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Analysis of Hybrid-Based Grid Integration for Vehicle-To-Grid-Based Energy Management

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ABSTRACT

The main objective of this paper is energy management between Electric Vehicle to grid system for Hybrid integration. In recent years, the scale of global renewable energy power, especially for wind power, has rapidly expanded under the background of ecological deterioration and the lack of fossil energy. However, the randomness, intermittent and uncertainty seriously affects the reliability of the power system and causes a great deal of problems when connected to the power grid. So, grid-connected power is required to be within certain limits to ensure the safety and stability of the power system. And it has become a great challenge to improve the penetration rate of Hybrid power generation in the power system. An approach to smoothing the fluctuations of large-scale wind power is investigated using vehicle-to-grid (V2G) systems. In order to reduce the investment costs of energy storage, electric vehicles (EVs), as energy storage components, are gradually being considered to replace battery cells. And its operability is becoming more and more satisfactory with the increasing number of EVs. Therefore, to overcome the fluctuations in the voltage and manage the energy instantly in this paper an energy management and optimization system is designed and modeled. The performance results of electric vehicles, grid and load with different characteristics waveforms of voltage, current and power waveforms can be evaluated by using MATLAB/SIMULINK 2018a Software.

Keywords— Electric Vehicle, solar PV, wind turbine, Hybrid energy resource, Grid connected system, Matlab/Simulink

I. INTRODUCTION

expanded under the background of ecological deterioration and the lack of fossil energy [1].

IN recent years, the scale of global renewable energy However, the randomness, intermittent and power, especially for wind power, has rapidly uncertainty seriously affects the reliability of the

power system and causes a great deal of problems when connected to the power grid. So, gridconnected power is required to be within certain limits to ensure the safety and stability of the power system [2], [3]. And it has become a great challenge to improve the penetration rate of wind power generation in the power system [4] Existing studies have shown that the applications of energy storage technology provide great help for the integration of fluctuant renewable energies [5] – [7]. And issues, such as the acquisition of target grid-connected power, the energy storage equipment selection, the energy storage capacity configuration method, and the control of energy storage equipment, have been widely studied. For the target grid-connected power acquisition, wavelet packet decomposition (WPD) based methods are commonly utilized due to their advantages on multiscale decomposition and frequency band division in the signal, and have been proven through good performance [8] – [10]. As for the energy equipment selection, an active battery supercapacitor (SC) hybrid energy storage system (HESS) [11] - [13] has been put into use for assisting renewable energy grid connections due to their complementary characteristics: a battery has a relatively high energy density but a low power density, whereas an SC has a relatively high-power density but a low energy density [14]. In order to reduce the investment costs of energy storage, electric vehicles (EVs), as energy storage components, are gradually being considered to replace battery cells [15], And its operability is becoming more and more satisfactory with the increasing number of EVs. However, the mobility and uncertainty of EVs make their dispatch modes and methods quite different from the traditional battery when participating in smoothing the fluctuations of renewable energies. A highly comprehensive energy storage model for EVs, that can calculate the output power of each EV with high accuracy, is examined in. A novel integrated framework of EVs and wind farms (WEV) is proposed in to use the EVs charging and discharging to smooth the wind power penalty costs that are caused by overestimating and underestimating available wind power. In the meantime, a new multi-objective dynamic economic emission dispatching model based on the WEV system is developed to consider both emission and total cost objectives. A dispatch model considering several conflicting and competing objectives, such as providing vehicle-to-grid (V2G) service or coordinating with wind power, is presented in. A HESS model containing EVs is built, and its comprehensive energy management method is analysed in Subsequently, various strategies for EVs supporting renewable energy integration are developed on the basis of advanced smart metering and communication infrastructure However, the problem still remains of how to dispatch and control the power output of EVs in the grid as the dynamic selection of optimal EV clusters for scheduling are a typical non-deterministic polynomial (NP) hard problem And there are still several bottleneck problems which have to be urgently determined First, the energy storage model of each EV varies because of its uncertainties. Second, the dynamic changes in the EV clusters in the grid and the realtime status of each EV are hard to evaluate. Third, EV clusters fail to maximize the suppression of power fluctuations, based on the fact that EV power dispatch simply follows the waiting principle without allocating power according to the optimal state of each EV.

This study proposes a collaborative optimal dispatch method of vehicle-to-grid (V2G) systems for wind power integration. The proposed method also takes advantage of the hybrid energy storage technology. The methods presented in this paper are briefly summarized as follows: 1) a highly accurate hybrid energy storage structure, especially for a single EV, is established in this study. The EV model becomes more complete by adding the constraint of charging and discharging times and the parking status in the scheduling process.

