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Prefeasibility Analysis of 10 KW Hybrid System of Wind And Biomass Energy System

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***Abstract*--Hybrid system of wind and biomass energy system is the most cost effective and efficient way to achieve highly reliable option for power generation especially in isolated locations where the grid power is not available. Present work is the effort towards the prefeasibility analysis of a 10 KW hybrid system of wind and biomass energy. Hourly data of wind and biomass is analyzed with the help of HOMER software (Hybrid Optimization Model for Electric Renewable) for the prefeasibility analysis. The result of the work shows that there is strong potential for the utilization of wind and biomass energy system for electricity generation.**

Keywords: - Wind, Biomass, HOMER.

I. INTRODUCTION

Energy is the one of the foremost inputs for the financially viable development of any country and is very significant to the nourishment of a modern economy. Future economic intensification significantly depends on the enduring availability of energy from sources that are affordable, accessible and environmental friendly. In the case of the developing countries, the energy segment assumes a significant magnitude in view of the persistently increasing energy needs requiring gigantic investments to congregate them. Worldwide, politicians, industrialists, environmentalists, economists and technologist affirm that the principles of sustain development must be applied at international, national and local level. Actually applying it in practice and in detail is of course much harder. In the international context, the word 'development' refers to improvement in quality of life, and, especially, standard of living in the less developed countries of the world. The aim of sustainable development is for the improvement to be achieved whilst maintaining the ecological processes on which life depends. At a local level, progressive business aim to report a positive triple bottom line, i.e. a positive involvement to the economic, social and ecological comfort of the society in which they work.

India has an enormous renewable energy potential of about 100,000MW, which is mostly untouched [1]. It is anticipated that 40% of villages in the country are not electrified through grid electricity mainly due to capacity shortage and difficult terrain and environmental considerations. It becomes essential to take up electrification of isolated villages through non-conventional energy sources such as biomass, micro-hydro and wind systems. Stand-alone units are already in operation at many plantations/colonies though the accessibility of biomass, hydro or wind energy is not continuous. Isolated function of these power plants may not be feasible in terms of cost, efficiency and reliability. A viable substitute solution is by combining these different renewable energy sources to form a hybrid energy system [2]. A system using a combination of these different sources has the advantage of balance and steadiness that offers the strengths of each type of sources that accompaniment one another. The main objective is to provide 24 hours grid quality power in isolated communities. Hybrid energy systems are pollution free, takes low cost and less gestation period, user and social friendly. Such systems are important sources of energy for shops, schools, and clinics in village communities particularly in isolated areas. Hybrid systems can provide electricity at a comparatively economic price in many inaccessible areas. In order to obtain electricity from a hybrid system reliably and at an economical price, its design must be optimal in terms of operation and component selection. Many attempts have been tried to explore a relatively simple method for designing hybrid energy systems.

Different system developments in hybrid energy system for Thailand were published [3]. A simple numerical algorithm was used for unit sizing and cost analysis of a stand-alone wind, solar PV hybrid system [4]. A linear programming technique was developed for optimal design of a hybrid wind/ solar PV power system for either autonomous or grid-linked applications [5]. Different aspects of PV, wind diesel and battery-based hybrid system including optimal sizing and operation has been detailed [6,7]. A probabilistic performance of stand alone Solar PV, wind energy system with several wind turbines of same or different sizes, with PV models and storage batteries has been presented [8]. A hydro-based system was discussed in synchronized operation with wind energy [9]. Pre-feasibility study on hybrid energy based on wind and fuel cell system was published [10]

II. HYBRID SYSTEM

To accomplishment over the shortcoming of unavailability of power at all times, and to isolated places, hybrid systems are developed. In a hybrid power system, different methods of producing electricity are combined to make sure a uninterrupted power supply. When the two or more power generating systems are integrated to generate power, it is known as hybrid system. Such as the combination of a wind turbine along with solar or a biomass system or a micro hydropower plant system is termed as a hybrid energy system. Hybrid generation system selected in this design, harnesses both renewable sources of biomass and wind power to form an equivalent of a miniature grid. When the systems are connected together, they will have enhanced reliability, higher efficiency, and lower emissions with an affordable cost.

