

# Power Generation through Hybrid Renewable Energy Resources Wind and Solar in Jhimpir

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**ABSTRACT**-- Power generation is basic to the monetary development and social improvement of any nation. This prompted to a lift in innovative work and additionally interest in renewable electricity generation looking for approaches to take care of electricity, vitality(energy) demand and to lessen reliance on fossil powers. This theory concentrates on an incorporated cross breed renewable electricity generation framework comprising of wind and sun powered vitality.

The cross-breed control framework was intended for Jhimpir in Thatta District Sindh Pakistan. Through the reenactment procedure, establishment of 8 quantities of 840kW wind turbines and 1MW sunlight-based PV modules were recognized as most practical to supply normal of 3MW load associated with lattice where the straightforward payback time of the framework was 3.4 years. In this review, HOMER (Hybrid Optimization Model for Electric Renewables) PC demonstrating programming was utilized to display the power framework, its physical conduct and its life cycle cost.

**Index Terms**—Hybrid, renewable, wind energy, solar energy, renewable resources, energy deficiency, power generation.

## 1.Introduction

In the present world, each nation is giving essential place on vitality security and practical improvement; henceforth part of renewable vitality has turned out to be always huge. With the desire of advancing power era in view of non-traditional renewable vitality, the administration of Pakistan acquainted electricity generation arrangements with accomplish a 10% focus of producing power with the help of extendable(renewable) vitality in 2016, almost 20% by 2020[1]. Electricity generation in Pakistan comprise of principally non-conventional ways like burning of petroleum, diesel, coal, natural gas etc. which are very costly and contribute in great amount of carbon dioxide emissions. There is a need for developing the renewable energy generation ways for Pakistan in order to meet the country power demand and also to reduce the co2 emissions [2]. The hydro power generation is mainly dependent on water stored in reservoirs basically under the double purpose of power generation and irrigation. Due to the limited fuel resources the county has to import the required fuel and that is not cheap. Country's economy is extremely disturbed when the price of petroleum shoots up in the whole world. Yearly rise in power request evaluated as 7 to 11 percent, Individual power utilization is 519kWh/per individual in 2013 [3].

In any case, presently electricity generation assets across country neglect to overcome the needs so, the requirement for expansion emerges. Usage of continuously producing power assets, for example, sun based, twist, little hydro and biomass is moderately little in the nation.

The half and half renewable power era is a framework went for the creation and use of the electrical producing by different sources, and each of them are renewable. For it to happens it is required to worry about the progress in field of sun-wind based half and half power era frameworks

where wind sunlight-based potential is high in Pakistan.

Under this proposition sun-wind based half and half power era framework possibilities will be examined at Jhimpir in Sindh

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Pakistan. This area will be examined utilizing a product apparatus. Half and half Optimization Model for Electric Renewables (**HOMER**) programming will be utilized to break down the information. The product is a miniaturized scale control streamlining model for both off network and lattice associated control frameworks in an assortment of utilizations.

## 2.Main Goals and Objectives

The fundamental goal of the theory is to plan and survey the execution of a solar-wind powered crossover framework for power production in Pakistan.

### 2.1:Specific Objectives:

- Discuss energy market in Pakistan
- Discuss problems of energy sector and need for renewable energy in Pakistan.
- Concentrate the Solar-wind potential in various geological areas in Pakistan by dissecting information from various sources.
- Design a solar-wind based system.
- Economic analysis of the wind-solar hybrid power generation system.

### 2.2:Methodology

Initially, literature review was done to get better understanding about the energy situation and problems of energy sector in Pakistan. Designing wind-solar hybrid system is new concept in a Pakistan context. Hence related literature was studied. In order to identify wind and solar potential of Pakistan, previous study was analyzed that has been carried out in Pakistan.

#### 2.2.1 Literature review

- 1.Analyze energy situation in Pakistan
- 2.Identify different locations where wind and solar potential are high
- 3.Analyze wind and solar data available in different identified locations.
  - Data from NASA Satellite Surface Meteorology and Solar Energy
  - Wind and solar data available in Meteorological Department, Pakistan Wind and solar data available in Pakistan Sustainable Energy Authority
- 4.Identify a location that has available both wind and solar potential.

