Integration Of Energy Resources

Bhupesh Singh

M tech first yr student
Uttarakhand technical university
Dehradun , India
bhanu140389@gmail.com

Abstract—One of the problem world is facing today is the energy crisis. Fossil fuels are being consumed at an alarming rate; there is an immediate need to switch to non-conventional sources of energy, namely solar and wind power. An integrated model is presented in this paper comprising of solar and wind-power The new model was tested and results are presented here using matlab simulink.

I. INTRODUCTION

Solar energy is the oldest and most abundant source of energy, and it is the root material for all almost all fossil fuels renewable sources of energy. This energy resource has a number of characteristics that make it a very desirable option for utilization. The perennial source of solar energy provides unlimited supply, has no negative impact on the environment, is distributed everywhere, and is available freely. In India, the annual solar radiation is about 5 kWh/m^2 per day; with about 2300-3200 sunshine hours per year. Solar energy can be exploited for meeting the ever-increasing demand of energy in our country. Its suitability for decentralized applications and its environmental-friendly nature makes it an attractive option to supplement the energy from other sources.

Another source of clean and renewable energy that has emerged as one of the most attractive solutions is the wind power. Major factors that have accelerated the wind-power development technology are high-strength fiber composites for constructing large low-cost blades,falling prices of the power electronics,variable speed operation of electrical generators to capture maximum energy.

 In 1995, India had 565 MW of wind capacity, and some 1,800 MW additional capacity in various stages of planning. The government has identified 77 sites for economically feasible wind-power generation, with a generating capacity of 4,000 MW of grid-quality power.

Model proposed in this paper is a circuitry based model to be used with Simulink. The proposed model was simulated and results are presented using matlab simulink.

WIND ENERGY SYSTEM

I. Based on Utilization aspect:
1. Wind electric energy systems connected to grid (without need for energy storage facility).
2. Stand-alone (Isolated) wind energy systems (with need for energy storage facility).
3. Non-critical wind electric or wind mechanical energy systems (without storage).
4. Wind Electric + Diesel Electric Hybrid or Wind Electric + Solar Electric +Battery Hybrid.

II. Based on wind turbine rotor and electrical output:
1. Constant speed constant frequency system.
2. Variable speed constant frequency system.
3. Nearly constant speed and constant frequency system.

Constant speed constant frequency system
1. Here, shafts of generators are coupled to output shaft of wind turbine. As wind speed is variable, therefore variable pitch control and gears are required to maintain constant torque output.
2. Constant frequency systems are essential for modern wind farms as the output is either grid connected or delivered to consumers.

Variable speed constant frequency system
1. Thyristor converters are used.
2. Due to variable wind speed, the generator produces variable frequency output.
3. Rectifier-inverter combination delivers constant frequency electrical output to load or grid.
4. Here, there is no need to regulate blade speed. So, turbine operates at maximum efficiency.

Nearly constant speed and constant frequency of grid
1. Small and medium generator units rated 100 kW, 200 kW or 300 kW belong to this category.
2. They use induction generators and are connected to grid.
3. Excitation current is received from grid. So, induction generator cannot be operated alone.
4. Power factor correction capacitors are also necessary.

CONTROL AND MONITORING SYATEM OF WIND FARM

1. A complete wind farm is controlled from the control room located in the main sub-station.

2. (X-1, X-2, X-3….) represent control cables between individual WTG units and the master turbine controller.

3. The variables like power, voltage, power factor, frequency, rotor speed, pitch angle, bearing temperatures, vibrations, wind direction, wind speed etc. are measured. They are converted to equivalent digital signals and transmitted via (X-1, X-2, X-3….) to the master controller.

4. The control has 3 levels:

i). Distribution Network Control Centre
    ii). Master Wind Farm Controller
    iii). Unit WTG Controller

5. Signals are transmitted by radio signal system.

6. Station controller sets the power level according to instructions from the Central Distribution Control Centre.

Wind Power Quality

Power quality is the term used to describe how closely the electrical power delivered to customers corresponds to the appropriate standards so that the equipments of customers operate satisfactorily.

