Economic Feasibility Study of a Hybrid Power Station Between Solar Panels and Wind Turbine with The National Grid in Al-Hayy City in the Central of Iraq

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Abstract. In view of the increasing demand for electric energy, parallel to global warming and increasing temperatures in the world, efforts must be made to find new and environmentally friendly ways to produce electric energy and eliminate the burning of fossil fuels. In this paper, we propose to approve hybrid plants for the production of electric power in Iraq due to the availability of the privileged location and the amount of clean energies that can be invested. We have chosen a small area located in the south of Iraq and suggested the establishment of a hybrid plant between solar energy, wind, and the national grid, and the results were very impressive, where at a very low cost it is possible to cover the district’s need of electricity and export the rest to the national grid at a price (0.015 kwh). We chose this type of station, wherein in the daytime, it is possible to take advantage of solar energy, as well as wind energy, if available. And wind energy can be used at any time when there is wind at a speed higher than 3 m/s, where energy can be generated at night hours and the absence of sunlight for any reason. This study was carried out with the help of the NASA space website and the Homer program to study renewable energies.

Keywords: Renewable energy, hybrid plant, solar energy, wind energy.

1. Introduction

“Al- hayy district” is an Iraqi town and a district center in Wasit Governorate. The city’s population is estimated at 171,000, while the district is approximately 280,000, along with the surrounding villages and sub-districts. The city has two sub-districts (Al-Bashaer and Al-Mawfakia)[1]. These two areas are distinguished by their good geographical location and the abundance of easy and flatlands. In addition, the city of Al- hay suffers, like the rest of the other cities of Iraq, from poor and shortage of electric power. In this paper, we will deal with the sub-district of Al-Bashayer as an example that can be applied to the rest of the neighboring cities, and how the city can be made self-sufficient in generating electrical energy through the exploitation of available clean energy resources, as well as the possibility of the city being an energy source for neighboring sub-districts and villages in some times. The problem of the shortage in the provision of electrical energy in Iraq, beginning in 1991 after the US-Iraq war, when the American forces bombed most of the Iraqi installations, including the electrical infrastructure such as the generation, transmission, and distribution station[2-8]. Look at the figure below:
2. Weather in Al-Hayy

Al-summers hayy's are long, hot, arid, windy, and clear, while the winters are cool, dry, and mostly clear. The temperature typically ranges from 7 to 46 degrees Celsius throughout the year, with temperatures rarely falling below 3 degrees Celsius or rising above 49 degrees Celsius. The graph below depicts a summary of climate change[13-16].
The average percentage of cloudy sky in Al-hayy varies significantly throughout the year due to seasonal variations. In Al-hayy, the clearer season begins around May 22nd and lasts for 4.7 months, ending around October 13th. The sky is completely obvious, mostly concise, or cloudy weather 100% of the time on June 30th, the clearest day of the year, and cloudy or mostly stormy 0% of the time. The cloudier season begins around October 13th and lasts for 7.3 months, ending around May 22nd. As a result, the clear weather encourages people to invest in solar panels; the graph below depicts the sky over a year.

2.1. Solar Energy and Hours of Daylight in Al-Hayy

This section will discuss the total daily infrafract solar energy reaching the ground over a large area in Al-hayy, taking into account seasonal variations in the length of the day, the elevation of the Sun above the horizon, as well as absorption by clouds and another atmospheric component, as mentioned earlier. Shortwave radiation includes visible light and ultraviolet radiation. The mean daily incident solar energy experiences extreme seasonal variation over the year. The brighter time of the year continues for 3.4 months, from May 14th to August 25th, with average daily incident energy above 7.3 kWh/m². The brightest day of the year is June 19th, with an average of 8.3 kWh/m². The darker part of the year continues for 3.2 months, from the first of November to February 8th, with a mean daily incident energy of 4.1 kWh/m²[17].
Figure 5. Average solar energy in Al-hayy