The paper is organized as follows Section-II possesses a system description, Section-III depicts the controller topology, and Section-IV includes the results and Discussion, and Section-V conclusion.

II. System description

A. Solar power generation:

The solar panels are placed in earth the sunlight is coming to the earth and touch solar panels. At the time solar power producing this is called solar PV or solar photovoltaic.

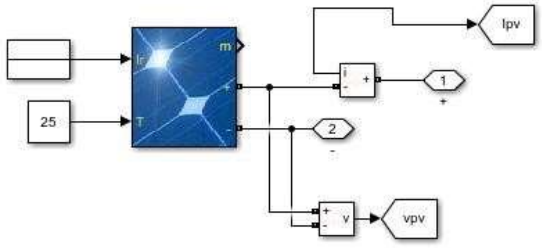


Fig.1 : Solar power system

The solar energy generation of electricity for power generation in this method called by photovoltaic effect. The PV panels have some materials. The materials have got in direct sun light and produce an electric power. This system has two then layers of

metal one is gets photons from sunlight and another one metrical produced an electron so the electric power created. The two semiconductor metals used for the solar system the one metal reduced for electrons and another one metal taken for photon in sunlight... The produced solar power will be not similarly so the PV connected for metal strips because it is moved to electric power in battery one solar panel don't produced for more power it is produced for low power only. The low amount of solar power moved to battery. The connected for battery stored for electric power the total system called as a solar system or PV. The total process called for solar cell or photovoltaic effect.

The current output of PV module is:

$$I = N_p * I_{ph} - N_p * I_0 * [\exp(\frac{v * N_s + I * \frac{R_s}{N_p}}{n * V_t}) - 1] - I_{sh}$$

$$V_t = (k * T)/q$$

Photo-current I_{ph}

$$I_{ph} = [I_{sc} + K_i(T - 298)] * I_r/1000$$

Here

I_{ph} - PV- current (A)

I_{sc}- Short circuit current (A)

K_i - Short-circuit current of cell at 25 °C and 1000 W/m²

T- Operating temperature (K)

I_r- solar irradiation (W/m²) =

The module saturation current I0 varies with the cell temperature, which is given by

$$T^{3} \qquad q * E_{go} 1 \qquad 1$$

$$I_0 = I_{rs}x\,[\frac{}{T_r}]\exp[\frac{}{nk}\ \frac{}{T}\ (\frac{}{T_r} -)]$$

Here,

T_r-Nominal temperature = 298.15 K

Band gap energy of the semiconductor E_{go}: = 1.1 eV

Reverse saturation current I_{rs}

$$I_{rs} = I_{sc}/[\exp(\frac{qV_{oc}}{N_s knT}) - 1]$$

Electron charge q = 1.6 × 10–19C

V_{oc}- Open circuit voltage (V) N_s-
Number of cells connected in series n-
The ideality factor of the diode

Boltzmann's constant k = 1.3805 × 10–23 J/K And,

$$I_{sh} = \frac{V * \frac{N^p}{N_s} + I * R_s}{R_{sh}}$$

N_p- Number of PV modules connected in parallel =

R_s- Series resistance (Ω)

R_{sh}- Shunt resistance (Ω)

V- Diode thermal voltage (V)

Wind power generation:

A. WIND SYSTEM MODELING

AC-DC RECTIFIER CONNVERTER

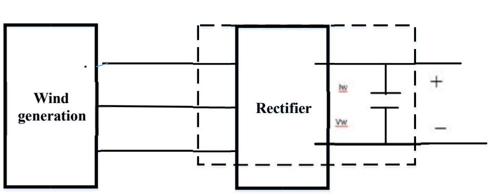


Figure 2 : Wind power generation

Wind system is a device which convert wind energy to electricity form .it is comprise with wind turbine PMSG generator, uncontrolled rectifier which convert AC to DC form. The governing mechanism for wind system which command the mechanical torque, wind speed, mechanical input and modelling of wind turbine respectively.