Electrical behavior of Wind Turbine Generators

There are following inequality constraints:

1.For voltage change:

$$\sum S_{WKA}(\frac{1}{S_{KE}} - \frac{1}{S_{KSS}}) \leq \frac{1}{33}$$

2.For voltage fluctuation:

$$\sqrt{\sum(\frac{P_{WKA}}{S_{KE}})^2} \leq \frac{1}{25}$$

3.For lighter flicker:

$$\sqrt{\sum(\frac{P_{WKA} P_{ST}}{S_{KE}})^2} \leq \frac{1}{25}$$

Here, S_{WKA} = Wind Power generator apparent power
P_{WKA} = Wind Power generator real power
P_{ST} = Short term flicker severity
S_{KE} = Short- circuit level at tie-line
S_{KSS} = Short-circuit level at transformer station bus-bar

Most wind turbines run at almost constant speed with direct grid connection since it is required to keep a constant frequency equal to the grid frequency. With indirect grid connection (in our case) turbine generator runs in its own, separate mini AC-grid. This grid is controlled electronically (using an inverter), so that the frequency of the alternating current in the stator of the generator may be varied. In this way it is possible to run the turbine at variable rotational speed. Thus the turbine will generate alternating current at exactly the variable frequency applied to the stator.

There are three inputs to the turbine block:

- Generator speed : the speed of the generator is given in p.u. of the generator base speed i.e. 1 p.u.
- Pitch angle : the pitch angle is being controlled by the pitch angle controller and the initial value is taken as zero.
- Wind speed : the base wind speed is taken as 12m/s.

The output is the torque applied to the generator shaft which is equal to 2100 watts.

The output power of the turbine is given by the following equation:

$$P_m = c_p(\lambda, \beta)\frac{\rho A}{2} v_{wind}^3$$

P_m = mechanical output power of the turbine (W)
C_P = performance co-efficient of the turbine
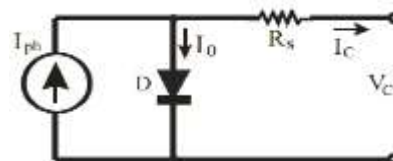ρ = air density kg/m^3
A=turbine swept area (m^2)
v_{wind} = wind speed (m/s)
λ= tip speed ratio of the rotor blade tip speed to wind speed
β = blade pitch angle (deg)

SOLAR ENERGY SYSTEM

The solar energy system consists of arrays of solar cell or PV cell.
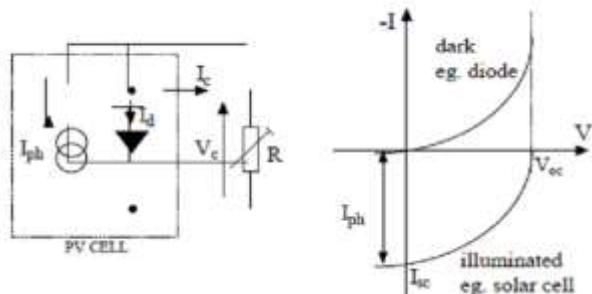

PV cell circuit and characteristics

The formula governing the PV cell output are as

$$V_c = \frac{AkT_c}{e} \ln\left(\frac{I_{ph} + I_0 - I_c}{I_0}\right) - R_s I_c$$

follows.

II.

k: Boltzmann constant (1.38×10^{-23} J/°K).
I_c: cell output current, A.
I_{ph}: photocurrent, function of irradiation level and junction temperature (5 A).
I_0: reverse saturation current of diode (0.0002 A).
R_s: series resistance of cell (0.001 Ω).
T_c: reference cell operating temperature (20 °C).
V_c: cell output voltage, V.