5.Design and analyze a wind-solar hybrid system for the selected location using the software tool (HOMER).

### 3. Hybrid Resources in Jhimpir

#### 3.1 Wind resource

Hourly measured wind speed information of Jhimpir for the year 2012 at 10m stature (Source: Sustainable Energy Authority) is utilized as wind asset input information. Figure given below outlines the month to month found the middle value of wind speed information acquired for Jhimpir. The normal wind speed ranges from 4.4m/s to 8.1m/s with a yearly normal of 6.69m/s.

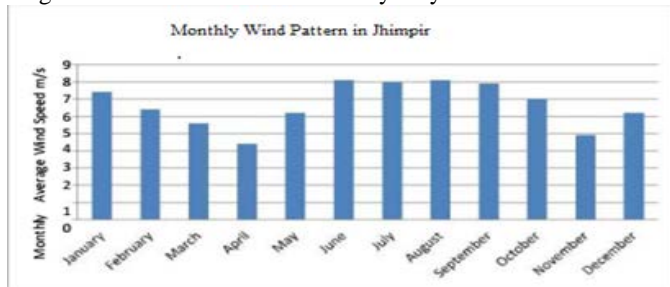


Fig. 1 Monthly wind pattern in jhimpir

Table 1 Monthly average wind speed at 15m above ground for Jhimpir Meteorological site

| Month                 | Monthly Average Wind Speed (m/s) |
|-----------------------|----------------------------------|
| January               | 7.4                              |
| February              | 6.4                              |
| March                 | 5.6                              |
| April                 | 4.4                              |
| May                   | 6.2                              |
| June                  | 8.1                              |
| July                  | 8.0                              |
| August                | 8.1                              |
| September             | 7.9                              |
| October               | 7.0                              |
| November              | 4.9                              |
| December              | 6.2                              |
| <b>Annual Average</b> | <b>6.68</b>                      |

#### 3.2 Solar resource

Sunlight based asset information shows the measure of worldwide sun powered radiation that strikes earth surface in a common year. Measured hourly normal sun oriented radiation on flat surface (kWh/m<sup>2</sup>) of Jhimpir from September 2011 to August 2012 (Source: Pakistan Sustainable Energy Authority) is utilized as sunlight based asset input information. Considering 60 15' as scope and 81o 5' as

longitude for the area. The normal sun based radiation ranges from 4.46kWh/m<sup>2</sup>/day to 6.44kWh/m<sup>2</sup>/day with a yearly normal of 5.59kWh/m<sup>2</sup>/day. The normal clearness record is 0.56.

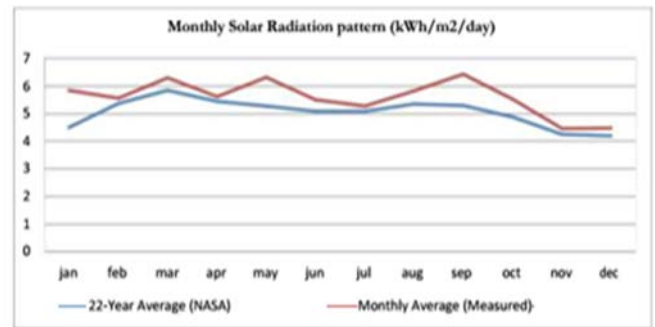


Fig. 2 Monthly Average solar radiation kWh/m<sup>2</sup>/day for Jhimpir

Table 2 Monthly average solar radiation of jhimpir

| Month                 | Jhimpir Measured (kWh/m <sup>2</sup> /day) | Jhimpir-22 Year Average |
|-----------------------|--|-------------------------|
| January               | 5.79                                       | 4.49                    |
| February              | 5.50                                       | 5.36                    |
| March                 | 6.34                                       | 5.90                    |
| April                 | 5.58                                       | 5.41                    |
| May                   | 6.22                                       | 5.27                    |
| June                  | 5.47                                       | 5.06                    |
| July                  | 5.31                                       | 5.05                    |
| August                | 5.92                                       | 5.39                    |
| September             | 6.13                                       | 5.29                    |
| October               | 5.44                                       | 4.82                    |
| November              | 4.26                                       | 4.24                    |
| December              | 4.37                                       | 4.17                    |
| <b>Annual Average</b> | <b>5.54</b>                                | <b>5.03</b>             |