Expression for kinetic energy= ½ mv^2

The wind power produce by wind turbine based on aerodynamic characteristics can be expressed

$$Pmechp = Cpc(\alpha, \gamma)\rho A/2$$

Mechanical power for wind system is expressed as

Pmech=Cpc (a, y) Pa/2

Here □ =1.225kg/m3 which is denote air density, Cpc is represent power coefficient constant Vwind is wind speed in(m/s) area of rotor is shown by A. Cqs is torque coefficient and it is related with Cps as

$$Cqs = \frac{Cps}{\alpha}$$

$$\alpha = \frac{Rw * \omega s}{Vswind}$$

$$Tw = \frac{Psmech}{\omega s}$$

Cps = performance coefficient

P= air density

Vswind = speed of wind

A = swept area of turbine

Rs = wind turbine radius

Tw = wind turbine torque s

= angular freq.

III. Lithium-Ion Battery

The LI Battery is similar to the normal battery. It consists of the current collector with aluminium coated and the negative collector is coated with carbon. Salt product of Lithium ion is used an electrolyte. Totally this process is related to electrolysis.

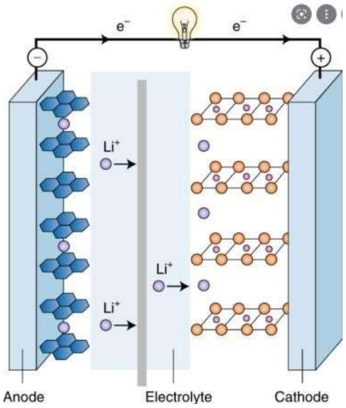


Fig 3: Li-ion Battery The passage of lithium ions from anode to cathode will be evaluated by using electrolytic process. If the battery gets discharged then the electric current is produced. The charging of the battery can takes place if the passage of lithium ion is considered from cathode to anode.

IV. Mathematical model of li-ion battery

This article covers the construction and analysis of a Li-ion battery mathematical model. The analogous circuit of a Li-ion battery is shown in the diagram below. Explain the charging and discharging properties of Li-ion batteries in this section. The equivalent circuit of a LI-ion battery is shown in Figure 3.3

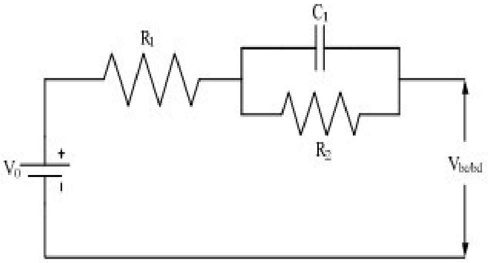


Fig 4: Li-ion battery electric equivalent circuit

In the above fig, some parameters are,

V_o = open circuit voltage

R_1, R_2 = internal resistance (R_{int})

C_1 = effective capacitance

In this model different charge or discharge rate used for circuit parameters. This model calculated for accurate value, for comparison of battery actual & rated voltages. The measured battery terminal voltage for collect from battery manufacture side. In mathematical equation of constant current charge conation in internal resistance, effective capacitance and open circuit voltage is explained for equation 1 to 4. The battery parameters of used for charging scenario mentioned for SOC and discharging scenario mentioned by DOD

$$R1 = (a1 + a2 * Cr + a3 + Cr2) * e{-a4*SOC} + (a_5 + a_6 * C_r + a_7 * C_r{}^2) \qquad 1$$

$$R2 = (a8 + a9 * Cr + a10 + Cr2) * e{-a11*SOC} + (a_{12} + a_{13} * C_r + a_{14} * C_r{}^2) \qquad 2$$

$$C1 = (a15 + a16 * Cr + a17 + Cr2) * e{-a18*SOC} + (a_{19} + a_{20} * C_r + a_{21} * C_r{}^2) \qquad 3$$

$$V0 = (a22 + a23 * Cr + a24 + Cr2) * e{-a25*SOC} + (a_{26} + a_{27} * SOC + a_{28} * SOC^2 + a_{29} * SOC^3) -$$

Discharging scenario of battery terminal voltage equation in given for 10, and it is calculated for constant current contrition.

$$V_{bd}(t_d) = ((Q_C + I_d * R_2) * exp^{\left(-\frac{d}{R_2*C_1}\right)}) + V_0 -_t (I_d * (R_1 + R_2)) \qquad 10$$

V. Li-Ion Battery in Electric Vehicles

For electric vehicle uses, many types of battery chemistry are available. In comparison to alternative battery solutions for an electric vehicle, the Li-ion battery is more ideal for EVs due to its battery properties. Hybrid energy storage electric vehicles (HEVs), external plug-based plug hybrid energy storage electric vehicles (PHEVs), and battery-based energy storage only vehicles (EVs) are the three topologies of battery-based energy storage technology. In previous methods employed HEV is an IC engine paired with electric driven motors that store energy in batteries. In a HEV, the primary energy source is a gasoline-powered IC engine, with batteries serving as backup. With a battery energy storage capacity of 1-3

$a_{30} * C_r + a_{31}$

4

the BDC, the voltage controller and current also have their major contributions in this work.