Table 1. Average solar energy in Al-hayy [7]

| LAT  | LON  | PARAMETER | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|------|------|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 32.25| 46.25| DNR       | 5.16| 5.8 | 5.51| 5.49| 6.75| 8.66| 8.1 | 7.64| 6.9 | 4.8 | 4.14| 4.46| 6.12|
| 32.25| 46.25| DNR_MAX   | 6.27| 7.85| 7.11| 6.72| 8.37| 10.74| 9.6 | 8.65| 7.83| 5.87| 4.98| 5.17| 7.43|
| 32.25| 46.25| DNR_MIN   | 3.59| 4.2 | 4.45| 4.04| 5.64| 6.48| 6.12| 6.61| 5.32| 3.87| 3.34| 3.2 | 4.74|

The length of the day in Al-hayy varies greatly throughout the year. The tightest day in 2020 is December 21st, which has ten hours and two seconds of daylight, and the lengthiest day is June 21st, which has fourteen hours and sixteen minutes of daylight. The diagram below depicts the hours of daylight:

Figure 6. the average of hours daylight in Al-hayy
2.2. Wind Energy in Al-Hayy

This part explains the wide-area hourly rate speed of wind at ten meters above the land. The wind experienced at any specific location is based on local topography and other elements, and instantaneous wind (speed & direction) varies more widely than hourly rates. The rate hourly wind speed in the Al Hayy having significant seasonal variation over the year. The most windier time of the year continues for 3.5 months, from May 26^{th} to September 8^{th}, with mean wind speeds of more than 5 m/s\[18\]. The other time of year lasts for more than 8 months, from September 8^{th} to May 26^{th} with an average hourly wind speed between (3.5 m/s to 4.5 m/s). The figure below shows the average wind speed in Al-hayy:

![Figure 8. average wind speed in Al-hayy](image)

2.3. Case Study and Calculation Method

In this paper, we will deal with one of the small sub-districts of the Al-hayy city, as mentioned earlier, and it is called Al-Bashaer. The load in this sub-district is distributed between the center and the surrounding villages, and the load ranges from 800 kW to 1.3 MW, the peak load in summer. By using some programs and websites specialized in monitoring and following up space and weather conditions, such as the NASA space organization, we surveyed the city about the quantities of clean energy sources in the city and how they are used, and their economic viability. And by using the famous program HOMER [19-21], which is specialized in calculating all
types of renewable energies. As well as the use of important mathematical equations and we will mention here the most important of these equations, HOMER uses the following equation to calculate the output of the PV array:

3. Simulation and Results
By using the Homer program, we were able to obtain wonderful results that are close to reality, and this study helps us to get rid of the dire reality of electrical energy and to identify the volume of clean energy that is not being used properly. The proposed station is a hybrid between solar energy, wind, and the national grid. The solar station consists of a solar panel station with a capacity of 540 kW (Schneider ConextCoreXC 540kW with Generic PV), distributed over an area of about 100 acres. The wind station is of the type (Vergnet GEV MP-C [275kW])[12, 22, 23]
- 2-blade downwind rotor, two-speed generator
- Cut-in wind speed is 3.5 m/s
- Cut out wind speed is 25 m/s
- Output Voltage & Frequency (3-phase are 400 V - 50 Hz respectively
- Hub height is 55/60 m
- Rotor diameter is 32 m
- Rotation speed (50 & 60 Hz) is from 31 to 46 rpm.

Looking at figure 9 gives us a clear vision of the power plant and its components and connecting it to the national network [8].

![Figure 9 Single diagram for the system](image)

After entering all the data about the city Al-hayy and sub-district Al-Bashayr from the geographical location and daily loads, we get the following results electrical summary

| Table 2. Fabrication Summary |
|-----------------------------|
| Component                   | Production (kWh/yr) | Percent |
| Schneider ConextCoreXC 540kW with Generic PV | 32,888,049          | 20.07   |
| Vergnet GEV MP-C [275kW]    | 65,965,943          | 78.4    |
| Grid Purchases              | 1,417,801           | 1.55    |
| **Total**                   | **91,271,793**      | **100** |

| Table 3. Consumption Summary |
|-----------------------------|
| Component                   | Consumption (kWh/yr) | Percent |
| AC Primary Load             | 6,164,453            | 6.75    |
| DC Primary Load             | 0                    | 0       |


Figure 10 shows the production of electrical energy, where it appears that the highest percentage is for wind energy, as it constitutes about 70% of the total product, and then solar energy production is in second place by about 20%, and the rest is provided by the national grid.