### 4. Winds-Solar Hybrid Power Generation System

The half breed control era idea is a framework went for the creation and usage of electrical vitality originating from more than one source inside an incorporated course of action. The half and half framework examined in this proposal is one consolidating sunlight based PV and twist turbines with power molding units, for example, inverters. Mixture wind turbine and sun oriented PV modules offer more noteworthy unwavering

quality than any of them, since neighborhood vitality supply can't depend completely on any of these sources. Different points of interest of the half and half framework are the strength and dependability of the framework and the lower support necessity along these lines lessening downtime amid repairs and routine upkeep. What's more, and additionally being indigenous and free, renewable vitality assets likewise add to the diminishment of contamination emanations. In this postulation, the proposed crossover control era framework makes utilization of sunlight based PV and twist turbine to deliver power and supply the heap by interfacing with the matrix.

### 5. Planning and Modeling of Hybrid Power Generation System with HOMER Software

This software is a PC display made by the US National Renewable Vitality Laboratory (NREL) to help the arrangement of constrain structures and support the examination of power era progressions over a broad assortment of employments [HOMER, ver. 2.81 Beta]. This product used to demonstrate a power era structure physical lead and its life-cycle cost, which is the total cost of presenting and working the system over its life time. It runs essential errand which are: recreation, streamlining and affectability investigation in light of the crude information given by client. In reenactment procedure, execution of specific power generation framework design for every hour of the year is demonstrated to decide its specialized plausibility and lifecycle cost. It duplicates wide variety of constrain structure courses of action, containing any blend of PV show, wind turbines, continue running off stream hydro turbines, generators and battery bank systems with grid affiliation or off framework that can serve electrical burdens and warm loads. Reproduction procedure fills two needs. In start, it figures out if the framework is plausible. Second, it surveys the lifecycle cost of system, which is the total cost of presenting and working the structure over its lifetime.

#### 5.1 Wind and Solar Hybrid Power System Configuration

The matrix associated wind sun based half breed framework comprises of a neighborhood network, PV exhibits, wind turbines and inverters. HOMER programming is utilized as a device to complete the examination. Figure given below demonstrates the design of the matrix associated half breed control framework. HOMER requires input data with a specific end goal to dissect the framework. Those information sources are portrayed in detail beneath.

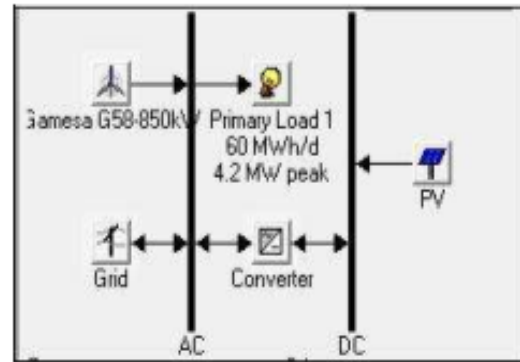


Fig. 3 Configuration of grid connected hybrid wind-solar system in HOMER

Table 3 homer software inputs

|           | Size    | Capitol Investment per unit (\$) | O & M cost per year | Lifetime |
|-----------|---------|----------------------------------|---------------------|----------|
| Wind      | 840 kW  | 1.6 million USD                  | 32,000 USD          | 25 Years |
| PV        | 1000 kW | 3 million USD                    | 30,000 USD          | 25 Years |
| Converter | 250 kW  | 1 million USD                    | 20,000 USD          | 15 Years |

The components are chosen by considering present availability in the global market and the costs are estimated according to the governing present local and global prices of the components and project costs.

### 6. Economic inputs

The monetary info parameter for this plan including the yearly genuine financing cost and venture lifetime are required for the HOMER reenactment. Expected power plant lifetime is 25 years and yearly genuine financing cost is 10%.

### 7. Observations and Results

This section contains the report of power generation through the purposed hybrid power generation system.

