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Hybrid Power System with Grid Tied Integration of Wind, Fuel, Battery and PV Using Neuro Fuzzy Based MPPT Algorithm

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ABSTRACT: This project process energy management system for micro grid using hybrid energy system. In recent years with the depletion of traditional primary energy, the exploitation of renewable energy such as Fuel cell, PV array, and Wind energy is urgently required. The fuel cells are considered as one of the most promising devices for standalone/grid connected distributed generations (DGs) due to its cleanliness, modularity and higher potential capability. A new topology comprising of fuel cells and solar photovoltaic (PV) array for renewable energy harvesting is proposed in this work .The inputs for the proposed system parameters such as solar insolation. The main objective of the proposed project is to reduce the Total Harmonic Distortion (THD).To maintain constant voltage to the DC grid using Landsman converter with Neuro fuzzy based MPPT algorithm. To achieve grid synchronization using hysteresis current controller. Fuel cells are connected to the DC bus through the Boost converter. This three phase voltage source inverter is controlled by PI controller. PV arrays are connected to the DC bus through Landsman converter to simulate DC sources. The results of PV system using the LMMN based adaptive control method integrating the Neuro fuzzy based MPPT method. A battery with bidirectional DC/DC converter is connected to DC bus as energy storage.

KEYWORDS: Utility grid, PV, Wind, Fuel, Battery DFIG, UGC, GC, LMMN control.

I. INTRODUCTION

The ever-growing energy demand and emphasis on clean energy have solar and wind based renewable power generations system. Therefore, many households and commercial places are being powered by solar power [1]. The solar power generating systems make use of power electronics based dc-dc and dc-ac converters to transform the dc voltage generated by the solar panels into an usable ac voltage [2]. The power electronic converters are controlled to operate the solar panels at maximum power points.

.. Operation of microgrid needs implementation of high performance power control and voltage regulation algorithm [3]-[5]. To realize the emerging potential of distributed generation, a system approach i.e. microgrid is proposed which considers generation and associated loads as a subsystem. nal islanding and use available waste heat of power generation systems [6].

Inverters are implemented for power transfer between AC and DC buses If in any case renewable source can't supply enough power and state of charge of storage devices are low microgrid disconnects common loads and supply power to the sensitive loads [7]-[8].

The vector control technique use for the speed control of DFIG. The vector control technique requires the elements of rotor speed and position. These are estimated by using sensor based or sensorlss based techniques. The use of sensorless technique has reduce the complexity and enhances the system reliability [9]-[11]. The nonlinear voltage current characteristics of the solar PV array has need for the MPPT. The various MPPT techniques can be perturb and observe method (P&O), Incremental conductance maethod (IC), Voltage based peak power, Current based peak power, and the other soft computing techniques are Fuzzy logic control (FLC), Artificial neural network (ANN), Genetic algorithm (GA), Particle swarm optimization (PSO) [12-13].

The adaptive filtering methods are Least Mean Square (LMS) and Least Mean Fourth (LMF) Perturb and Observe method of MPPT (Maximum Power Point Tracking) integrated with the LMS based control technique the drawback of

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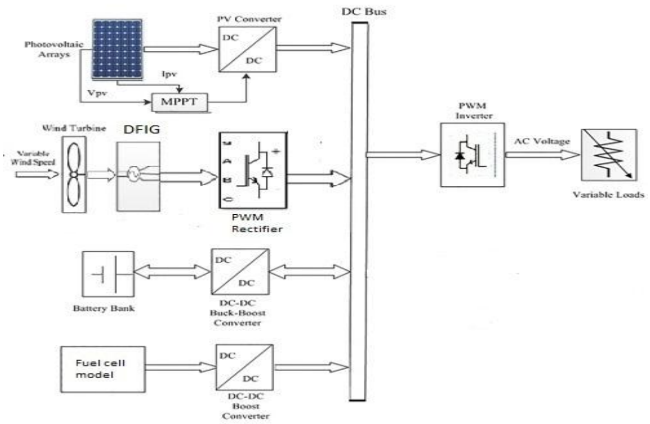
the steady state performance is not attained and it has the low signal to noise ratio. The LMS technique act as a lower order adaptive filter. The least mean fourth based control technique has high signal to noise ratio. The LMF technique act as a higher adaptive filter. The higher order adaptive filter with the Mean Square Error (MSE) has less compared to the lower order adaptive filter [14]-[15]. The above issues are overcome by using the method of least mean mixed norm (LMMN). The LMMN control technique by using the proposed work. The LMMN control technique has lesser MSE resulting in reduced misadjustment. use appilcabel in harmonic compensation.[16]

