Abstract: Trade of electricity is rising all over the world, both in developing and developed countries due to rise in world population and economic magnification. Hybrid Renewable Energy System (HRES) are gradually propagating both for grid connected and stand-alone applications as an eco-friendly economical solution. These paper focuses on hybrid system (wind – PV) inter connection operation with distribution system. In PV system perturb & observe (P&O) algorithm is used as control logic for maximum power point tracking (MPPT). The work presented in this paper consists of wind turbine, PMSG, Solar array, boost converter and grid interface inverter. The power electronic interface transfer power engendered from wind turbine and solar array into the grid by keeping capacitor dc voltage constant and power flow to grid was controlled by PQ controller. Modeling and simulation of system is carried utilizing MATLAB/SIMULINK.

Keywords: Hybrid Distributed Generators, Wind-Driven PMSG-PV, MPPT, Grid Connected Hybrid System.

I. INTRODUCTION

In the current wide-ranging energy framework, importance of power generation from renewable energy sources is increasing day by day. In India sector wise consumption of electrical energy (utilities) during 2011-2012 in percentage was 22 in domestic, 17 in agriculture, 45 in industry, 9 in commercial, 2 in traction and railways, 5 in others. By 2013 total installed capacity of electrical power in India is 2,25,793.10 MW, in which state sector is contributing 89,092 MW, central sector 65,612.94 MW and private sector 71,088.04 MW. Fuel wise power generation capacity varies as total thermal power is 153,847.99MW in which coal is 132,288.39MW, hydro(Renewable) is 39,623.40MW, Nuclear is 4,780.00MW and renewable energy sources is 27,541.71 MW. The major power generation is due to fossil fuels. But the availability these fuels are narrow and various environmental fortuity associated with traditional power generation methods. The various type distribution generation like wind turbine, PV system, etc are connected to grid. The solar radiation falling on earth surface in about 90 PW, hence a small area use on earth surface can fulfill our electricity pre requisite. Wind energy is capable of producing more amounts of power but its vacancy can’t be predicted. Solar irradiance levels change because of the charges in the sun intensity and shadows caused by many reasons. Therefore the hybrid photovoltaic and wind energy system has higher integrity to give steady power than each of them wired distinctive. Other benefit of the hybrid system is that the amount of power can be storage in form of battery. Hybrid system (WES-PV) is more stable compared to their separate operation.

II. PROPOSED SYSTEM ARCHITECTURE.

The system subsist of a wind system (i.e) wind blades along with the direct driven Permanent magnet synchronous generator (PMSG). Energy drawn from this wind system is directly connected to uncontrolled AC/DC rectifier and it is connected to recurrent dc link voltage capacitor through grid interface voltage source inverter (VSI) the controlling of power flow to grid is decorous by VSI with help of dc link voltage. Another engendering system consists of solar array with MPPT and DC/DC boost converter which stimulate the voltage level to the common dc link voltage deck and connect the solar system to the common dc link.

![Fig.1. Block diagram of proposed architecture.](image)

With Induction generators oblige reactive power compensation. These problems are overcome by utilizing permanent magnet synchronous generators (PMSG) with power electronic interface linking the generator and the grid. With decrease in the price of the power electronic devices, the wind technology solutions employing power electronics equipment has become more captivating. A photovoltaic system transmutes sunlight into electrical energy. In order to overcome the damage of the stand-alone system the system is oversea in the grid connecting model.
III. PV CELL MODELING

The equal in value circuit of a PV cell is shown in Fig.2. An ideal solar cell is replica by a current source and a diode in collateral with it. However no solar cell is impeccable there by series resistance which has a minutely minuscule value. Applying Kirchhoff’s current law to the junction locus Iph diode, Rsh and Rs meet, we get,

\[ I_{ph} = I_d + I_{RP} + I \]  

(1)

\[ I = I_{ph} - (I_d + I_{RP}) \]  

(2)

We get the following equation for the PV cell current

\[ I = I_{ph} - I_d \left\{ \exp \left( \frac{e(V + I_R)}{AKT} \right) - 1 \right\} \frac{V + I_R}{R_p} \]  

(3)

Where Iph is insolation current, I is the cell current, Io is the inversion saturation current, V is the cell voltage, Rs is the succession resistance, Rsh is the parallel confrontation, and VT is the thermal voltage. Equation of cell is derived from the physics of the PN junction and is generally acquire as reflecting the Characteristic comportment of the cell.