### 8. Analysis

### 8.1 Simulation

HOMER software copies the working of the structure by doing imperativeness modify figuring's in every hour of the whole year. To determine every time period, this software takes a gander at the electricity need of that time. HOMER looks electric request in that time set out to the vitality that the structure can supply in that time step set out to the centrality that the structure can supply in that time step. By then discovers the surges of vitality to and from each section of the framework. HOMER plays out these criticalness change estimations for every framework arrange for that ought to be considered. It then comprehends if a course of

| PV (kW) | WT (kW) | Conv. (kW) | Grid (kW) | Initial Capital | Operating Cost (\$/yr) | Total NPC    | COE (\$/kWh) | Plan. Freq. |
|---------|---------|------------|-----------|-----------------|------------------------|--------------|--------------|-------------|
| 8       |         |            | 30000     | \$12,800,000    | 2,399,447              | \$34,579,872 | 0.130        | 0.69        |
| 1000    | 8       | 1000       | 30000     | \$16,800,000    | 2,009,440              | \$35,039,764 | 0.129        | 0.73        |
| 5000    |         | 3000       | 30000     | \$18,000,000    | 6,348,107              | \$75,622,016 | 0.368        | 0.32        |
|         |         |            | 30000     | \$0             | 8,806,873              | \$79,940,336 | 0.400        | 0.00        |

Fig. 4 Categorized HOMER optimization results

action is possible, i.e., paying little regard to regardless of whether it can manage the electric demand under the predefined conditions, and gages the cost of displaying and working the framework over the lifetime of the meander

The measure of displayed 840kW wind turbines is changed from 0 to 7 and solar photovoltaic modules and sizes of converters are wavered in between 0, 999.9kW, 1999.9kW, 2999.9kW, 3999.9kW, 4999.9kW, 5999.9kW, 6999.9kW, and 7999.9kW for the estimations of the proposed structure combination in size what's more, sort of plan.

### 8.2 Optimization

Subsequent to recreating the majority of the conceivable framework setups, HOMER shows a rundown of arrangements by showing the total cost (NPC), life cycle cost that is utilized for analyzing different framework plan alternatives. NPC (Net Present Cost) is present estimation of expenses for first time introducing and installation and the process it over venture lifetime, less present estimation of considerable number of incomes that it gains over the venture lifetime. HOMER computes the NPC of every part in the framework, and of the framework all in all. Figure below demonstrates the classified HOMER improvement comes about. In every class of modest plan sort, it demonstrates just the most reduced NPC arrangement. In figure below the general HOMER streamlining results are exhibited.