Hybrid energy systems have been defined in a number of ways. The most general, and probably most useful, is the following:

''Hybrid energy systems are combinations of two or more energy conversion devices (e.g., electricity generators or storage devices), or two or more fuels for the same device, that when integrated, overcome limitations that may be inherent in either.''

This definition is more practical because it includes a broad range of possibilities and the elementary characteristic of the assortment of energy conversion. However it is noted that this extensive definition does not necessarily take explanation of a renewable energy based device and allows for transportation energy systems.

There are basically three types of conventional systems of interest:

(1) large utility networks,
(2) isolated networks, and
(3) small electrical load with dedicated generator.

Large utility networks consist of power plants, transmission lines, distribution lines and electrical consumers (loads). These networks are based on alternating current (AC) with constant frequency. Such networks are frequently assumed to have an infinite bus. This means that the voltage and frequency are unaffected by the presence of additional generators or loads.

Isolated electrical networks are found on many islands or other isolated locations. They are similar in many ways to large networks, but they are normally supplied by one or more diesel generators. Generally, they do not have a transmission system distinct from the distribution system. Isolated networks do not behave as an infinite bus and may be affected by additional generators or loads.

III. SYSTEM MODEL

A wind-biomass gasifier hybrid energy system consisting of biomass gasifier, wind system with battery bank is modeled as shown in figure 1. This system is used to perform simulation, optimization and sensitivity analysis with the help of HOMER software. The power output from the biomass gasifier depends on the lower heating value of the biomass fuel used for gasification. Biomass gasifier efficiency is defined as the ratio of the heat content of the fuel gas generated by the gasification of the wood and of the heat content of that wood when it is totally burnt.

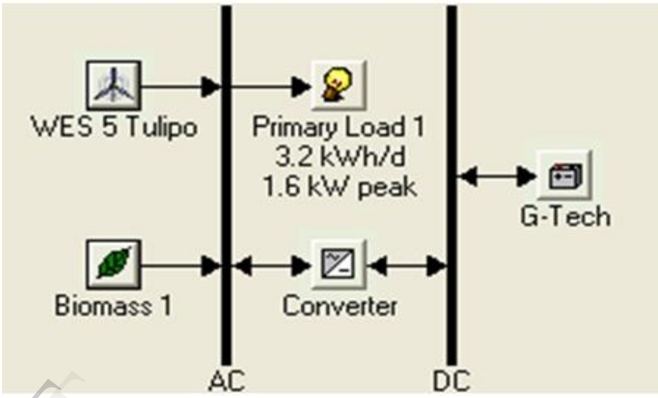

Figure 1 Arrangement of the hybrid energy system

IV. PRE-FEASIBILITY ANALYSIS OF HYBRID SYSTEM

Climatic conditions determine the availability and magnitude of wind and biomass energy at particular site. Pre-feasibility studies are based on weather data (wind speed, availability of biomass) and load requirements for specific site. In order to calculate the performance of an existing system, or to predict energy consumption or energy generated from a system in the design stage, appropriate weather data is required. The global weather data is obtained from local metrological station. The global weather pattern is taken from NASA surface metrological station shown in Fig. 2. In Fig. 2 the red and yellow indicate high wind energy is available while the blue colours reflect lower wind energy potential zone. Wind and biomass hybrid system can be designed with the help of these global weather patterns, for any location all over the world. Deciding on the best feasible solution will need to be done, on a site-to-site basis. Some sites can be best serviced by mains or grid power, others by generators, and some by combinations of the renewable energy solutions described above.

