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A Study on Electric Vehicle to Grid Implementation

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Abstract: Now a days, energy system and environment are dealing with huge challenges. In perspective of energy and transportation, electric vehicles have gained great attention during the adoption process. The EV's when collaborated with smart grid provides great worth like energy security, promoting energy saving, emission reduction & preventing air pollution. As a result, the idea of Vehicle-to-Grid (V2G) implementation has recently emerged. V2G is a technology which has the capability for bi-directional transmission between EVs & electric gird to send & receive power when EV's are implemented grid. In order to overcome these challenges a model is proposed in MATLAB simulator considering the different generating sources implemented with EV and results are obtained with the help of simulation. Finally Smart grid considering all generative sources was designed and implemented with EV to finally get V2G implementation. Simulation results show that in order to bridge the gap between demand and generation, energy stored in the EV batteries plays a very important role. The MATLAB simulator shows the 24-hour simulation of V2G system. Finally, benefits, disadvantages & future scope of V2G are also discussed.
Keywords: Smart grid; electric vehicles; renewable energy sources (RESs); vehicle-to-grid (V2G) implementation

I. INTRODUCTION

Currently, environment is handling great problems due to the greenhouse gases released by combustion of fossil fuel. EVs are drawing attention because of their ability to reduce emission, fuel consumption and ability to boost the use of sustainable energy (REs) into transportation area.

Carbon emission of EVs charged by grid is not less than that of traditional fuel cars because in our country 75% to 80% of electricity are produced by coal burning. Therefore increasing the use of sustainable energy into grid will be most effective way to decrease greenhouse gases emission. Presently renewable energies like wind, solar and water energy is used to generate power.

A. Smart Grid

A smart grid is an electrical network that allows the bidirectional flow of power and data through digital communication technology that allows access, responsiveness and action to change in many applications and issues. Smart grids are self-healing and allow electrical traders to become active participants. The benefits related with the smart grid are: efficient power transmission, faster recovery of power after power outages, lower demand, lower electricity prices and improved safety.

A new grid progressively formed with the integration of EVs. When EVs are regarded as load then optimal charging can be achieved by technical & financial means to organize charging period so as to attain maximum load shifting, improving the efficiency of system & reduce the impact on grid safety. When EVs are considered as assign energy-storage units, they can provide power to grid for the safe reliability of power system.

The architecture of smart grid with modern technologies is shown in Figure1. The smart grid contains Advanced metering (AMI) infrastructure which is an electronic device that can record and get real-time data usage of the user's electricity. One of the great features of a smart grid is that the user can communicate effectively with the power grid.

B. Vehicle-to-Grid Integration

Vehicle-to-grid explains a system in which the electric vehicle has the capability of two-way communication between the electrical grid & the EVs.

EVs can be used in additional services such as frequency control, power control, flow measurement, renewable energy storage or more. The storage capability of V2G allow EVs to store and extract electrical power generated from sustainable energy such as wind & solar with variable output depending on the weather and time of day.

However in V2G services not only bi-directional charger participate, unidirectional chargers can also participate. Fig. 2 shows the concept of V2G.

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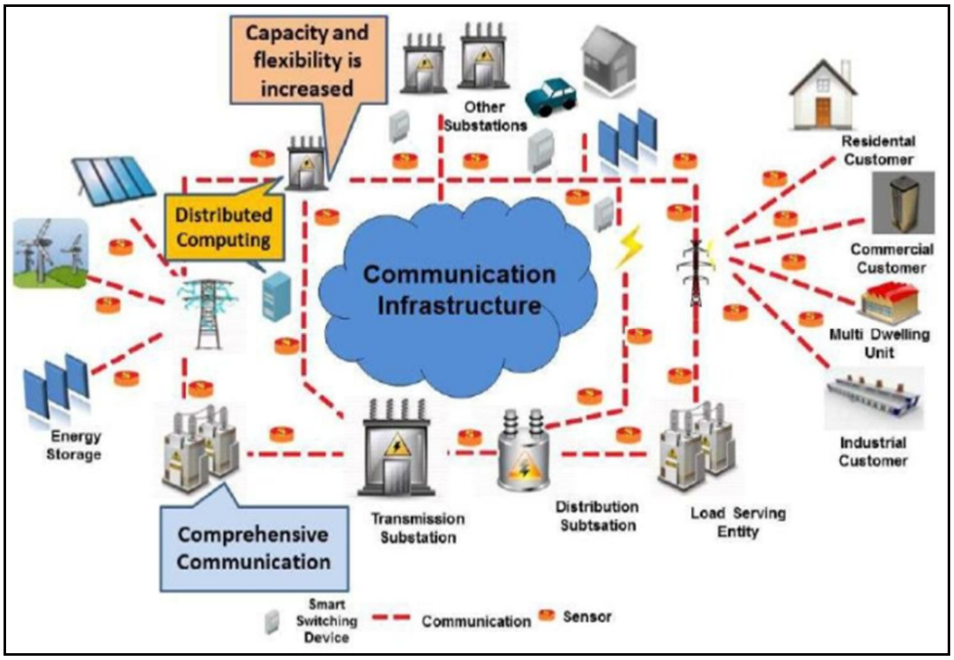