| PV (kW) | WT (kW) | Conv. (kW)   | Grid (kW)    | Initial Capital | Operating Cost (\$/yr) | Total NPC    | COE (\$/kWh) | Plan. Freq. |
|---------|---------|--------------|--------------|-----------------|------------------------|--------------|--------------|-------------|
| 8       |         |              | 30000        | \$12,800,000    | 2,399,447              | \$34,579,872 | 0.130        | 0.69        |
| 1000    | 8       | 1000         | 30000        | \$16,800,000    | 2,009,440              | \$35,039,764 | 0.129        | 0.73        |
| 2000    | 8       | 1000         | 30000        | \$19,800,000    | 1,709,320              | \$35,315,568 | 0.128        | 0.75        |
| 2000    | 8       | 2000         | 30000        | \$20,800,000    | 1,660,685              | \$35,874,100 | 0.130        | 0.76        |
| 3000    | 8       | 2000         | 30000        | \$23,800,000    | 1,332,574              | \$35,895,828 | 0.127        | 0.78        |
| 1000    | 8       | 2000         | 30000        | \$17,800,000    | 2,950,125              | \$36,409,968 | 0.134        | 0.73        |
| 3000    | 8       | 3000         | 30000        | \$24,800,000    | 1,354,849              | \$37,058,020 | 0.131        | 0.78        |
| 4000    | 8       | 2000         | 30000        | \$26,800,000    | 1,138,640              | \$37,135,476 | 0.130        | 0.79        |
| 2000    | 8       | 3000         | 30000        | \$21,800,000    | 1,701,370              | \$37,243,404 | 0.134        | 0.76        |
| 3000    | 8       | 1000         | 30000        | \$22,800,000    | 1,601,519              | \$37,337,044 | 0.135        | 0.76        |
| 4000    | 8       | 3000         | 30000        | \$27,800,000    | 1,060,765              | \$37,428,900 | 0.129        | 0.80        |
| 1000    | 8       | 3000         | 30000        | \$18,800,000    | 2,090,811              | \$37,778,376 | 0.139        | 0.73        |
| 3000    | 8       | 4000         | 30000        | \$25,800,000    | 1,395,535              | \$38,467,328 | 0.136        | 0.78        |
| 8       | 3       | 30000        | \$11,200,000 | 3,004,402       | \$38,471,072           | 0.154        | 0.65         |             |
| 8       | 3000    | \$30,800,000 | 851,068      | \$38,525,176    | 0.130                  | 0.81         |              |             |
| 8       | 4000    | \$22,800,000 | 1,742,056    | \$38,612,704    | 0.139                  | 0.76         |              |             |
| 1000    | 7       | 1000         | \$15,200,000 | 2,590,365       | \$38,712,844           | 0.152        | 0.69         |             |
| 2000    | 7       | 1000         | \$18,200,000 | 2,260,340       | \$38,717,196           | 0.149        | 0.72         |             |
| 4000    | 8       | 4000         | \$28,800,000 | 1,097,190       | \$38,759,232           | 0.133        | 0.80         |             |
| 3000    | 7       | 2000         | \$22,200,000 | 1,846,917       | \$38,964,536           | 0.146        | 0.75         |             |
| 5000    | 8       | 2000         | \$29,800,000 | 1,028,510       | \$39,135,824           | 0.136        | 0.80         |             |
| 1000    | 8       | 4000         | \$19,800,000 | 2,131,497       | \$39,147,680           | 0.144        | 0.73         |             |
| 2000    | 7       | 2000         | \$19,200,000 | 2,203,722       | \$39,203,272           | 0.150        | 0.72         |             |
| 5000    | 8       | 4000         | \$31,800,000 | 841,336         | \$39,436,840           | 0.132        | 0.81         |             |
| 3000    | 8       | 5000         | \$26,800,000 | 1,436,221       | \$39,838,532           | 0.141        | 0.78         |             |
| 4000    | 8       | 1000         | \$25,800,000 | 1,556,342       | \$39,926,976           | 0.144        | 0.77         |             |
| 2000    | 8       | 5000         | \$23,800,000 | 1,782,742       | \$39,962,012           | 0.144        | 0.76         |             |
| 4000    | 7       | 2000         | \$25,200,000 | 1,634,879       | \$40,039,860           | 0.148        | 0.77         |             |
| 1000    | 7       | 2000         | \$16,200,000 | 2,631,050       | \$40,082,148           | 0.157        | 0.69         |             |
| 4000    | 8       | 5000         | \$29,800,000 | 1,137,875       | \$40,128,536           | 0.138        | 0.80         |             |

Fig. 5 overall HOMER optimization results

From the above figure it can be seen that 8 wind turbines and 1000kW PV module with 1000kW converter gives the cheapest configuration. This configuration has COE of 0.129 USD/kWh and NPC value of 35,039,764 USD. Since a 1MW solar installation costs more than double the 1MW wind turbine, the HOMER model always gives priority to wind power. So it chooses a maximum number of wind turbines. But in such case the delivered power is much more than the load requirement (excess generation is fed into the grid as grid sales), so a configuration with minimum excess power is selected for the actual design. It has 6 wind turbines with 3000MW PV modules and 3000MW converter.