![Figure 10. Average electric production](image)

Table 4. Generic PV Electrical summary

| Quantity          | Value | Units |
|-------------------|-------|-------|
| Minimum Productivity | 0     | kW    |
| Optimum Productivity | 540   | kW    |
| PV Penetration    | 30.6  | %     |
| Operation Hours   | 4,387 | hrs/yr|
| Level of Cost     | 0.0371| $/kWh |

Table 5. Generic PV Statistics

| Quantity          | Value | Units |
|-------------------|-------|-------|
| Rated Capacity    | 2,111 | kW    |
| Mean Output       | 216   | kW    |
| Mean Output kWh/day | 5,173 | kWh/d |
| Capacity Factor   | 10.2  | %     |
| Total Production  | 32,888,049 | kWh/yr |

Figure 11 shows the production of electrical energy with the help of solar cells, which is limited during daylight hours only. It is also clear through the colors that it is produced during the summer months more than the rest of the year, where the color is more clear and deep during the summer than the rest of the year.
Figure 11. solar plant PV Output (kW)

In tables 6 and 7 a summary of the production of the wind turbine (Vergnet GEV MP-C [275kW]), as well as figure 12.

Figure 12. Wind turbine output (kW)

Table 6. Net energy purchased and sold in grid

| Month    | Energy Purchased (kWh) | Energy Sold (kWh) | Net Energy Purchased (kWh) | Peak Demand (kW) | Energy Charge |
|----------|------------------------|-------------------|---------------------------|-----------------|---------------|
| January  | 174,827                | 373,805           | -198,978                  | 889             | $43,333       |
| February | 135,823                | 453,015           | -317,192                  | 1,040           | $33,503       |
| March    | 152,419                | 616,709           | -464,291                  | 1,082           | $37,488       |
| April    | 132,720                | 704,178           | -571,457                  | 1,024           | $32,476       |
| May      | 139,972                | 829,675           | -689,704                  | 1,110           | $34,163       |
| June     | 146,608                | 846,050           | -699,442                  | 1,200           | $35,806       |
| July     | 176,338                | 710,671           | -534,334                  | 1,192           | $43,374       |
| August   | 199,608                | 679,603           | -479,995                  | 1,200           | $49,222       |
| September| 177,284                | 612,059           | -434,775                  | 1,119           | $43,709       |
| October  | 197,050                | 547,864           | -350,814                  | 1,200           | $48,715       |
| November | 206,641                | 361,470           | -154,828                  | 1,064           | $51,299       |
| December | 241,501                | 377,783           | -136,282                  | 1,186           | $59,998       |
| Annual   | 2,080,791              | 7,112,883         | -5,032,092                | 1,200           | $513,085      |
Conclusion

Given the privileged location of Iraq, which is rich in clean energy resources, and because of the positive results obtained from this study, clean energies must be invested in Iraq. This idea should be spread throughout Iraq, where clean energy can be produced at a very cheap cost (0.015$ kwh), get rid of burning fossil fuels, and create new jobs in the region that suffers from high unemployment. When looking at table 8, we see the amount of energy exported to the national grid, and throughout the year the energy exported is more than imported, and this can be seen from figures 12 and 13. It appears in table 4 that the number of working hours of the solar plant is about 4386 hours, which is a very large number, and this can be seen from figure 12, where most of the energy exported to the grid is during daylight hours. Table 6, shows us the number of working hours of the wind turbine, which is about 6414 hours, which is also a very large number, and this can be seen in figure 12, showing us the amount of energy produced during the year. This shows us the economic feasibility of this type of station.

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