
| Fluorescent Lamp | 60 |
| Fluorescent Lamp | 100 |
| Refrigerator | 400 |
| Cooking Range | 1500 |
| Air Cooler | 250 |
| Freezer | 250 |
| Color TV | 80 |
| Satellite Receiver | 25 |

The proposed loads are typed at excel sheet and the program was designed using visual basic program using the hybrid ( solar- diesel) power energy sources . The turn-on , turn-off operation for these loads will be done according to the strategy that shown in flowchart at Figure 6.

Where according to the existence of solar radiation and using diesel engine as buck-up source these loads will operate taking into account a factor that was added to this program deal with the fuel cost for diesel generator. The increasing and decreasing the value of this factor will affect on the loads implementation , all these procedures will appear at Figure 7.

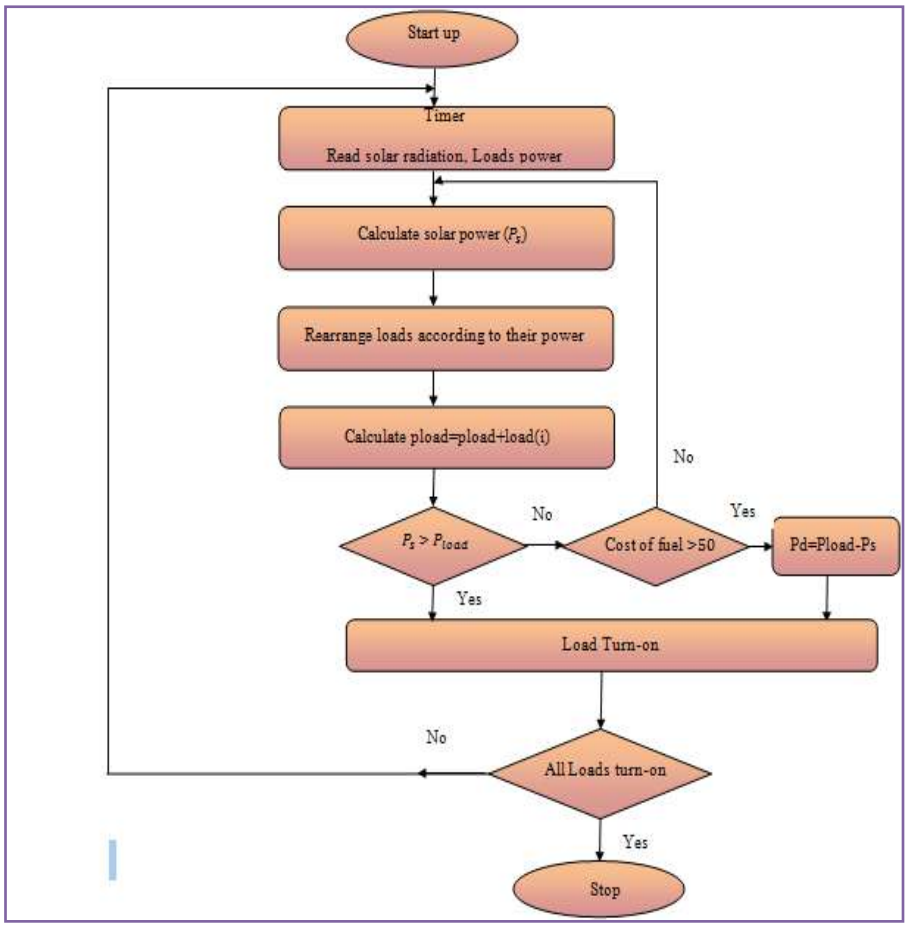


Figure 6 Flow chart of the control strategy

## 4. Results and Discussion

Figure 7 (a, b, and c) denotes the loads turn-on depending on solar energy only, it appears that not all loads will be turn-on since the solar power is low according to the loads power. Figure 7 (d) shows the operation of loads will increase according to the raising of the value of the factor that deals with cost of fuel as the scroll bar that shown in this figure, that's mean the diesel turn-on and then all loads turn-on.

The operation depend on the solar radiation and the cost of diesel fuel. The program having factor which represent the value of cost (I.D) which limit the turn-on for loads depending on its value. If the customer pay more money for fuel then will get more loads turn-on if the payment reduce the program immediately return back to solar energy with turn-off some loads.

a

b

c

d

Figure 7 loads turn-on using solar-diesel power system(a, b, c and d)

## 5. Conclusion

This research represented an option of supplying a remote area region in Iraq using PV-DG hybrid systems. It has been appeared that areal data calculated for solar radiation with proposed loads profile taken as a case study. Although the region has a good solar radiation the optimal system structure obtained by simulation using visual basic program which prefer using all PV power until the need for diesel in order to decrease the atmosphere pollution. There is an advantages by using this hybrid system by decreasing the pollution, and reducing charge on the country's economy by substituting using a lot of fuel. This scheme can be modified using addition of another renewable energy sources like wind, geothermal or batteries as backup system and for any season and any place ( village, building, …, etc).

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