A. Modeling of Solar PV system

The pile block of PV array is a solar cell, which transform light energy into electricity. The photo current Iph relay on the solar radiation and cell temperature as follows.

\[ I_{ph} = [I_{sc} + K_i (T - T_r)] S/100 \]  

(4)

Where Iscr is the cell short circuit current at citation temperature and radiation, Ki is the short circuit current temperature accompanying and S is the solar radiation in MW/cm2. With increase of cell’s working temperature, the current output of PV module increases, whereas the maximum Power output mitigate. Since the increase in the output current is much less than the decrease in the voltage, the total power decreases at high temperatures. On the contrary the temperature alarming rate around the Solar cell has a negative smash on the power generation capability. Increase in temperature is accompanied by a wane in the open circuit voltage efficacy. Increase in temperature causes increase in the band gap of the material and thus more energy is entailing to affrication this hurdle. Thus the efficiency of the solar cell is reduced.

Fig.2. PV Cell Circuit Model

Where Iph is insolation current, I is the cell current, Io is the inversion saturation current, V is the cell voltage, Rs is the succession resistance, Rsh is the parallel confrontation, and VT is the thermal voltage. Equation of cell is derived from the physics of the PN junction and is generally acquire as reflecting the Characteristic comportment of the cell.
Modeling and Simulation for Grid Connected PMSG Based Wind–PV Hybrid System with MPPT

### Table 1: Parameters of PV system

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value and units</th>
</tr>
</thead>
<tbody>
<tr>
<td>I_{mp}</td>
<td>7.61 A</td>
</tr>
<tr>
<td>V_{mp}</td>
<td>26.3 V</td>
</tr>
<tr>
<td>P_{max}</td>
<td>200.143 W</td>
</tr>
<tr>
<td>J_{sc}</td>
<td>8.21 A</td>
</tr>
<tr>
<td>V_{oc}</td>
<td>32.9 V</td>
</tr>
<tr>
<td>K_{v}</td>
<td>-0.1230 V/K</td>
</tr>
<tr>
<td>K_{I}</td>
<td>0.0032 A/K</td>
</tr>
<tr>
<td>N_{s}</td>
<td>54</td>
</tr>
<tr>
<td>I_{o}</td>
<td>9.825 x 10^-8 A</td>
</tr>
<tr>
<td>I_{pv}</td>
<td>8.214 A</td>
</tr>
<tr>
<td>A</td>
<td>1.3</td>
</tr>
<tr>
<td>R_{p}</td>
<td>415.405 $\Omega$</td>
</tr>
<tr>
<td>R_{s}</td>
<td>0.221 $\Omega$</td>
</tr>
</tbody>
</table>

### IV. DC-DC BOOST CONVERTER

A boost converter is a dc to dc voltage converter with a yield dc voltage pronounced than input dc voltage. This is an SMPS accommodate at least two semiconductor switches (a diode which act as freewheeling diode two shield a path of the current during the off state of variant switch and a transistor hitch in series of the source voltage). Filters made of capacitor and inductor is utilized to diminish the ripple in voltage and current respectively, is utilized at the output stage of the converter. Its firing pulses are generated by Perturb and Observe (P&O) MPPT technique.

### V. MPPT TECHNIQUE FOR SOLAR PANEL

Maximum power point tracking (MPPT) techniques are used in photovoltaic (PV) systems to maximize the PV array output power by tracking unrelenting the maximum power point (MPP) which depends on panels temperature and on irradiance conditions.

![Fig.4.Flows Char Perturb and Observe(P&O) Technique](image)

Heeding to Maximum Power Transfer theorem, the Power output of a circuit was maximum when the Thevenin impedance. Hence quandary of tracking the maximum power point lessens to an impedance matching problem. By transmuting the duty cycle of the boost converter commander. We can match the source impedance with that of the load impedance. This duty cycle is determined by MPPT techniques circuit (source impedance) matches with the load impedance. Perturb and observe (P&O) MPPT technique is utilized for the PV system.