This work proposes a grid intertie of wind PV system. A wind turbine driven by a DFIG is used for harnessing of wind energy. The solar PV array is connecting directly on the DC link. The benefits are less no of components, reduce the losses, high efficiency and provides the better utilization of power. The control schemes are power electronic converters used in utility grid side converter and the generator side converter

II. SYSTEM CONFIGURATION

In our proposed system configuration of the hybrid system is shown in Figure 1 where various AC and DC sources and loads are connected to the corresponding AC and DC networks. The AC bus of the hybrid grid is tied to the utility grid. The AC and DC grids have their corresponding sources, loads and energy storage elements, and are interconnected by a three phase converter.. In the proposed system, PV arrays are connected to the DC bus through Landsman converter to simulate DC sources. A DFIG wind generation system is connected to AC bus to simulate AC sources. A battery with bidirectional DC/DC converter is connected to DC bus as energy storage. A variable DC and AC load solar panel alters. A capacitor C is added to the PV terminal in order to suppress high frequency ripples of the PV output voltage The bidirectional DC/DC converter is designed to maintain the stable DC bus voltage through charging or discharging the battery when the system operates in the autonomous operation mode.



A wind generation system consists of doubly fed induction generator with back to back AC/DC/AC PWM converter connected between the rotor through slip rings and AC bus. The AC and DC buses are coupled through a three phase transformer and a main bidirectional power flow converter to exchange power between DC and AC sides. The transformer helps to step up the AC voltage of the main converter to utility voltage level and to isolate AC and DC grids.

MODELING OF PV CELL

The photovoltaic system converts sunlight directly to electricity without having any disastrous effect on our environment. The basic segment of PV array is PV cell, which is just a simple p-n junction device. The fig.4.4 manifests the equivalent circuit of PV cell. Equivalent circuit has a current source (photocurrent), a diode parallel to it, a resistor in series describing an internal resistance to the flow of current and a shunt resistance which expresses a leakage current. The current supplied to the load can be given as.

$$I = I_{PV} - I_O \left[\exp\left(\frac{V + IR_S}{aV_T} \right) - 1 \right] - \left(\frac{V + IR_S}{R_P} \right)$$

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$$I_{PV} = \left(I_{PV\_STC} + K_I \Delta T\right)\frac{G}{G_{STC}} \quad I_O = I_{O\_STC}\left(\frac{T_{STC}}{T}\right)^3 \exp\left[\frac{qE_g}{aK}\left(\frac{1}{T_{STC}} - \frac{1}{T}\right)\right]$$

Many authors proposed more developed models for better accuracy and for different purposes. In some of the models, the effect of the recombination of carriers is represented by an extra diode As the total power generated by a single PV cell is very low, we used a combination of PV cells to fulfill our desired requirement. This grid of PV cells is knows as PV array. The equations of the PV array can be represented as

$$I = I_{PV}N_P - I_O N_P\left[\exp\left(\frac{V + IR_S\left(\frac{N_S}{N_P}\right)}{aV_T N_S}\right) - 1\right] - \left(\frac{V + IR_S\left(\frac{N_S}{N_P}\right)}{R_P\left(\frac{N_S}{N_P}\right)}\right)$$

MODELING OF WIND TURBINE

The aerodynamic power of wind is converted into mechanical energy by wind turbine i.e. the blades obtain kinetic energy from the wind which is transformed to mechanical torque at the rotor shaft of the wind turbine. The wind power can be calculated by the following equation

$P_t = 1/2 \rho C_p A V^3$ (1)

Where

P_t is the rotor mechanical power (W)

V the wind speed (m/s)

$A = \pi R^2$ the rotor surface (m^2)

R is the rotor radius (m)

ρ the air density (kg/m^3)

C_p is the power coefficient.

