Potential of Renewable Energy in Al-Fourat Al-Awsat: Al Najaf City Case Study

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Abstract: This paper reviews an analytical study of the hybrid power generation system in the al Najaf city at Iraq Country. The design and analysis of optimum choice to supply specific load (Renewable Energy center) building in the al Najaf city. The steps of this project consist of the measuring and collection of the basic meteorological data of solar radiation for al Najaf city, renewable energy software HOMER used for developing off-grid and on-grid system optimization simulation models. The simulation model has been used to find out the best result optimization based on energy efficient system for the specific load and taking into account costs and environmental emissions. Two reference models used to compare the costs and environmental impact. The optimization results indicate that the appropriate system for al Najaf Renewable energy center is consists of (81 kW PV, 58 kW Converter and 108 kW Grid) which have good components with the city requirements, this system would be cause reduction in CO₂ by (174.38%) percentage.

1. Introduction
Climate change is the most serious environmental risks facing the planet and community. Green house gases, which are responsible for climate change appear from human activity. The most serious of these gases is Carbon dioxide (CO₂) which is raising the average temperatures at the surface of the Earth, leading to harsher weather events, droughts, storms, and flood as well as rising sea level and disruption to whole ecosystems[1,2].

The effect on communities across the world could be disastrous if steps to stop this danger did not take soon. To avert dangerous climate changes, rising global CO₂ emissions within the next decade must be controlled as well as saving energy and using it more efficiently. For these reasons, switching to forms of energy that do not produce CO₂ and there are plenty of them, such as sun, wind, tides, waves, plants and others which are inexhaustible sources of renewable energy. These natural sources could be exploited to create electricity without adding carbon to environmental.
To take a step towards improving the environment in Iraq, an analytical study of a hybrid energy system in al Najaf applied using the Hybrid Optimization Model for Electric Renewable (HOMER) software, which is a software that has been developed by NREL (National Renewable Energy Laboratory). It performs hourly simulations of each attainable combination of parts entered and ranks the systems in step with user-specified criteria, like price of energy or Capital cost.

Several studies have been reported to design optimal alternative energy systems around world. Henryson and Svensson [3] proposed strategies of meeting power and energy demands for the Swedish Antarctica Research Program (SWEDARP) underneath the strict natural enactments by a quite way exploitation the free renewable energy assets. The results depend upon analyses and computer simulations (HOMER) on how each primary system component is predicted to work in the harsh climate conditions existed at the station Wasa in Antarctica. It was found that the wind power has the greatest potential as an essential energy source in Antarctica supported by suitable batteries, a reliable and in many meaningfully systems can be obtained.

Mizani and Yazdani [4] used the HOMER software package to put the optimum microgrid configuration and their optimum generation combine. The results showed that the optimum choice of renewable energy sources and energy storage devices in a grid-connected microgrid, the lifetime cost and emissions of the microgrid could significantly reduce in conjunction with an optimal transmutation strategy. Lal, D.K., et al. [5] designed a hybrid power generation system adequate for remote area application by using HOMER software, supplying by a (Micro-hydro, wind turbine, PV array) model, a diesel generator and batteries. The author illustrated the importance of equalizing between environment, economy and energy, by determining the optimum hybrid composition. Additionally, the COE within the planned theme is comparably over the traditional energy sources notwithstanding additional potency and fewer environmental aspect effects.

Al-Hamdani, H. Ali, Dawood. A and et al [6] used weather data in the Homer program to get the optimum renewable energy program in Baghdad city, the result shows that the best chose Photoelectric cells with a total production equal to 8 kW cost of electricity produced 0.903 US$/kW this system were cost 32015 US$.

2. Parameters assumptions Inputs of models:

\textit{AC Load:}

Figure 1 shows the typical daily load profile of Hypothetical Renewable center building in the al Najaf city. The energy expendable by the microgrid is 203 kWh/day with a 108 kW peak demand (7 hour /day, 5 days/ week), this load includes (fans, lights, air conditioner and lab devices):

\textit{Solar Resource:}

Solar radiation information was obtained from, the National Aeronautics and Space, Surface Meteorology and solar power web site [5]. The annual average solar radiation for this city was (5.510 kWh/m²). Monthly clearness index and daily radiation profile as a monthly average for a year 2013 obtained through HOMER are given in Figure 2:

\textit{Photovoltaic modules:}

The PV module utilized in the simulations was mounted at a direction straight to the south, and also the slopes of the panels were calculated to be equal latitude of Najaf city 31.9833 (decimal degree).
Figure 1. The daily load profile of Hypothetical Renewable Centre building in the al Najaf city.