Figure 1 Smart Grid Architecture

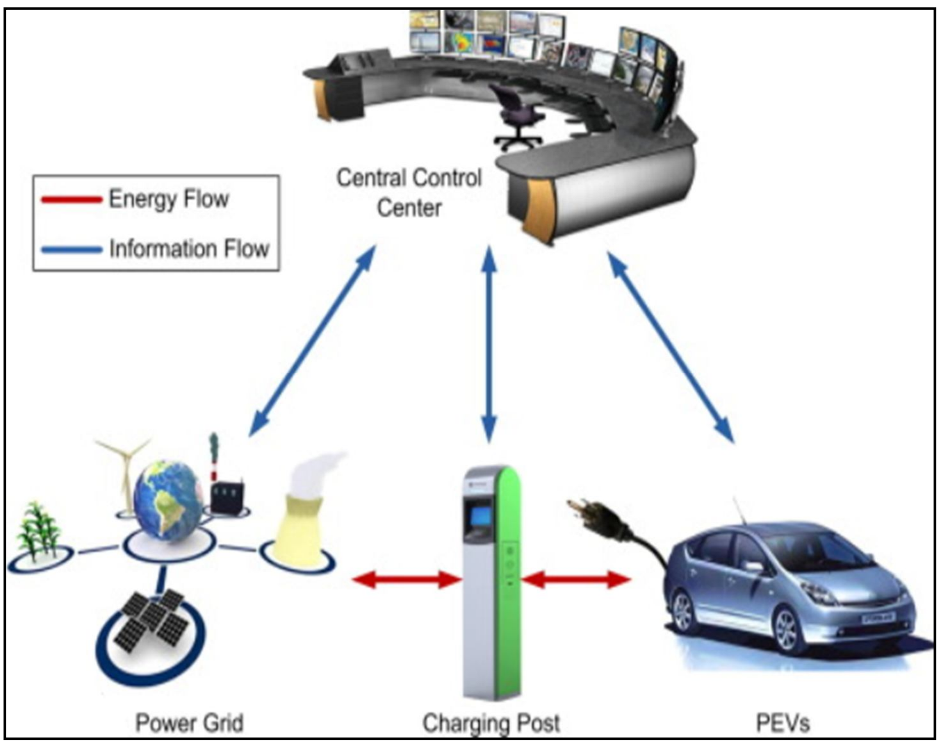

Figure 2 Basic Smart Grid Functions

II. PROBLEM STATEMENT

Because of rising fuel cost, EVs has come into eyes of public as well as government. However the incorporation of these EVs will present many issues for the electricity system because the EVs will need to be charged on daily basis which can create a lot of load on the electrical grids while charging. To handle this load issue on electrical grid, the incorporation of V2G can be helpful because it can control the load of EVs by permitting transmission between the electric grid and electrical vehicles.The grid idea consists of V2G technology. In V2G energy of battery is taken from the smart grid and vice-versa.

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III. LITERATURE REVIEW

In this paper implementation of electric vehicles to grid is discussed.At present, the energy system and environment face huge challenges such as air pollution, greenhouse gas emissions, energy waste. The EVs when collaborated with smart grid provide great importance like emission reduction, energy safety, preventing air pollution and promoting energy saving. As a result, the idea of Vehicle-to-Grid (V2G) Implementation has recently emerged. V2G is technology which have the capability for bi-directional transmission between EVs & electric gird to send & receive power when EVs are linked to grid.