The rotor aerodynamic power coefficient, C_p, is the function of blade pitch angle (β) and tip speed ration (λ)

λ= Tip speed/Wind speed

$\lambda = \omega_r R/V$ (2)

Sub eqn (2) in (1) we get

$P_t = 1\backslash 2\ C_p(\lambda)\rho A(R/\lambda)^3\omega^3$

The output torque of the wind turbine T_t is calculated by the following equation

$T_t = 1/2\ \rho C_p A(V/\lambda)$

Variable speed turbines are made to capture the maximum energy of the wind by operating them at a blade speed that gives the optimum tip speed ratio. This may be done by changing the speed of the turbine in proportion to the change in wind speed. The variable speed operation will allow a wind turbine to capture more energy from the wind.

DEVELOPMENT OF FUEL CELL

Fuel cell is an electrochemical device that continuously converts the chemical energy of a fuel and oxidant into electrical energy and heat as long as the fuel and oxidant are supplied to the electrodes. A fuel cell is similar to a battery as it operates on the electrochemical energy conversion principle but there is an important difference; a fuel cell does not store fuel like a battery, but runs on a continuous supply of fuel.

A fuel cell consists of a fuel electrode (anode) and an oxidant electrode (cathode), separated by an ion-conducting electrolyte as shown in Fig.The electrodes are

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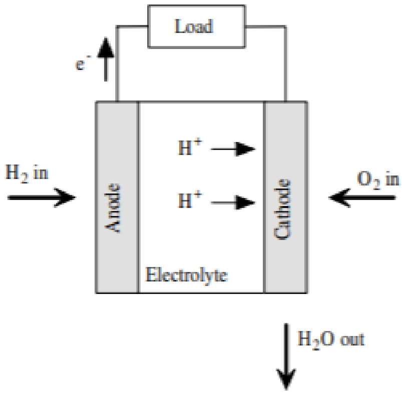

Fig.Fuel Cell model

connected externally through a load, thus completing the electronic - ionic circuit. A basic fuel cell with hydrogen as the fuel and oxygen as the oxidant is considered. The hydrogen is ionized at the anode to give hydrogen ions and electrons. The electrolyte allows only the ionic flow and resists the electronic flow. Hence the electrons flow through the electrical circuit and reach the cathode after supplying power to the load whereas the hydrogen ions flow through the electrolyte to reach the cathode.

III. CONTROL STRATEGY

The proposed PV-Wind hybrid system implements two appropriate control techniques for grid side and generator side control. The presented system works efficiency under variable wind velocity and changing solar insolation. The control techniques for discussed in below section.

- Generator side control technique.
- Grid side control technique.

.

LMMN CONTROL

The PV utilizes the LMMN adaptive control algorithm. LMMN corresponds to a new family of stochastic gradient adaptive filter algorithms based on mixed error norms. The LMMN method has combined the benefits of Least Mean Square and Least Mean Fourth technique . The performance of least mean square (LMS) is unstable in low signal-to-noise ratio (SNR) region and has more sensitive to noise . On the contrary, least mean fourth (LMF) algorithm is better convergence and it has difficult to implement in practical system because of its high computational complexity in high SNR region and lesser noise in weights

The LMMN algorithm operates by minimizing a cost function which is the convex combination of the squared and fourth powers of the error norms .

$$J(k) = \lambda E\{e(k)^2\} + (1-\lambda)E\{e(k)^4\}$$

Where,

λ =[0,1] mixing parameter.

E = Mathematical expectation operator

e = error adaptive component

k = sample index in time

The performance of LMMN algorithm is simple and faster than LMS and LMF. It has lower Mean Square Error which leads to quick convergence.