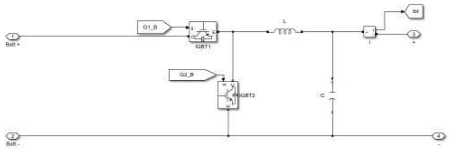


Figure 4: Simulink Model of BDC

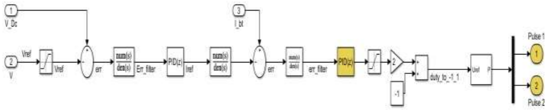


Figure 4.1: Schematic Representation of controlling

kWh, a vehicle can go around 10 kilometres.

BEVs are called zero carbon emission cars since they

The polynomial equations for discharging conditions do not emit direct exhaust or emissions as compared are given in Eq. 5-8 [1]

$2) * e_{-a_4*DOD} +$ to conventional automobiles. Charging stations are $R_1 = (a_1 +$

$a_2 * D_r + a_3 + D_r$

$(a_5 + a_6 * D_r + a_7 * D_{r}2)$ 5 powered by electricity. The energy storage capacity of

$R_2 = (a_8 + a_9 * D_r + a_{10} + D_{r}2) * e^{-a_{11}*DOD} +$ electric automobiles is up to 100 kWh, and the

$(a_{12} + a_{13} * D_r + a_{14} * D_{r}2)$ electric range is around 500 kilometres. The $C_1 = (a_{15} + a_{16} * D_r +$

$a_{17} + D_{r}2) * e_{-a_{18}*DOD} +$ possibilities have been investigated.

$(a_{19} + a_{20} * D_r + a_{21} * D_r^2)$ 7

$V_0 = (a_{22} + a_{23} * D_r + a_{24} + D_r^2) * e^{-a_{25}*DOD} +$

VI. CONTROLLER STRUCTURE

$(a_{26} + a_{27} * DOD + a_{28} * DOD^2 + a_{29} * DOD^3) -$

$a_{30} * D_r + a_{31}$ (a)

Controlling topology of Bidirectional DC-DC

8

Converter:

Charging scenario of battery terminal voltage

equation in given for 9, and it is calculated for In this implementation work the BDC converter plays constant current contrition. a major role. This BDC is controlled by using different

$$V_{bc}(t_c) = \left((Q_C + I_C * R_2) * exp\left(-\frac{c}{R_2 * C_1}\right)\right) + V_0 -$$

t controlling topologies in different energy storage systems. This can be clearly observed in the below

$(I_C * (R_1 + R_2))$ 9

shown figures. In the process of producing pulses to topology implemented in BDC

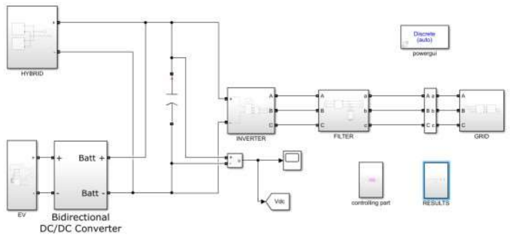


Figure 4.2: Schematic diagram of hybrid integrated EV to grid.

The proposed method of "Analysis of hybrid-based grid integration for vehicle-to-grid-based energy management project" suggests a strategy to integrate hybrid electric vehicles into the electrical grid to manage energy supply and demand.

The project seems to focus on vehicle-to-grid (V2G) technology, which enables electric vehicles to store and discharge electricity from the grid, thus providing additional storage capacity and grid stability. The proposed method includes the use of a hybrid system, which combines renewable energy sources, energy storage systems, and traditional grid infrastructure to provide a more reliable and efficient power supply.

To analyze this hybrid-based grid integration system, the project would need to consider several factors.
These include the power capacity and charging/discharging rates of the electric vehicles, the capacity of the energy storage system, the availability of renewable energy sources, the power demand of the grid, and the grid infrastructure's capabilities.

Overall, the proposed method of hybrid-based grid integration for V2G energy management is a promising concept that could provide significant benefits for both electric vehicle owners and the electrical grid. However, the analysis and implementation of such a system would require careful consideration of various technical and economic factors.