Aziz, M. et al. [1] has discussed a preliminary analysis on the implementation of VGI in Indonesian Grid, especially related to load leveling and frequency regulation. The VGI concept is considered very promising in Indonesia as well as the shift in the electricity market to be more open. Load leveling & frequency regulation using EV in Indonesia has been analyzed. When the EV adoption reached 20% & VGI participation is also 20%, about 2gw of peak electricity capacity can be levelized & almost 7GWh of power can be shifted to non-peak hours.

Ma, Y. et al.[2] has developed a MATLAB simulator to model the scenarios of V2G deployment within a daily power dispatch schedule. As an energy storage bank, V2G technology makes it possible to store the excess energy during low-level-demand time period and subsequently to release this stored energy during high-level-demand time periods. EVs are expected to significantly increase in future because of their environmental advantages.

Dai, J. et al. [3] has depicted, firstly, the architecture of smart grid & the interaction between electric vehicles & renewable energy. Then, the impact of electric vehicles & renewable energy development is analyzed. The operation cost can be minimized by the integration of grid, RESs & EVs. In the future, the synergies of EVs & RESs need a smarter grid, a storage system of large capacity & a better business structure.

Zhang, H. et al.[4] has proposed an aggregate model of a V2G fleet that employs aggregated parameters to represent energy & power constraints of the entire V2G fleet & therefore reduces the difficulty of forecasting. The optimal charge and discharge scheduling strategy based on the evaluation method proves to be a promising option for V2G applications. The revenue when utilizing the proposed strategy reaches 95.2% of that in the ideal situation. Hence the PEV aggregator should consider the uncertain reserve utilization in its charge & discharge scheduling strategies in order to ensure profit maximization & reliable reserve provision.

Amditis, A. et al. [5] has proposed the study of the system vehicle – power supply for identifying the ways and tools to transfer power grid to vehicle with simple and effective user-friendly operation. The Electric Mobility system can be optimized considering the integration of the system User - Vehicle – Infrastructure with the governance of a Management coordination supported by information and communication network and operating the energy transfer Grid to Vehicle with a user-friendly technology interface. The harmonized international Standards ISO, IEC, SAE, UL are an effective basis for the design manufacturing & use of interoperable technology solutions for electric power transfer Grid Infrastructure to Vehicle & for the relevant communication & management operations. [5]

Shi, L. et al.[6] has presented a framework for analyzing V2G service development from a co-evolutionary perspective in which the interactive relation between the diffusion of EVs & the upgrade of the distribution grid system is considered. This paper provides a new perspective of V2G services development, answer the core question on how to realize the V2G vision in synergy with the development of EVs & upgrade of the distribution grid, & offers advice on the future V2G management mechanism. [6]

Kumar, M. et al. [7] gives an account of the advantages and disadvantages of V2G, G2V, demand response, renewable energy. V2G mode of PEVs can support the grid as active-reactive power regulation service providers, peak reduction mechanism, load balancing by valley filling, voltage/frequency control providers. V2G can also provide the back-power support for the renewable energy & reduce intermittency during efficient integration of power production to the grid. [7]

Niddodi, C. et al. [8] has proposed a novel Cyber-Physical Anomaly Detection Engine that monitors system behavior & detect anomalies almost instantaneously. Since the V2G system is time-sensitive the anomaly detection engine also monitors the timing requirements of the protocol message to enhance the safety of the aggregator. The main components in this system includes EVs, aggregators & the power grid. The simple model of our anomaly detection engine demonstrates that accurate & almost instantaneous detection of anomalies is feasible.

Sami, I. et al.[9] in this paper demonstrated Smart Building (SB) interaction with energy storage devices, power EVs for grid load shifting, peak trimming & reduction of annual energy usage. V2G interfacing, quick charging & discharging, battery backup & reliability are the main challenges that are discussed in the paper. The author also presented V2G & G2V simulation model to describe various parameters affecting the grid-interface network.

V2G & G2V connection mode need quality-of-service to be addressed. Synchronization, harmonic distortion, grid demand-supply EMS, & reactive power absorption & injection are some of the issues that need to be considered.