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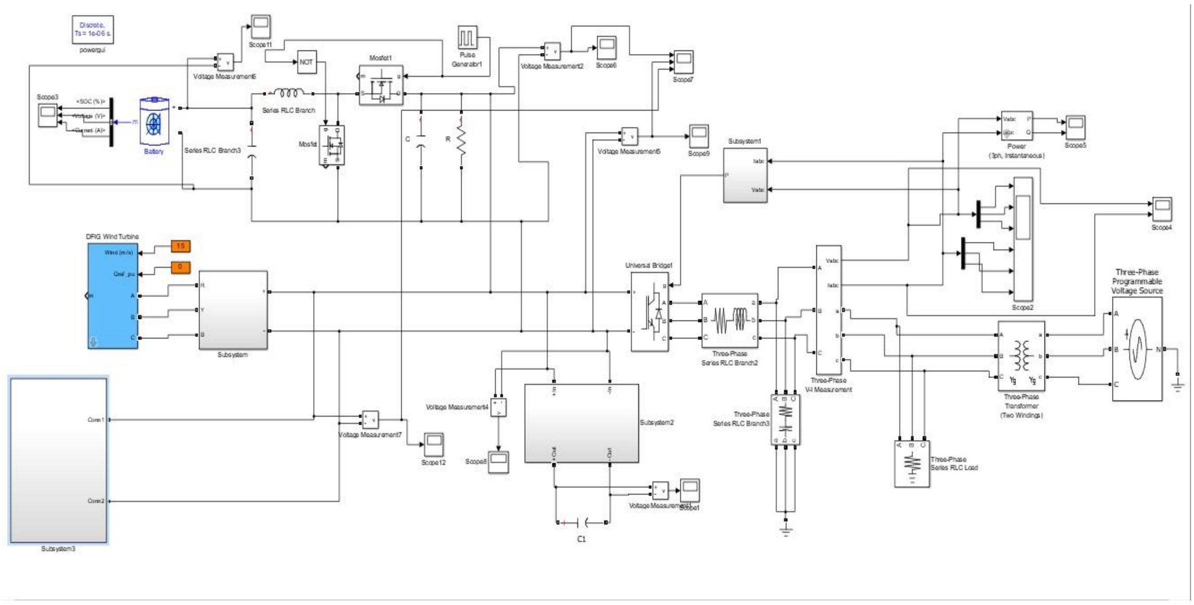
IV. SIMULATION RESULTS

A hybrid micro grid is simulated using MATLAB/SIMULINK environment. The performance analysis is done using simulated results which are found using MATLAB.



RESULTS:

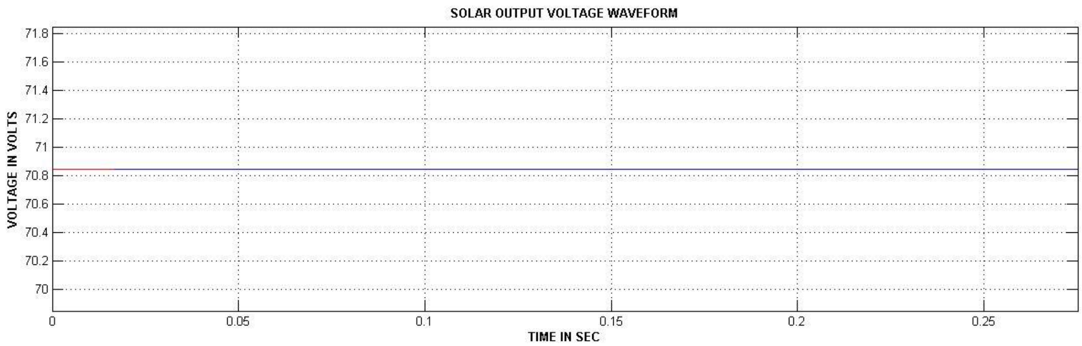


Fig a.solar output waveform

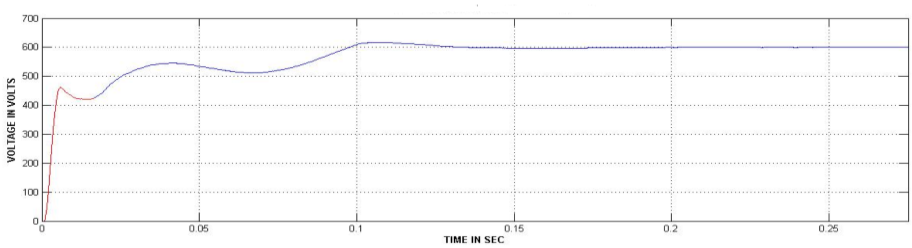


Fig b. Landsman converter input voltage waveform

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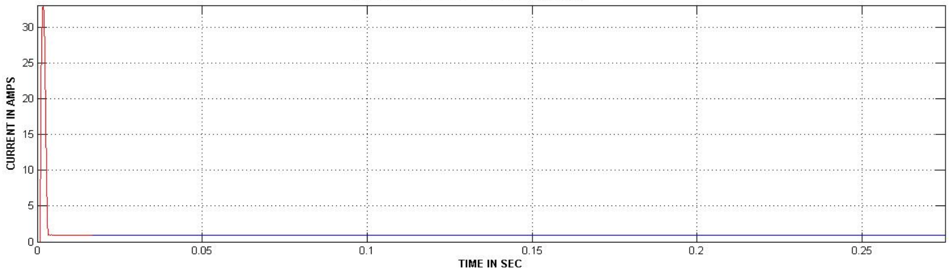

Fig c. Landsman converter input current waveform

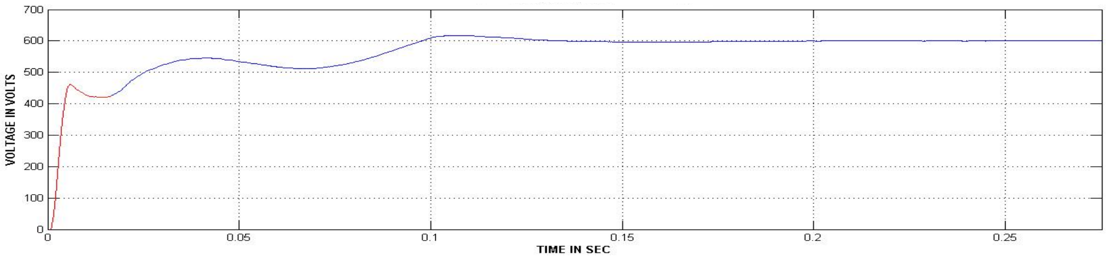

Fig d. Landsman converter output voltage waveform

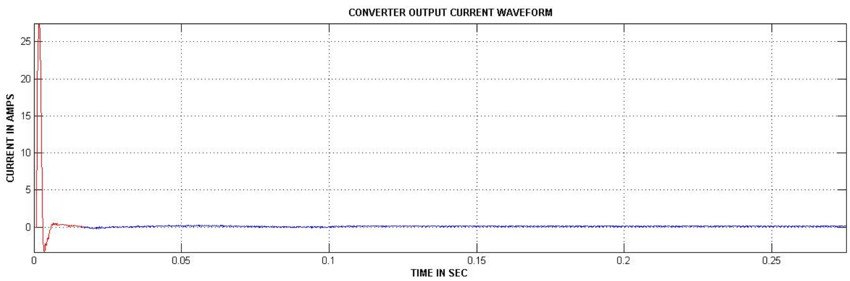

Fig e. Landsman converter output current waveform

Figure a. shows the solar output waveform, b. Landsman converter input voltage waveform, Landsman converter input current waveform, d.Landsman converter output voltage waveform and e. Landsman converter output current waveform.