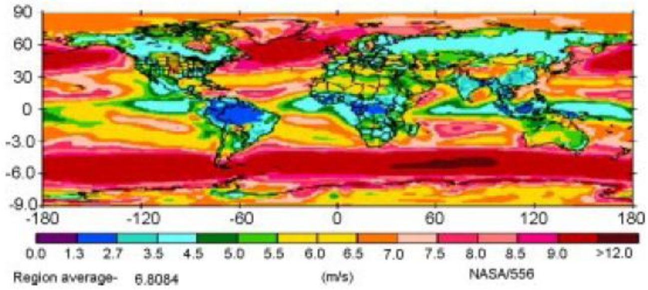

Figure 2 Global wind energy potential

Some researchers used metrological station data for pre-feasibility study and design of hybrid energy system. Combination of biomass and wind in a hybrid energy system reduces the battery bank and diesel requirements. Feasibility of hybrid wind and biomass energy system strongly depends on biomass and wind energy potential available at the site. The monthly performance of autonomous small-scale wind energy systems with battery storage has been analysed. A total of 12 months worth of measured wind speed data from five different locations throughout the world have been used to determine the monthly system autonomies through simulations. Based on these simulated autonomies, a simplified method was derived for estimating the monthly system performance of wind energy systems. The output is the monthly system autonomy. This approach does not only eliminate the requirement of a detailed and complex simulation programs but also makes it possible to estimate the performance of such systems where the hour-by-hour measured wind speed data are not available. Considering the limited number of sizing and design algorithms for small wind energy systems, it is safe to say that such simplified algorithms are of a vital importance if the wind energy systems are going to be alternative to conventional energy systems. Various feasibility and performance studies are reported to use a hybrid energy system in parallel with some hydrogen energy storage.

V. WIND POTENTIAL ASSESSMENT

Wind power is the extraction of power from the wind with the help of turbines and conversion of this energy into electrical energy. Hourly wind data for round the year is shaped in the form of text file. This file contains day, month, year, time wind speed and wind direction (degree). However HOMER expects a '.wnd' file, but a text file with any extension can also be imported. So this file is of 8760 row. The first line represents the average wind speed (in m/s) over a single hour between midnight and 1 a.m. on January 1, the second line between 1 a.m. to 2 a.m., and so on. When a text file data is imported, HOMER creates a copy of the data set and integrates it with the HOMER (.hmr) file. Once the data is part of the HOMER file, HOMER no longer refers to the original text file. If any modification data in the original file is needed, modified file must import in order for the modification to be included in the HOMER file. After this HOMER calculates twelve monthly average wind speed values and displays them in the form of table and graph. HOMER also displays the name of the imported data file in the title of the stream flow graph. The four advanced parameters (Weibull distribution factor, Auto correlation factor, Diurnal pattern strength, Hour of peak wind speed) are also calculated from the imported data and displayed in the text boxes. Thus provided monthly data (Based on hourly data) is the main source of calculations to know the output of wind energy that can be generated by the wind turbine.

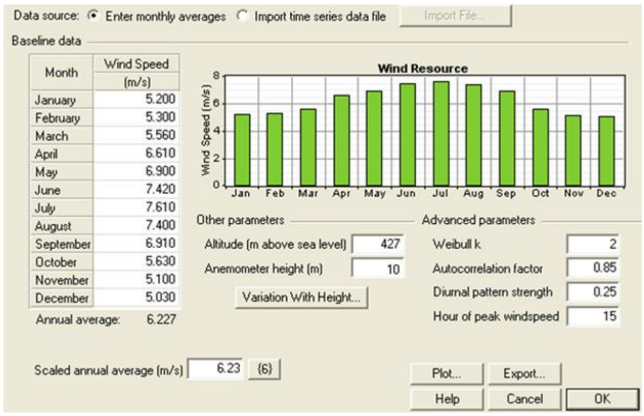

Figure 3 Wind resource input window

Wind resource input window of HOMER software (Shown in Figure 3) is showing the monthly average value, pattern of wind speed variation, four advanced parameters and scaled annual average wind speed (m/s). input summary is showing the monthly averages of wind speed for twelve month, annual average 6.227 m/s, Weibull distribution factor 2, Auto correlation factor 0.85, Diurnal pattern strength 0.25, Hour of peak wind speed as 15.