Khemakhem, S. et. Al, in this paper investigates the contribution of PEVs in demand response for smart households' applications. In this context, a "PEV contribution for residential demand response strategy" is developed. This algorithm is proposed to decrease the peak demand ensuring a flattened demand profile. The contribution of PEVs in demand response for household areas is introduced. The purpose of this study is to shift the schedulable appliances from peak to off-peak hours & to highlight the impact of home-to-vehicle operation (H2V) & vehicle-to-home (V2H) on peak demand intensity minimizing. In this study, a "PEV contribution for residential demand response strategy" to reduce peak was investigated. The main goal if the algorithm, i.e., minimization of peak load, reduce fluctuations on power demand curve & smoothness was achieved. [10]

Alghsoon, E. et al.[11] has proposed about Electric Vehicles (EV) which supplies energy with storage batteries which are powered from the grid. So the EV are considered as a load on the electrical network but on the other hand power can be recovered back to the grid in case of out use. V2G technology allows generation of power at a distribution at peak hour to make peak shaving for the load profile which may affect the frequency by reducing it instead of increasing frequency for the same fault with a bigger difference.

Fahad, M. et al.[12] has reviewed an efficient model which will save energy in power systems and smart grid using Genetic Algorithm. Smart Grid requires efficient and secure connection with all other services, since 4G is using till now but if there is availability of 5G connection then it will be more secure and it provide the better communication. Furthermore, analysis, challenges, advantages, problem faced during implementation is discussed as well. Then it moved to consumption of energy in V2G. The concepts of vehicle to grid framework, the power flow between vehicles and the power grid, types of vehicle to grid technologies and their advantages and challenges faced is present in the paper and the efficient solution is presented.

Shi, L. et al.[13] in this paper has provided a new perspective of V2G services development it answers about the core question on how to realize the V2G vision in synergy with the development of EVs and how to upgrade the distribution grid, and offers advice on the future V2G management mechanism. The basic idea of the Paper for V2G is to use EV batteries as the intermediate storage facilities for providing services to the electric power system when EVs are parked. The relation with the power grid is one of the vital factors to hedge against the negative influence of EV charging.

Uddin, K. et. al.[14] reviewed the associated technology and policy implications of better managing battery use in vehicle and electrical grid applications and on how methodologies to manage battery degradation can reliably extend battery life. Through offering frequency regulation and energy storage facilities to the grid. The simple approach adopted by Energy current V2G studies namely that an EV is discharged and charged without consideration of battery degradation, on-line, is not economically viable because of the impact additional V2G cycling has on battery life.

Huang, Q. et al.[15] in this paper reviewed PEV aggregator charge-discharge boundaries considering the effect of TOU electricity price is calculated, and optimal scheduling method for multiple PEV aggregators in different dispatch regions considering the travel demand of EVs is proposed. The method which is used can bring effectiveness of the proposed method and the benefit of V2G to power system optimal dispatch. Plug-in electric vehicles (PEVs) can even discharge the power grid when necessary to maintain the safe and stable operation of the power grid, which is called vehicle-to-grid (V2G) technology. An optimal strategy based on the model predictive control (MPC) framework for charging EVs in parking lots is proposed.

IV. BENEFITS OF V2G

A. Ancillary Services

V2G system mode is able toimparting the qualityappropriate ancillary offerings like voltage and frequency regulation, peak shaving, load controlvia demand side management.

B. Frequency and voltage regulation:

In V2G mode a vehicle's battery can offer fast regulation through converting its charging and discharging rates. V2G approach also can deliver active/reactive energy assist with frequency regulation.

C. Peak shaving & Load Management

V2G mode also can offer assist in peak shaving at the grid through discharging the PEV battery throughout peak hours of the grid and charging in off-peak hours. EV charging and discharging time period of EVs enables in pulling down the load curve through additionally provisioning for valley filling.

D. *Renewable Energy and Supporting*

V2G mode can offer the specified assist to the Renewable Energy like solar & wind energy plants. When RES produces excessive energy, the EV battery can shop extra strength in line with its battery potential and may be used for traction or may be fed to the grid in V2G mode throughout grid peak.

V. CHALLENFES WITH V2G

A. *Investment Costs and Energy Losses*

In one-of-a-kind research it’s been proven that at growing EV penetration tiers on distribution networks, the investment cost and strength losses additionally boom. To triumph over those power losses, big infrastructure price and smart charging might be required with inside the energy system.