VII. Simulation results

I.Wind integration with vehicle to grid configuration:

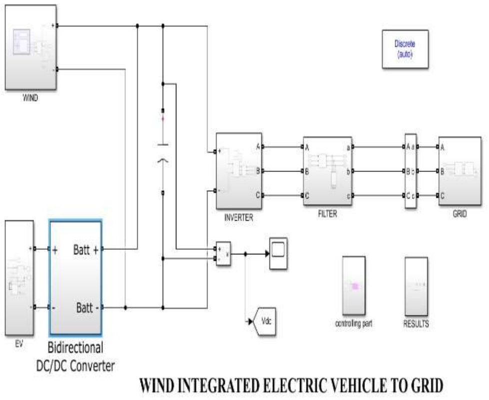


Figure 5: Schematic diagram

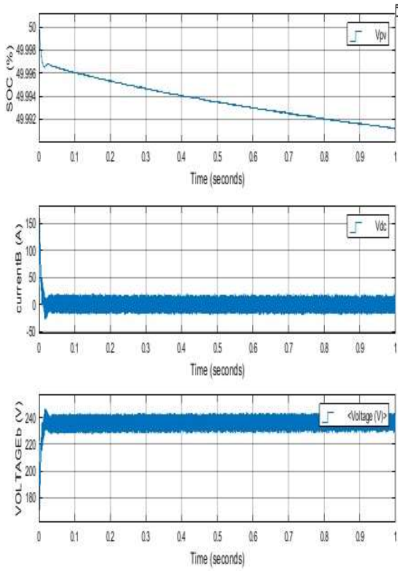
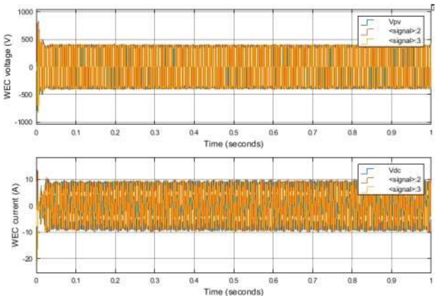