### VI. WIND ENERGY SYSTEM (WES)

The wind turbine (WT) system transfigures wind energy to mechanical energy. The wind turbine (WT) is indispensable to evaluate the torque and power engender for a given wind speed and to study the effect of wind speed variations on the engendered torque. The torque and power fabricated by the WT within the interludes $[V_{min} \cdot V_{max}]$, where $V_{min}$ is minimum wind speed and $V_{max}$ is maximum wind speed, are outcome of the blade radius $R$ air pressure, wind speed and co-efficient $C_p$ and $C_q$. The power available in the wind can be calculated by the equation.

$$P_m = C_p (\lambda, \beta) \frac{\rho A V^3_{wind}}{2}$$  \hspace{1cm} (5)

Where $P_m =$ Power in watts, $\rho =$ air density, $A =$ rotor swept area, $V_w =$ wind speed in m/sec $C_p$ notable as the power coefficient of rotor the effective area of rotor blade

$$T = \frac{P_m}{\omega_m} \hspace{1cm} (6)$$

$$\lambda = \frac{R^* \omega}{V_{WIND}} \hspace{1cm} (7)$$

The performance coefficient $C_p (\lambda, \beta)$, which depends on tip speed ratio and blade pitch angle $\beta$ determines the amount of wind energy that can be captured by the wind turbine system nonlinear model describes $C_p (\lambda, \beta)$ as in equation8.

$$C_p (\lambda, \beta) = C_1 \left( \frac{C_2}{\lambda_i} + \frac{C_3}{\lambda_i} + \frac{C_4}{\lambda_i} + \frac{C_5}{\lambda_i} + C_6 \right)$$  \hspace{1cm} (8)

Where, $C_1=0.5176$, $C_2=116$, $C_3=0.4$, $C_4=5$, $C_5=21$and $C_6=0.0068\lambda_i$ is expressed in terms of $\lambda$ and $\beta$ as in equation6.

$$\frac{1}{\lambda_i} = \frac{1}{\lambda + 0.08 \beta} \frac{0.035}{\beta^3 + 1} \hspace{1cm} (9)$$

### VII. INTEGRATION OF HYBRID SYSTEM (WIND-PV) TO THE GRID

As the system is operating in the inter relationship approach to the grid, so for grid-connection of these two sources, discrete power electronic interfaces are not entailing for grid connection. At the grid side because of this converter it is aimed at DC link voltage is kept constant and adjusts the active power and reactive power delivered to the grid. The
value of DC link voltage is given by
\[ 0.6124n_0V_{dc} \geq \left| V_{ac} \right| + 3 \left| \alpha L_f I_{ac} \right| \]

(10)

The PI controller was used to modulate dc voltage of the boost converter whatever transmutations in the input conditions. PQ control scheme was acclimated to predominance the VSI. In PQ control the real and reactive powers transfer with the grid was the variables controlled by the inverter. We select decoupled active and reactive power channels in inverter in order to have a more expeditious replicatio. The dynamic mockup of this converter in rotating frame is calculated by

\[ u_d = e_d - R_{id} - \omega L_{id} - L \frac{d i_d}{d t} \]

(11)

\[ u_q = e_q - R_{iq} - \omega L_{iq} - L \frac{d i_q}{d t} \]

(12)

The equation 13 shows the active power of grid side inverter and this is controlled with the pi controllers.

\[ P = \frac{3}{2} \left[ V_{gd} I_d + V_{gq} I_q \right] \]

(13)

\[ Q = \frac{3}{2} \left[ V_{q} I_d - V_{gd} I_q \right] \]

(14)

VIII. RESULTS AND DISCUSSIONS

The 120KW hybrid (wind-PV) model with MPPT simulated is tested for different conditions like with connected MPPT technique and other is without MPPT technique. It is seen that the dc link voltage was maintained stable by the controllers for changes in the wind speed in wind energy system and changes in irradiation and temperature with MPPT in case of PV system. Fig 6 show dc link voltage of Wind energy system and PV energy system respectively maintained at the reference value, when the inputs like irradiation, temperature, wind speed and the load demand are kept stable with irradiation 1000 W/m2, temperature 25°C, wind speed 12 m/s and load with active power demand of 220 kW and reactive power demand of 41.08 kVAr. It is visually perceived that the dc link voltage is maintained stable at the reference voltage by the controllers.