INTEGRATION USING MATLAB/SIMULINK

The following section will elaborate on each of the Simulink system components. The project was implemented using MATLAB (Simulink). Each of the components mentioned above was modeled individually. These components were then linked, taking into consideration the control aspect of the system.

The general methodology used in the development of the Simulink program is the following. Initially, each of the system blocks (these include inputs such as wind speed, required area for PV cells, and system components) was modeled in isolation. After completing models for the main blocks (the main components) of the system, the group began linking these components in a manner that would provide the desired output; i.e. taking into consideration the control aspect of routing power to the system's components. After modeling the energy sources and sinks, we modeled several control blocks to control the energy flow. The control aspect of the system was our main focus throughout the implementation of the Simulink section.

The integrated system block is shown below

GENERAL INPUTS

Area: This input describes the swept area of the blades. This is used in determining the energy produced by the wind turbines.
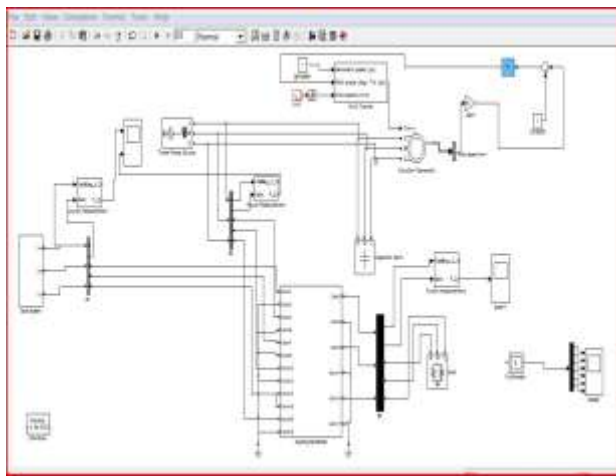
W: This input describes the wind speed. This can be entered as an average value or as a random graph.
S: This input describes the solar irradiance in the area of the PV cells. This can also be entered as an average value or a random graph. Needless to say, this is instrumental in calculating the energy produced by the solar panels.
*a_pv:* This input describes the area occupied by the PV cells, also instrumental in the calculation of the energy produced by the PV cells.
G1/G2/G3: These are control inputs. These determine whether the user has opted to use an average value or import a random graph (input 0).

CONTROL BLOCK 1

The task of this control block is to decide what sort of input the system will receive; it allows the user to choose between using an average value and importing a random graph for both solar and wind. The output of this block is the user's chosen mode.
The switches above decide the type of input the user wants. If the user inputs "0", the switch chooses to pass a random graph, if the user inputs a numeric value, the switch chooses that numeric value as an average speed. This block also allows the user to choose which type of wind turbine to employ. The scopes are placed to verify that the proper input was chosen and to view the random graph


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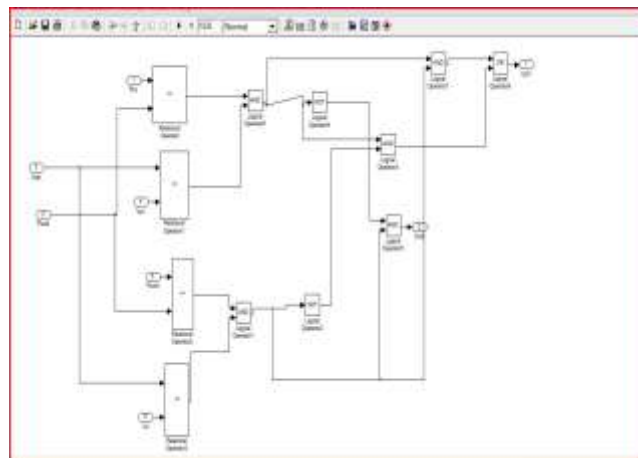
WIND TURBINE CONTROL

The task of this block is the measuring of wind speed and making sure it is within the acceptable range. It applies the principles of Cut in and Cut off discussed previously.