Figure 5.1: Battery related



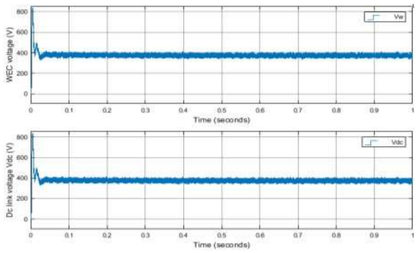


Figure 5.2: Wind side voltage and current

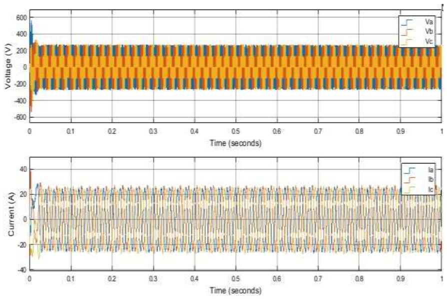


Figure 5.4: Inverter side voltage and current

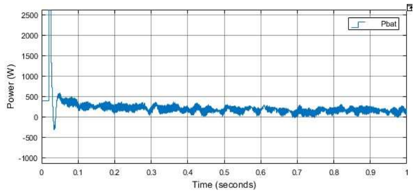


Figure 5.5: Grid side voltage and current

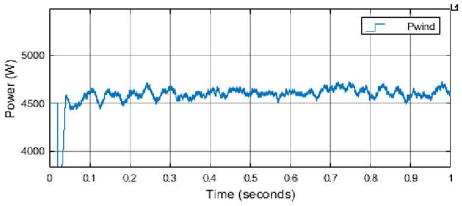


Figure 5.7: Wind active power

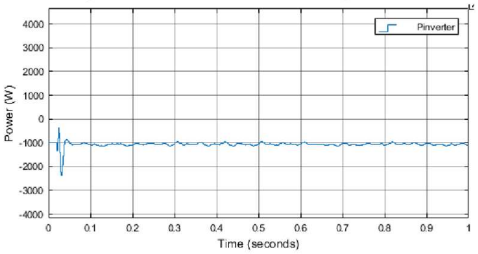


Figure 5.8: Inverter active power

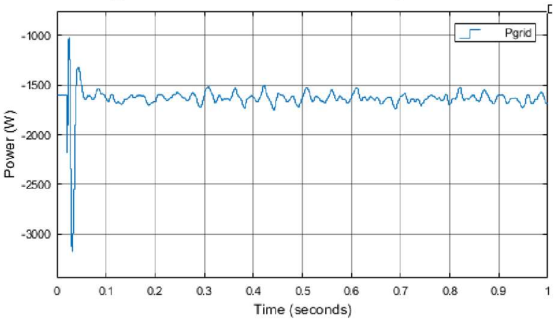


Figure 5.9: Grid active power

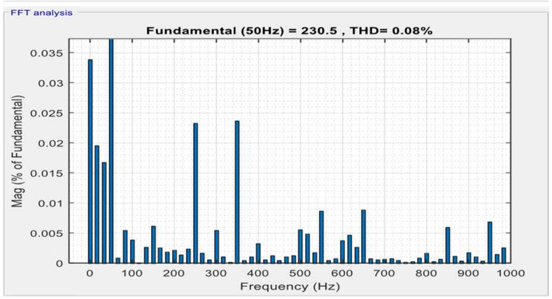
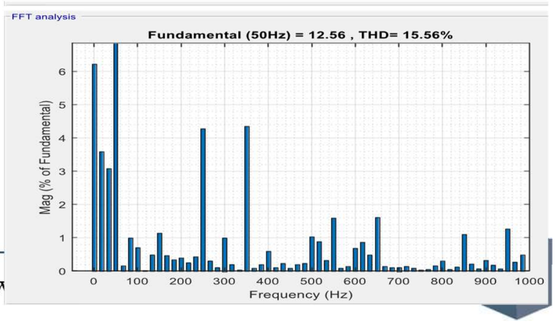


Figure 5.10: Vg



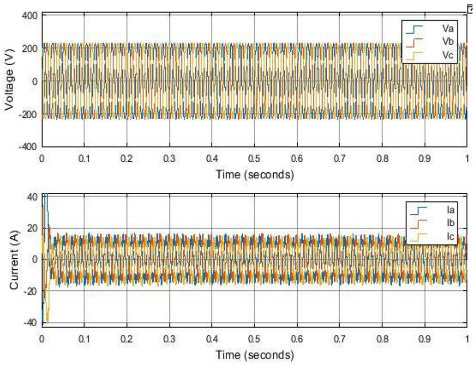


Figure 5.6: Battery power

Figure 5.11: Ig

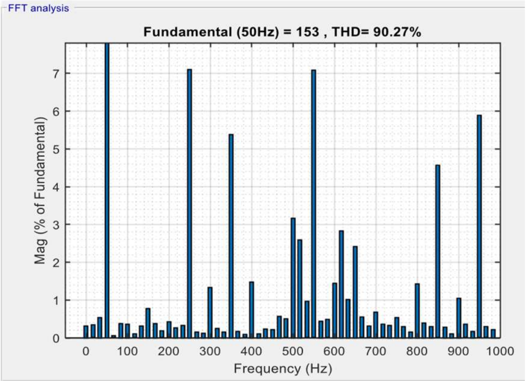


Figure 5.12: Vi

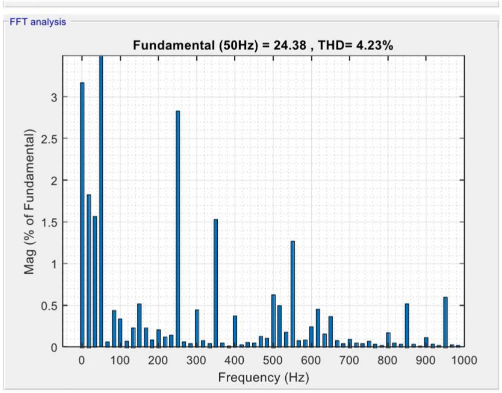


Figure 5.13: Ii

(a) Simulation results obtained in wind integration with vehicle to grid configuration of battery related voltage (V) state of charge soc and current, Vwec, Vpv and Vdc wind side dc link voltage, wind power, wind side current and grid active power, inverter side voltage and current grid side voltage and current thd's of ig&il and vi.