B. *Battery Degradation*

When PEVs are connected in V2G mode and after they carry out numerous charge/discharge cycles, there's a degrading effect at the existence cycle of EV batteries. Therefore, it's far required to assess the pricerelated to the degradation price of the battery

C. *Challenges on supply-demand Balance*

Various research has proven that there is a primary effect of V2G mode on peak demand of the application. When the better variety of EVs goes through charging/discharging, there's an increase the utility peak demand. Due to those out of control charging/discharging of EVs, there's an unbalance among utility supply & demand powers.

VI. SYSTEM CONFIGURATION

The version indicates a vehicle-to-grid network which regulates the frequency on a micro grid whilst occasions arise throughout a cycle of 24 hours. The proposed micro grid model has following four important components. i) a diesel generator which is the principle supply of energy generation ii) a Photo Voltaic farm connected with a wind farm, as a source of renewable power iii) a V2G system, the block liable for two-way power transfer and iv) is a residential load that is the overhead energy necessities to be fulfilled through power source. This micro grid represents a network of thousand familiesat some stage in a running, windy day in summer. There are 100 electric EVs with inside the V2G version which offers a 1:10 quantitative ratio among the vehicles and the families.

1) *Diesel Generator:* The diesel generator balances the energy fed on and the energy produced. We can decide the frequency deviation of the grid through searching on the rotor speed of its synchronous machine.
2) *Renewable Energy:* There are 2 sources of renewable energyon this microgrid. First, a PV farm produces energy proportional to 3 factors: the dimensions of the vicinity included through the PV farm, the efficiency of the PV panels and the irradiance data. Second, a simplified version of a wind farm produces electric energy following a linear courting with the wind. When the wind reaches a nominal value, the wind farm produces the nominal energy. The wind farm trips from the grid whilst the wind pace exceeds the maximum wind value, till the wind getsagain to its nominal value.
3) *Vehicle-to-Grid:* The V2G has functions: Controls the charge of the batteries connected to it and makes use of the available energy to modify the grid whilst an occasion takes place throughout the day. The block implements 5different vehicle-user profiles:
   a) Profile #1: People going to work with an opportunity to charge their automobile at work.
   b) Profile #2: People going to work with an opportunity to charge their automobile at workhowever with a longer ride.
   c) Profile #3: People going to workwithout anopportunity to rate their automobile at work.
   d) Profile #4: People staying at home.
   e) Profile #5: People working on a night time.
4) *Load:* The load consists of residential load and an asynchronous machine this is used to represents the effect of a commercial inductive load at the microgrid. The residential load follows a consumption profile with a given pf. The asynchronous machine is managedthrough a square relation among the rotor speed and the mechanical torque.
5) *Scenario:* The simulation lasts 24 hours. The solar intensity follows an ordinary distribution where the highest intensity is reached at midday. The wind varies substantially throughout the day and has a couple of peaks and lows. The residential load follows a normal pattern similar to a typical residential consumption. The intake is low throughout the day and will increase to a peak throughout the evening and slowly decreases throughout the night time. Three occasions will have an effect on the grid frequency throughout the day:

a) The kick-off of the asynchronous machine early at the third hour.
b) A partial shading at midday affecting the production of solar energy.
c) A wind farm trip at 22h whilst the wind exceeds the maximum wind energy allowed.