![Fig.5. Block Diagram of AC-Shunted Grid-Connected Hybrid PV/Wind Energy System.](image)

![Fig.6. DC Link Voltage of Hybrid System](image)

**Table 2: Real Power of Hybrid System and Grid**

<table>
<thead>
<tr>
<th>S.no</th>
<th>Real power</th>
<th>Without MPPT</th>
<th>With MPPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Real power of hybrid (Wind-PV system)</td>
<td>1.3×10^5</td>
<td>1.5×10^5</td>
</tr>
<tr>
<td>2</td>
<td>Real power of grid</td>
<td>0.9×10^5</td>
<td>0.7×10^5</td>
</tr>
<tr>
<td>3</td>
<td>Total load</td>
<td>2.2×10^5</td>
<td>2.2×10^5</td>
</tr>
<tr>
<td>4</td>
<td>DC-link voltage</td>
<td>1200</td>
<td>1200</td>
</tr>
</tbody>
</table>
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Fig 7 without connected MPPT to hybrid system active power supplied by the wind energy system, PV energy system, load power and the power supplied by the grid. Both wind energy system and PV power system integrate the load demand of 220kw, the hybrid generated power of 130Kw and 90Kw power tired from the grid.

Table 3: Reactive Power of Hybrid System and Grid.

<table>
<thead>
<tr>
<th>S.no</th>
<th>Reactive power</th>
<th>Without MPPT</th>
<th>With MPPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reactive power of hybrid (Wind–PV) system</td>
<td>-0.3×10⁴</td>
<td>-0.4×10⁴</td>
</tr>
<tr>
<td>2</td>
<td>Real power of grid</td>
<td>2.4×10⁵</td>
<td>2.5×10⁵</td>
</tr>
<tr>
<td>3</td>
<td>Total load</td>
<td>1.94×10⁵</td>
<td>1.94×10⁵</td>
</tr>
<tr>
<td>4</td>
<td>DC Link voltage</td>
<td>1200</td>
<td>1200</td>
</tr>
</tbody>
</table>

Fig 7: without MPPT, DC Link Voltage Real Power of Grid, Real Power of Hybrid System, Grid Voltage.

Fig 7 Connected MPPT technique to hybrid system it real power given by the wind energy system, PV energy system, load power and the power given by the grid. Both wind energy system and PV power system integrate the load demand of 220kw, the hybrid system generated power of 150Kw and 70Kw being tired from the grid. By utilizing MPPT technique power of generating is increases by 20KW as shown in fig7.

Fig 8: with MPPT DC link voltage real power of grid, Real power of hybrid system.

Fig 9: without MPPT, Reactive Power of Load, Grid, Hybrid System.

Fig 9 It is additionally detected that the reactive power of hybrid system (wind-PV) energy system is constant at zero which is controlled by PQ controllers with zero reactive power reference. The enforced reactive power of load is given by the grid.

Fig 10: with MPPT, Reactive Power of Load, Grid, and Hybrid System.
Fig 9: Connected MPPT technique to hybrid system it reactive power generated less than without connected MPPT technique. The hybrid system constant at zero which controlled by PQ controllers with zero reactive power reference, the enforced reactive power of load is given by the grid, the current of wind, PV system and load are stable with reverence to the input and load parameters.

IX. CONCLUSION

Modeling of PMSG based Wind turbine and photovoltaic energy system with MPPT is developed utilizing MATLAB. The models of hybrid system (wind–PV) energy systems with MPPT are integrated with grid through VSI utilizing AC-shunted grid-connection scheme. PQ control strategy is utilized to control VSI. The analysis Hybrid system (Wind-PV) is connected with MPPT and without connected MPPT techquies. It was seen that the dc link voltage is maintained stable by the controllers for changes in the wind speed in WES and changes in irradiation and temperature in case of PV system. The simulation results shows that, utilizing a VSI and PQ control strategies, it is available to have a great replication of grid-connected hybrid energy system.

X. REFERENCES

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