II.Hybrid integration with vehicle to grid configuration

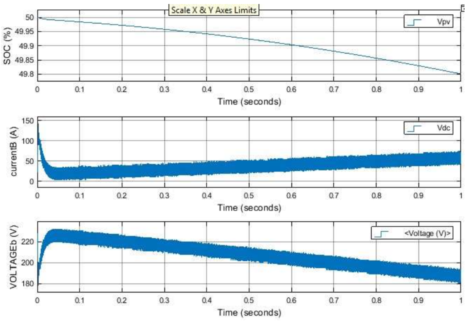


Figure 6: Battery related

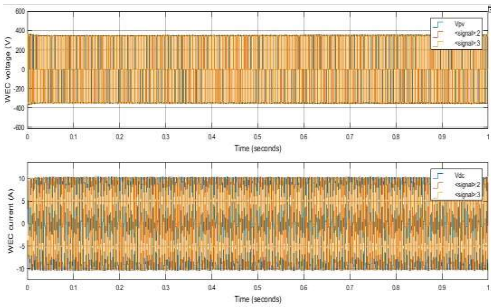


Figure 6.1: Wind side voltage and current

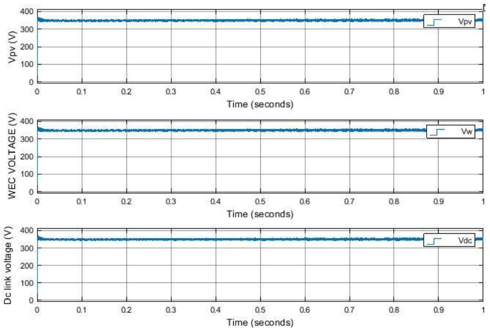


Figure 6.2: Vwec, Vpv and Vdc

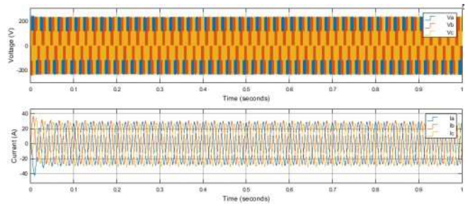


Figure 6.3: Inverter side voltage and current

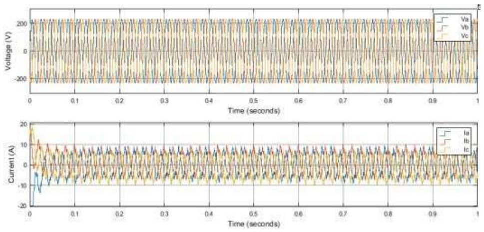


Figure 6.4: Grid side voltage and current

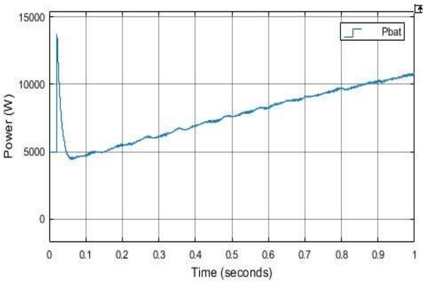


Figure 6.5: Battery power

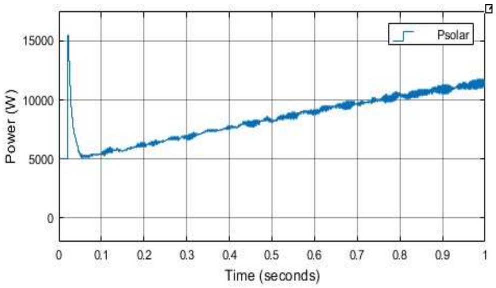


Figure 6.6: Solar power

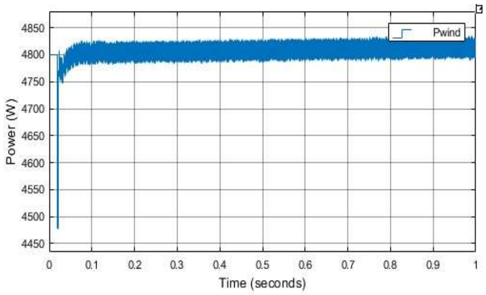


Figure 6.7: Wind power

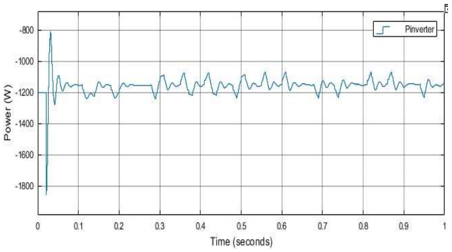


Figure 6.8: Inverter active power

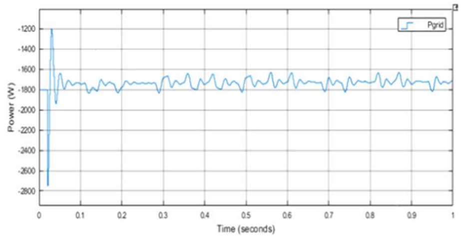


Figure 6.9: Grid active power

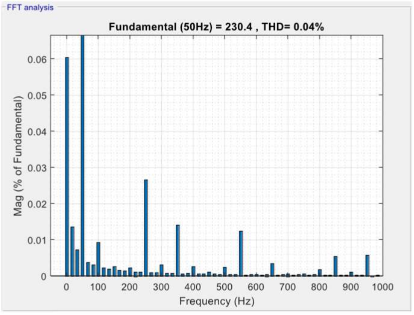


Figure 6.10: Vg

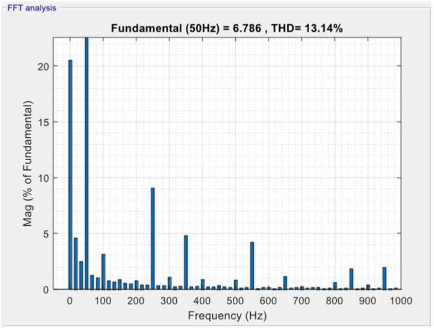


Figure 6.11: Ig

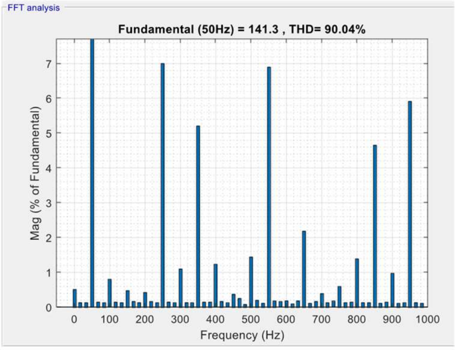


Figure 6.12: vi

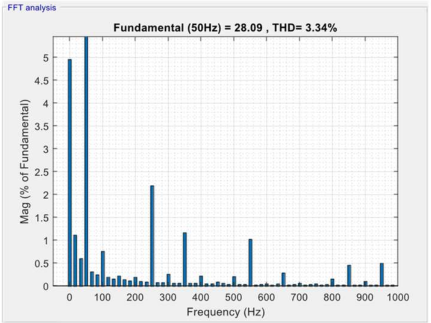


Figure 6.13: Ii

(b) Simulation results obtained in Hybrid integration with vehicle to grid configuration of battery related voltage (V) state of charge soc and current , Vwec, Vpv and Vdc wind side dc link voltage , wind power , wind side current and grid active power ,inverter active power inverter side voltage and current grid side voltage and current solar power and wind power are obtained thds of ig vi and li &

The analysis of a hybrid-based grid integration for vehicle-to-grid-based energy management project can provide valuable insights into its performance and effectiveness. In this section, we will discuss the results and implications of the project.

The integration of hybrid technology and vehicle-togrid energy management has led to significant improvements in energy efficiency. The vehicles connected to the grid can draw power from the grid during off-peak hours, which can be used to charge the batteries of electric vehicles. This stored energy can be used during peak hours to power the vehicles, reducing the need for energy from the grid. In