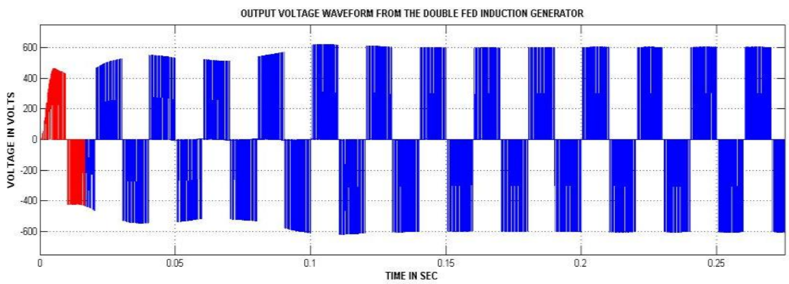

Fig f. Output voltage waveform in DFIG

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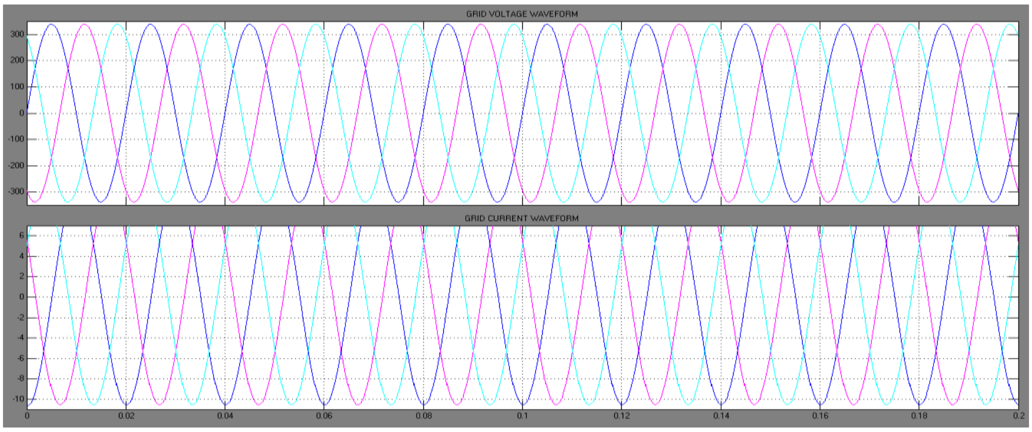
Current

(A)

Voltage

(V)

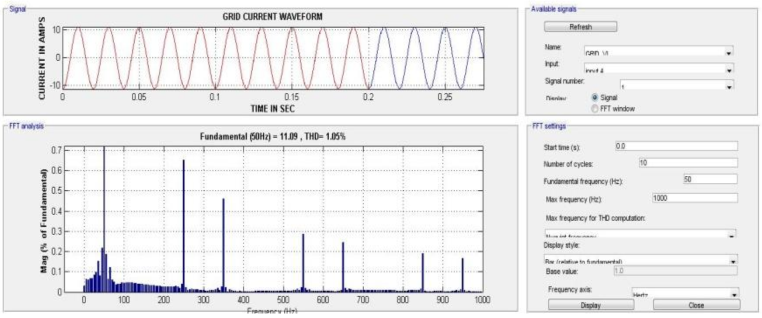


Time (S)

Fig i. Three phase grid voltage and current waveform

The above figure shows the performance of grid. The figures are represented in g. Grid current waveform, h. Grid voltage waveform , and fig i.represnt the Three phase grid voltage and current waveform.The Fig f.represnt the Output voltage waveform in DFIG

FFT ANALYSIS



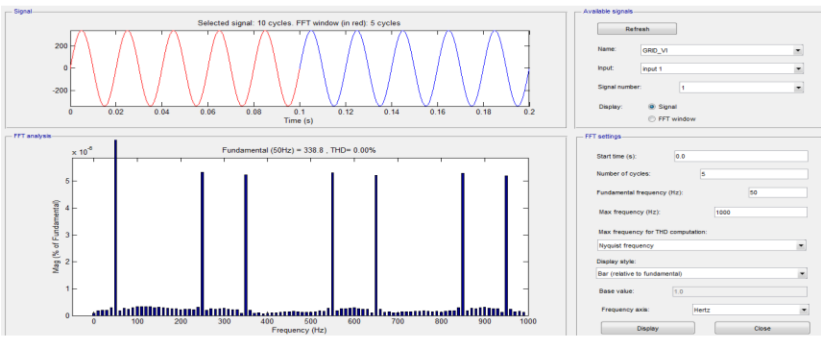


Fig THD value

The above figure shows that the Totsl Harmonic Distortion value.

V. CONCLUSION

The modelling of hybrid micro grid for power system configuration is done in MATLAB/SIMULINK environment. The present work mainly includes the grid tied mode of operation of hybrid grid. The models are developed for all the converters to maintain stable system under various loads and resource conditions and also the control mechanism are studied. MPPT Neuro fuzzy based algorithm is used to harness maximum power from DC sources and to coordinate the power exchange between DC and AC grid. Although the hybrid grid can diminish the processes of DC/AC and AC/DC conversions in an individual AC or DC grid, there are many practical problems for the implementation of the hybrid grid based on the current AC dominated infrastructure. The efficiency of the total system depends on the diminution of conversion losses and the increase for an extra DC link. The hybrid grid can provide a reliable, high quality and more efficient power to consumer. The hybrid grid may be feasible for small isolated industrial plants with both PV systems and Fuel cell model and wind turbine generator as the major power supply.

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