The cut in and cut out speeds are determined according to the choice of turbine the user makes. The block compares the inputted wind speed to these values, if it falls within the acceptable range; it is passed to the wind power block. The AND operator will make sure that a value not in the acceptable range is not passed. Again, the scopes are present for verification purposes.

WIND POWER

The Task of this block is to compute the power generated by the wind turbines. It has three inputs; wind speed, the swept area of the blades, and a control input which is discussed above and wind turbine asynchronous generator block is shown below
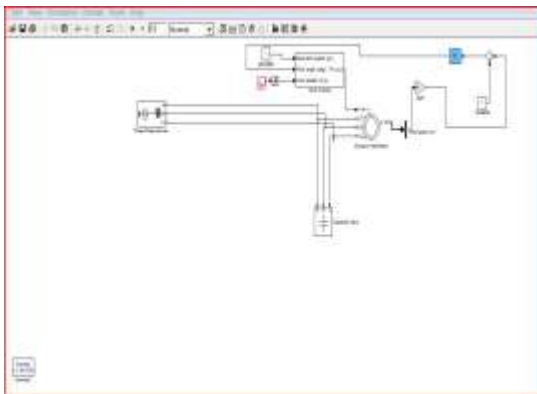
SPECIFICATIONS FOR IMPLEMENTATION

The function of this block is to apply the formula for calculating the power generated by the turbines (mentioned earlier); the application of the formula occupies all inputs except the last. The last input is the number of turbines; this takes into consideration the number of turbines employed by the user. The mechanical torque output from the turbine is being fed to the asynchronous machine. The ratings for the asynchronous machine are :

1. P(nominal)= 2e3 VA
2. Phase to phase voltage (RMS)= 380 V
3. Frequency= 50 Hz
4. Excitation Source= Phase to phase voltage (RMS)= 380 V
5. Frequency= 50 Hz
6. Three Phase Short Circuit VA= 10e3 VA

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7. Base Voltage, V(RMS) Phase to Phase= 380 V
8.
   /R = 7

SOLAR POWER

As with the wind power block, the task of this block is to apply the formula. It calculates the power generated by the PV cells as stated in the governing formula. **The PV cell output voltage is a function of the photo current that mainly determined by load current depending on the solar irradiation level during the operation. Voltage of single solar cell is multiplied by number of solar cell connected in series to calculate the full array voltage.**
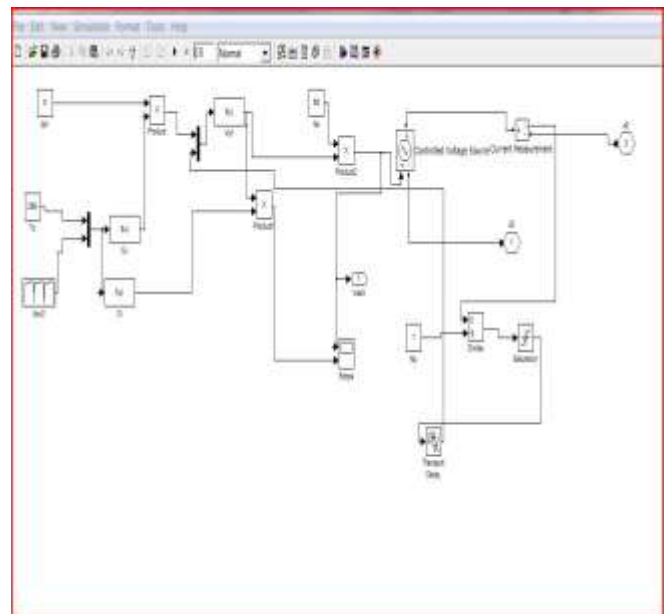

III. RESULT

The simulation model is primarily designed for the opportunity analysis of renewable energy resources usage, for their management in the design phase and for the study of problems that may occur due to the adopted solution. The adopted solution concerns the management the monitoring, control and command of renewable energy sources and power system. In addition to the above functions, the model is designed and developed for the study of real-time system operation and for power quality analysis of the studied system.