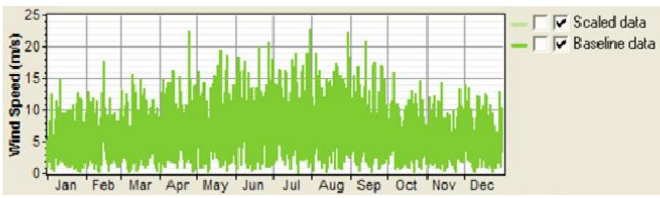

Figure 4 Baseline data of wind for round the year

Baseline data of wind for round the year is shown in figure 4. This figure is software generated which shows hourly wind speed for twelve months. It can be seen from the figure that the maximum data of wind speed is varying from 0 m/s to 22 m/s. However it also shows high wind speeds of more than 18 m/s velocities.

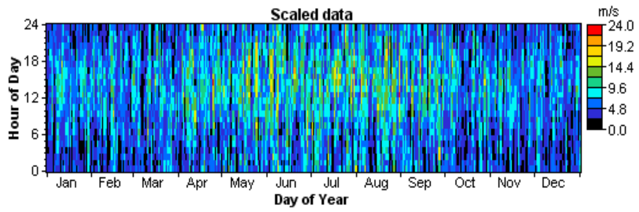

Figure 5 Scaled monthly data of wind for the hour of the day

Figure 5 shows the scaled monthly data for the hour of the day. It shows the hourly availability of wind speed round the year. A data map is a type of graph showing one year of hourly data. With time of day on one axis and day of the year on the other, each hour of the year is represented by a rectangle which is colored according to the data value for that hour. The data map allows daily and seasonal patterns to be seen much more easily than would be possible with a simple time series plot.

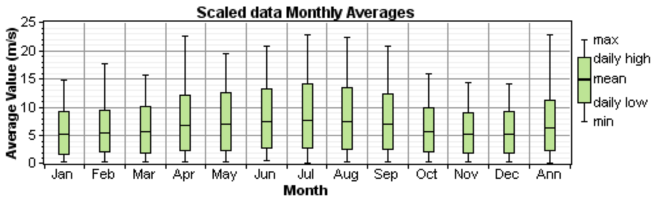

Figure 6 Monthly average values of wind

Figure 6 shows the monthly average values of available wind. Monthly average is calculated on the basis of hourly data available for the month. Figure shows maximum daily high value of wind speed during the month, minimum daily low value of wind speed during the month and monthly average. It can be seen from the figure that the maximum average value is seen during the month of July. While the minimum average value is seen during the month of December.

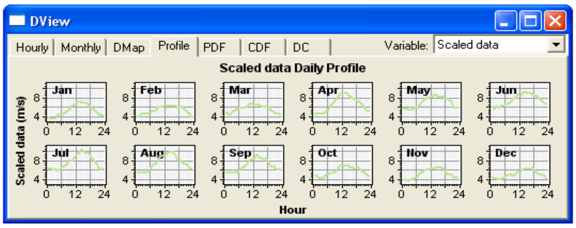

Figure 7 Scaled data daily profile

Figure 7 shows the scaled data daily profile for round the year. It gives map of each month as per availability of wind speed on the basis of hourly wind speed.

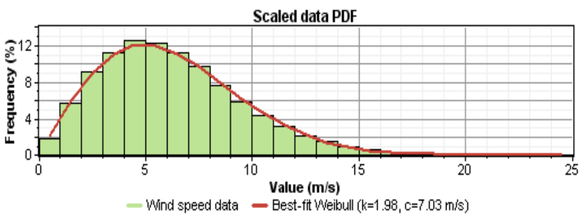

Figure 8 Frequency of wind speed and Weibull curve

Figure 8 shows frequency of wind speed and Weibull curve. It can be seen from the figure that most probable wind speed lies in between 5 to 6 m/s. it is also suitable for Weibull distribution. Figure shows various wind speed frequencies these are available in recorded wind data and also shows that these are best suitable to Weibull distribution curve. Weibull is a measure of long term distribution of wind speeds.