conclusion, the analysis shows that the hybridbased grid integration for vehicle-to-grid-based energy management project can achieve significant improvements in energy efficiency, cost-effectiveness, environmental impact, and user satisfaction. The project's success can be enhanced by implementing a smart grid system, providing training and support to the users, and optimizing the system's design and operation.

Table 1:THD Comparison

configuration/parameter	Wind integrated	Hybrid integrated
Inverter side voltage	90.27	90.04
Inverter side current	4.23	3.34
Grid side voltage	0.08	0.04
Grid side current	15.56	13.14

Table II: Power Comparison

configuration/parameter	Wind integrated	Hybrid integrated
Dc link power	2000	7000
Inverter power	1000	1200

Grid power	1600	1800

The comparison between proposed method and existing method results evaluated in terms of total harmonic distortions and power comparison shown in table 1 and table 2.

VIII. CONCLUSION

After analysing the project on "hybrid-based grid integration for vehicle-to-grid-based energy management," it can be concluded that the integration of electric vehicles into the grid has significant potential for the management of renewable energy sources. The study proposed a hybrid energy management system that integrates electric vehicles into the grid and balances the load of the grid, reducing the need for energy storage and increasing the use of renewable energy sources.

The project's findings suggest that the integration of electric vehicles into the grid can lead to a more efficient and sustainable energy system. The hybrid energy management system was found to be effective in reducing the peak load on the grid, which can help prevent blackouts and brownouts.

Overall, the project demonstrates the potential for vehicle-to-grid-based energy management to contribute to a more sustainable and efficient energy system. Further research and development in this area can lead to more widespread adoption of electric vehicles and a more sustainable future for energy management.

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