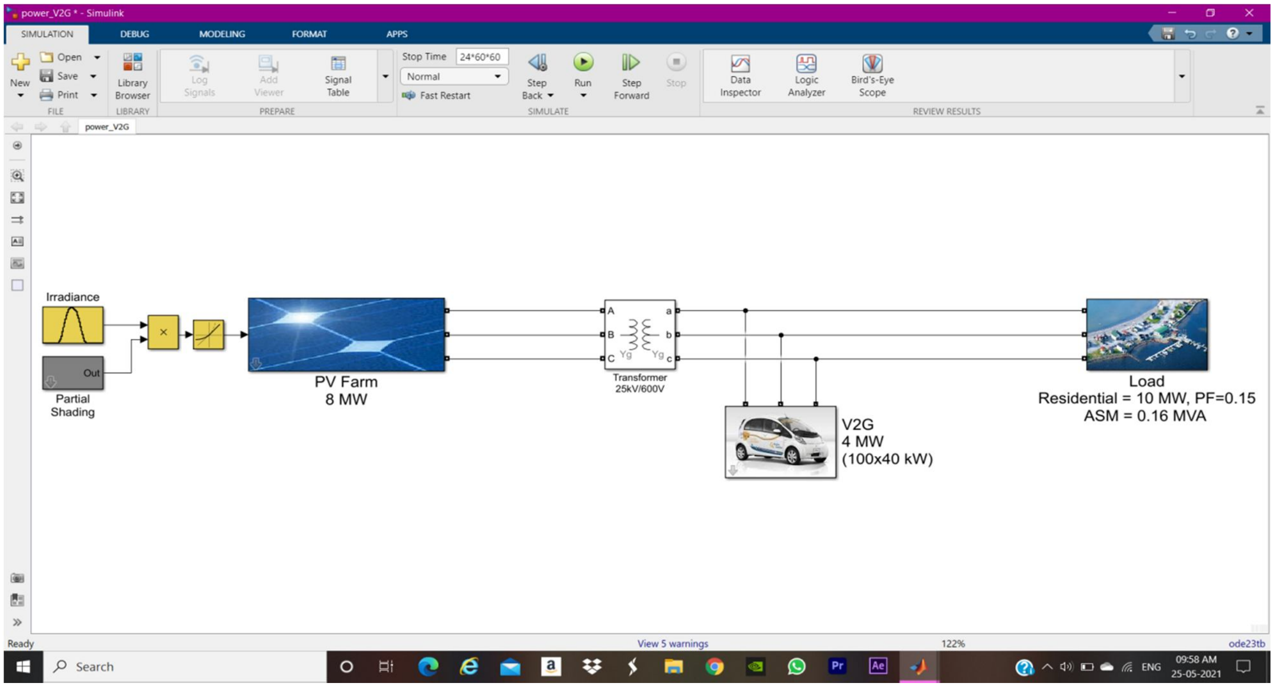

Figure 3 MATLAB/Simulation Model of a PV implemented with EV

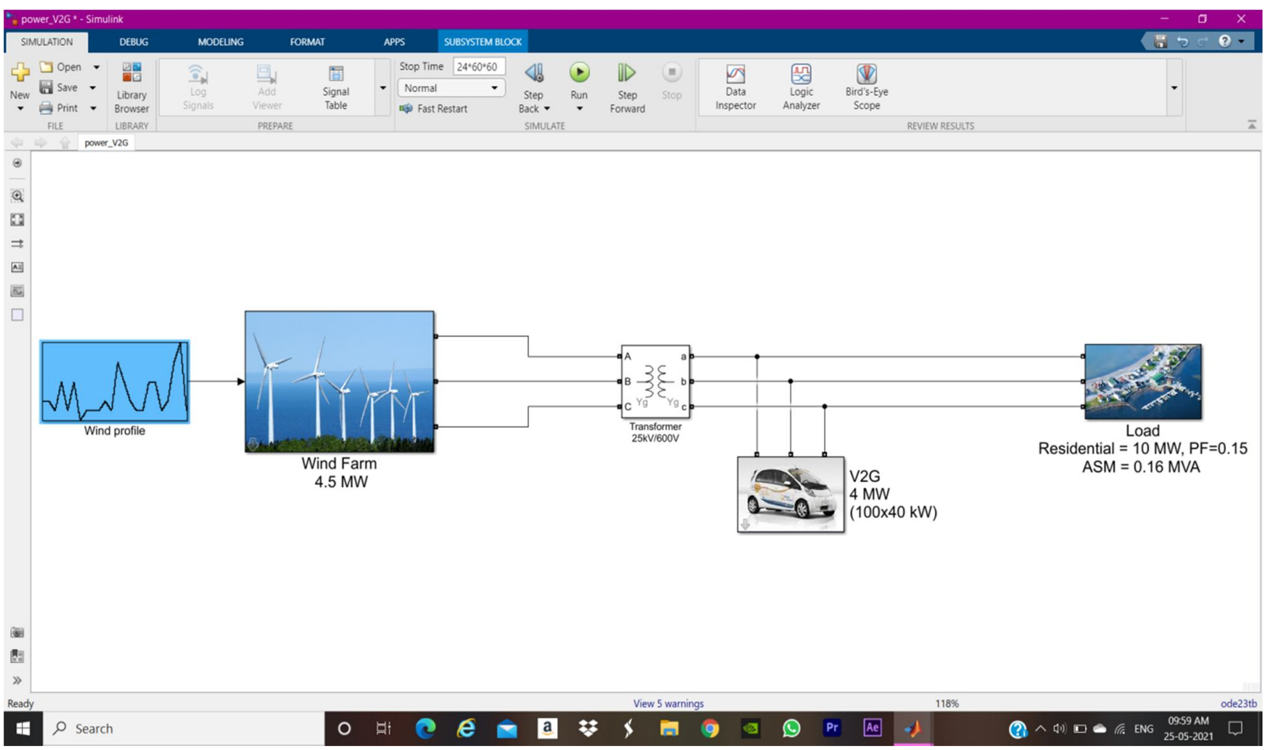

Figure 4 MATLAB/Simulation Model of a Wind farm implemented with EV

Figure 3 and Figure 4 shows the MATLAB model of PV and Wind farm implemented with