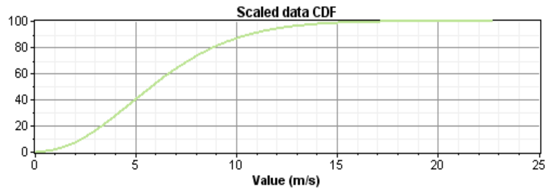

Figure 9 Wind speed scaled data curve

Figure 9 shows the frequencies of different wind speeds. It can be seen from the figure that lower wind speed is in less frequency. But high wind speeds are available at a large frequency. It is obvious from the figure that the site is quite windy and there will be no problem of wind energy generation.

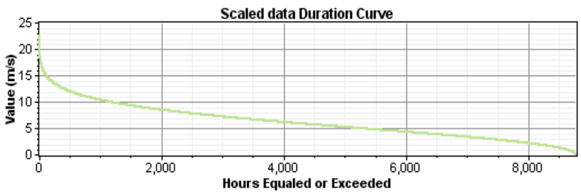

Figure 10 Scaled data duration curve

Figure 10 shows the wind speed availability for hours. It is clear from the figure that the most probable wind speed (5 to 6 m/s) is available for nearly 5000 hours. HOMER uses scaled data for calculations. Reason to scale the baseline data is to do a sensitivity analysis on the wind resource.

VI. BIOMASS POTENTIAL ASSESSMENT

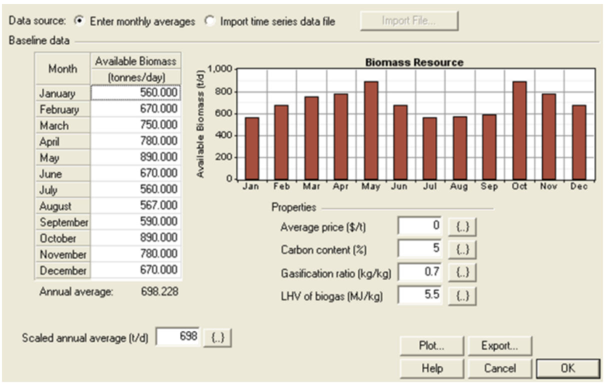

Figure 11 Biomass resource input window

The baseline data is the set of 8,760 values (one value for each hour) representing the average biomass feedstock availability, expressed in kilograms, for each hour of the year. HOMER displays the monthly averages calculated from the baseline data in the biomass resource table and graph.

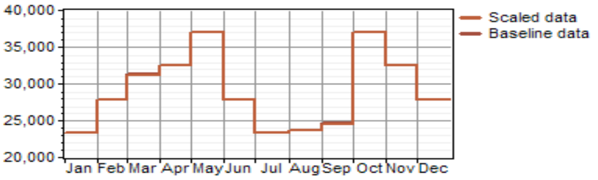

Figure 12 Baseline data of biomass for round the year

Figure 12 shows the baseline data for whole year on the basis of monthly average. It can be seen from the figure that availability of biomass is not uniform throughout the year. It is maximum during month of May and October. It is minimum during month of January and July.

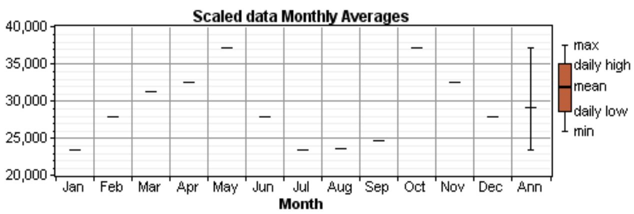

Figure 13 Monthly average data

Figure 13 shows the monthly average values of available biomass. Monthly average is calculated on the basis of hourly data available for the month. It can be seen from the figure that the maximum average value is seen during the month of May and October. The minimum average value is seen during the month of January and July. The availability biomass during the month of August is also very close to the minimum value.

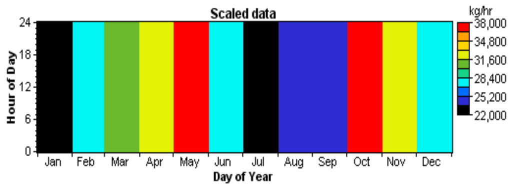

Figure 14 Scaled monthly data

Data map (Figure 14) shows the scaled monthly data for the hour of the day. It shows the hourly availability of biomass round the year. A data map is a type of graph showing one year of hourly data. With time of day on one axis and day of the year on the other, each hour of the year is represented by a rectangle which is colored according to the data value for that hour. The data map allows daily and seasonal patterns to be seen much more easily than would be possible with a simple time series plot.