After running the simulation, power flow graphs among hybrid system based on renewable sources and the instantaneous voltages and currents graphics can be obtained. In the performed study were considered different

configurations and situations of renewable energy sources availability and different types of consumers.

In this section the renewable energy resource availability was taken within the range of 0.8 - 3kWh/m2 for solar resource, a variable wind speed from 2 to 20 m/s and a water flow between 30 and 100 l/s at 50m level difference from the hydro resource. A linear and a nonlinear consumer (Pi=33kW) were also considered. The results obtained were perfectly matching the requirement ,the figure below shows the voltage and current wave forrn in three phases.
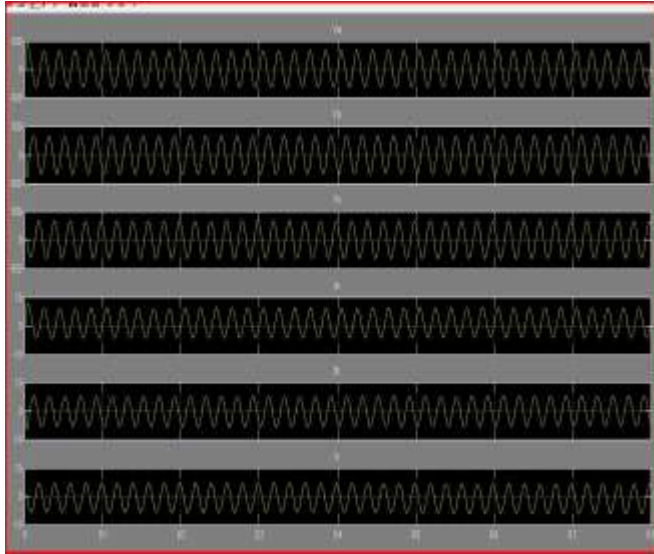
Power quality achieved is very much close to the one it should be under theoretical considerations or ideal conditions,the figure below shows the active and reactive power in the line.

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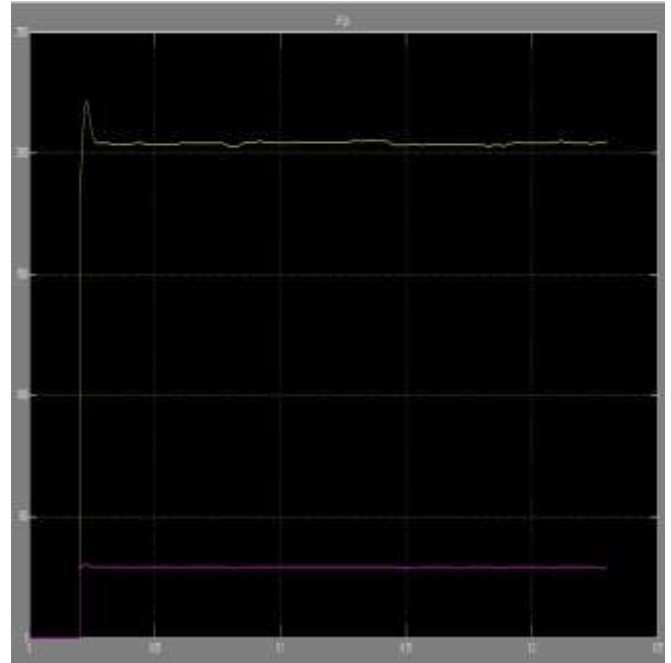
IV. CONCLUSION

This paper introduces a simulation model used in Matlab-Simulink .The proposed model has a generalized structure so that it can be used as a integrated power generator along with wind, fuel cells and small hydro system by establishing proper interfacing and controllers. The model is simulated connecting a three phase inverter showing that, the generated dc voltage can be converted to ac and interfaced to ac loads as well as ac utility grid system. Therefore the model proposed here can be considered as a part of distributed power generation systems .

V. REFRENCES

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