Figure 2. Monthly clearness index and daily radiation of Najaf city.

Figure 3. Monthly average wind speed profile of Najaf city.

Wind Resource: Wind data for regions of study are obtained from the NASA global satellite database at 10 m anemometer height. Figure 3 below shows the monthly average wind speed profile over the year of 2013.

Wind Turbine: The chosen type of wind turbine was DC current RCVA-60KW type, which has a hub height of 18 m [8], it has a power curve profile shown in Figure 4. The lifetime of the turbine was assumed to be 15 years.
Figures 4. RCVA-60KW power curve [7].

Converter and battery: The battery chosen is the Vision 6FM200D. It has a nominal voltage of 12 Volts and nominal capacity of 200 Ah (2.4 kWh). While, the converter efficiency is assumed 85 %., and its lifetime is up to 15 years.

Generator: The AC diesel generator was scheduled to be operated all day of the week (except weekend days) from (8 am to 3 pm), which has 15000 operating hour life.

Constraint: The Maximum annual capacity shortage assumed to be 20%

Economic: This paper used the project lifetime of 15 years and interest rate of 6 %, table 1 shows the costs parameter.

Table 1. Renewable system components cost

| Components          | Cost       | Operating & Maintenance |
|---------------------|------------|-------------------------|
|                     | Capital    | Replacement             |                        |
| Solar               | 2000 $/kW  | 2000 $/kW               | 10 $/year              |
| Wind turbine        | 89200 $/turbine | 89200 $/turbine         | 10 $/year              |
| Converter           | 3000 $/10 kW | 3000 $/10 kW             | 10 $/year              |
| Battery             | 300 $/battery | 300 $/battery           | 10 $/year              |
| Diesel generator    | 500 $/kW   | 500 $/kW                 | 0.0136 $/hr.           |

Grid: The maximum amount of power that can be drawn from the grid set to be 108 kW with (0.0081799, 0.0040899) $/kWh power price and sell back rate, respectively.

Grid and generator emission factor: HOMER multiplies the net grid purchases (in kWh) by the emission factor (in g/kWh) for each pollutant insert. If the system sells additional power to the grid than it buys from the grid over the year, the net grid purchases will be negative sign and so will the grid-related emissions of all pollutants inserted [9,10].

While the emissions factor determined (kg of pollutant emitted per unit of fuel consumed) for each pollutant. After the simulation, it calculates the annual emissions of that pollutant by multiplying the emissions factor by the total annual fuel consumption. Table 2 shows CO$_2$ emission factors used in system that content Grid or generator.

Table 2. CO2 emission factors

| Type of system | CO2 factors       |
|----------------|-------------------|
| Generator [9]  | 6.5 (g/l)         |
| Grid [11]      | 907.685(g/kWh)    |

1- Iraqi Local market.
2- Qingdao Richuan Precision Machinery Co., Ltd.
3- http://www.maxima.net.au/.
4- Iraq Global Technologies Company, http://www.iraqglobal.com/

*0.0081799 = (10 DIQ/kWh) * (1222.5$/IQD) [Iraqi ministry of electricity] [9].
*0.0040899 = (5 DIQ/kWh) * (1222.5$/IQD) [assumed].
Case studies:

Six models systems cases study was used in this paper which includes;
1. The first case study consists of PV generators only. (off-grid)
2. The second case study consists of wind turbine only. (off-grid)
3. The third case study of the hybrid system consists of PV and Wind turbine. (off-grid)
4. The fourth case study consists of PV generators only. (on-grid)
5. The fifth case study consists of wind turbine only. (on-grid)
6. The sixth case study consists of wind turbine only. (on-grid)

The process to find the best suitable system for Najaf is by using Homer optimization for each of the above systems individually and evaluate the suitable system (low cost and low CO₂ emission). Then compassion was made with a reference system (diesel and government guide) as shown in figure 5 and 6.
3. Results and conclusion:

After evaluating and optimization all the case studies mentioned in above. An analysis was done includes the total system prices and the amount of CO2 contribution for each case studies to the environment of the Najaf town. It was found that the system which is suitable for this load in the Najaf is a grid-on system which consists of (81 kW PV, 58 kW Converter and 108 kW Grid). This system has good components with the city requirements. The total net present cost of this system is 186729 $, in this city for (15 year). So one concludes that the solar energy (PV) system is more effective than other renewable energies in the Al-Fourat Alawsat or Al Najaf. This system would cause CO2 reduction by 174.38% as it would produce more renewable energy than consumed.

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