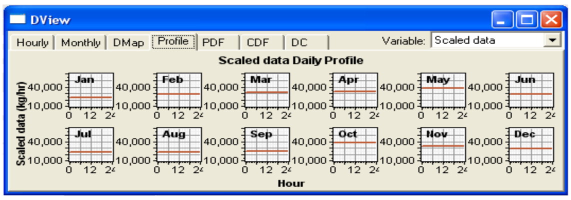

Figure 15 Monthly profile window

Figure 15 shows the monthly profile window of HOMER. It gives the detail of monthly profile of availability of biomass resource.

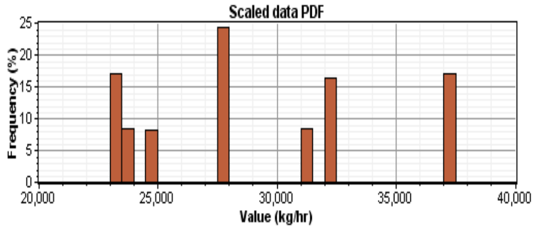

Figure 16 Frequency (percentage) of availability of biomass

Figure 16 shows the frequency (percentage) of availability of biomass. It is clear from the figure that 28000 Kg/hr is available 24 times in a year.23500 Kg/hr, 32000 Kg/hr; 38000 Kg/hr are available 17 times in a year. 24000 Kg/hr, 24500 Kg/hr, 31500 Kg/hr are available 13 times in a year. Rests of the values are less than 20000 Kg/hr. And these are not considered in this figure.

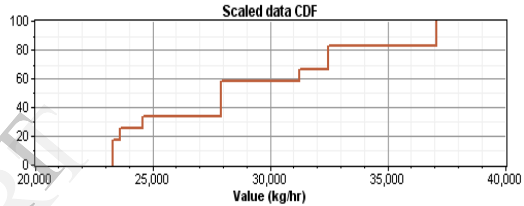

Figure 17 Frequency (percentage) of availability of biomass

HOMER uses scaled data for calculations. Scaled data is created by multiplying each of the 8,760 baseline values by a common factor that results in an annual average value equal to the value that is specified in Scaled annual average. The value of common factor is finding out by the ratio of the scaled annual average to the baseline annual average. The scaled data retains the shape and statistical characteristics of the baseline data, but may differ in magnitude. The default value for the scaled annual average is the baseline annual average. When the two values are equal, the scaled data and baseline are identical. HOMER interprets a scaled annual average of zero to mean that there is no biomass resource.

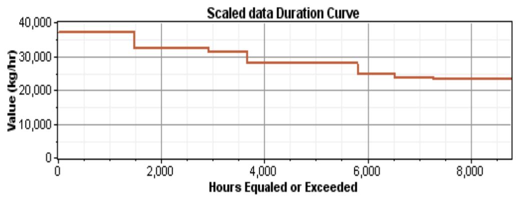

Figure 18 Frequency (percentage) of availability of biomass

Figure 18 shows the scaled data duration curve plotted by the HOMER. To synthesize data, twelve average values of biomass availability are entered (one for each month of the year). The average value of biomass availability (in tonnes per day) for each month is entered in the appropriate row of the biomass resource table. As soon as the values are entered in the table, HOMER builds a set of 8,760 values, or one value for each hour of the year. HOMER creates the synthesized values by assuming that the biomass availability is constant throughout each month; HOMER simply assigns the monthly average value to each hour in that month.

VII. CONCLUSION

It is clear from the work that renewable energy sources are going to play a very important role in coming future for the society as well as environment. As these sources are clubbed together for higher reliability and economy. The optimization of these sources is done with the help of HOMER software. The results are indicating that the said hybrid system will be effective. The feasibility analysis for the various parameters of the wind and biomass hybrid system is also done with the help of HOMER software. The system is reliable and enough capable to generate sufficient power with all weather conditions.

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