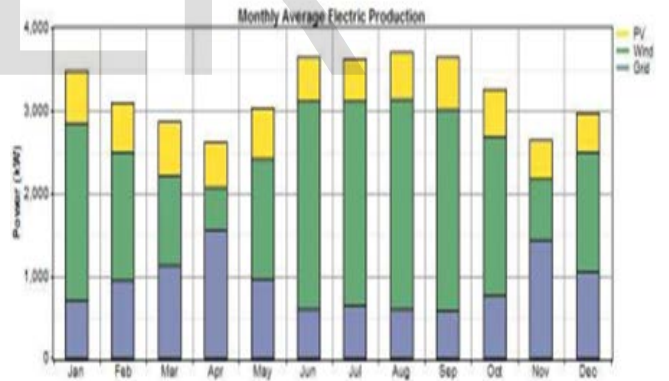


Fig. 6 Monthly average power productions of the wind-solar hybrid system

Total annual power generation from the hybrid system is 20.27GWh, where solar contributes with 5GWh (25%) and 15.27GWh (75%) are derived from wind. Annual generation details obtained from HOMER are given in table.

Table 4 Annual generation details of the proposed Hybrid system

| Quantity       | Units | PV Array | Wind Turbines |
|----------------|-------|----------|---------------|
| Rated capacity | kW    | 3000     | 5100 (840x6)  |
| Mean output    | kW    | 570      | 1744          |

|                    |        |           |            |
|--------------------|--------|-----------|------------|
| Maximum output     | kW     | 2958      | 5100       |
| Total production   | kWh/yr | 4,993,002 | 15,281,525 |
| Hours of operation | hr/yr  | 4,421     | 8,508      |
| Capacity factor    | %      | 19.0      | 34.2       |

### 9. Financial Evaluation

The financial feasibility of the project was examined using simple payback method, in which the payback period is the time it takes for the return on the investment to re-pay the sum of the original investment. The original investment in this context is the sum of all investments that are related to the purchasing and installation of wind-solar hybrid system. The return is the income generated by sale of electricity, reduced by the cost of operation and maintenance. Figure below shows the cost and income distributed over the lifetime of the project.

Total generation capacity of the design plant = 20.27 GWh/year  
 Initial investment = 21.6 million USD  
 Simple payback period = 3.4 years  
 Internal Rate of Return (IRR) = 29.6%.

The half and half model gives a basic payback time of just 3.4 years. Given that a run of the mill wind turbine and sunlight based PV cluster have efficient lifecycle of 30 years, this shows that venture can benefit from particular neighborhood states of relatively stable renewable vitality asset accessibility and high expenses of conceded petroleum control era.

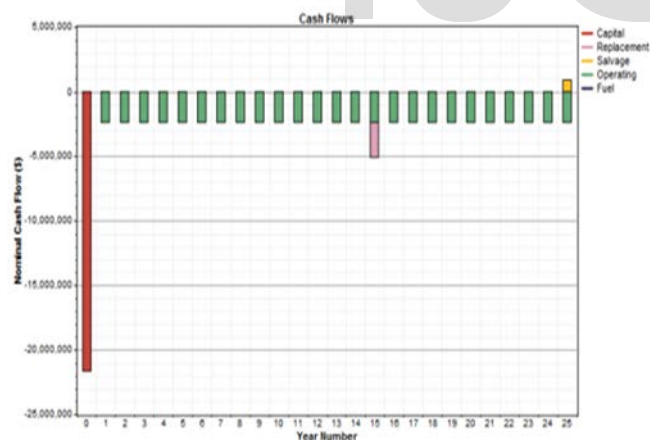


Fig. 7 Cost and income distributed over the lifetime of the project.

### 10. Conclusion

Practical improvement and security, these are the most important concerns for the vitality in our country. In this way renewable power generation plants could turn out to be always huge. The created world is as of now on the track for exiting from the fossil fuel time and including for the most part the regions of renewable vitality innovations and vitality proficiency. By making the thesis it was understood that our country has financially practical power era capability of

hybrid solar and wind oriented vitality. There are a lot of good locations available in Punjab and Sindh province for planning the wind power plants. By using this software reenactment programming, matrix tied solar-wind oriented half and half power era framework was displayed for a chosen area in the Jhimpir in Thatta District Sindh Pakistan. By recreation procedure, establishment of 8 quantities of 840kW wind turbines and 1MW sun powered photovoltaic cluster was recognized as the financially practical plan for supply the normal 3MW load associated with lattice where payback time of the outline is 3 years.

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