EV. Figure 5 shows the MATLAB model of Diesel generator implemented with EV. Figure 6 shows the MATLAB Model of V2G implementation

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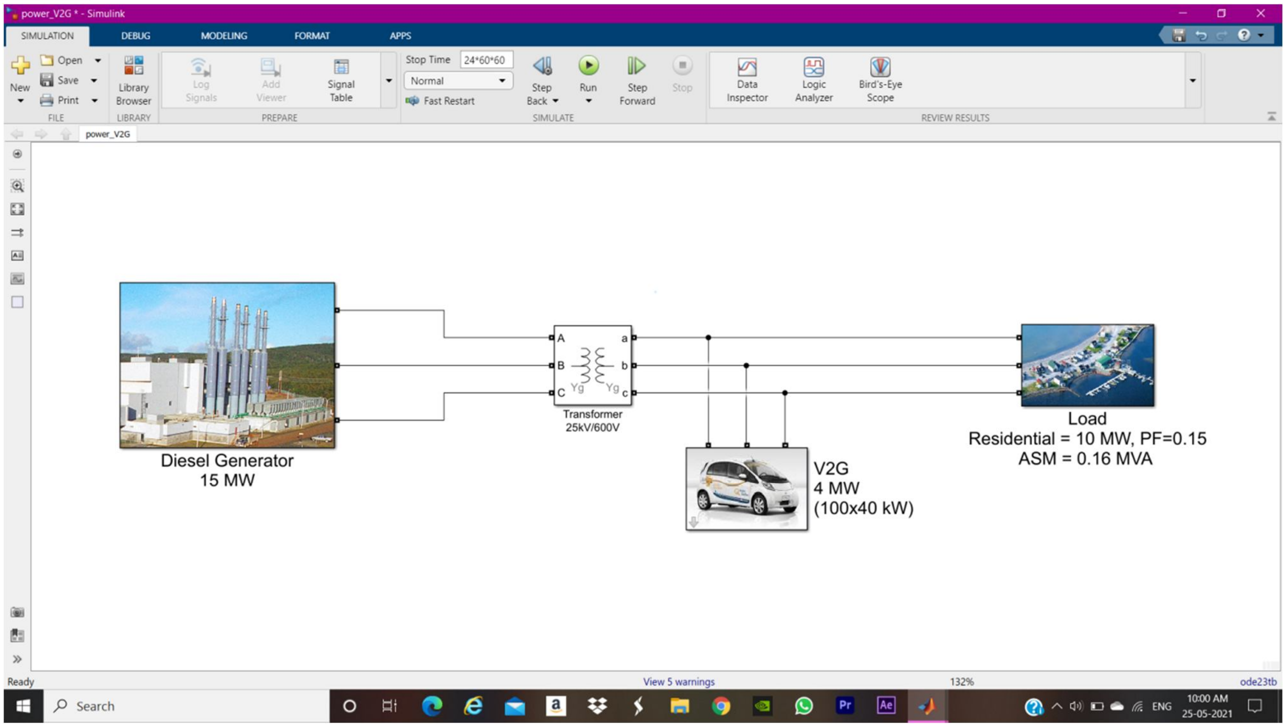

Figure 5 MATLAB/Simulation Model of a Diesel generator implemented with EV

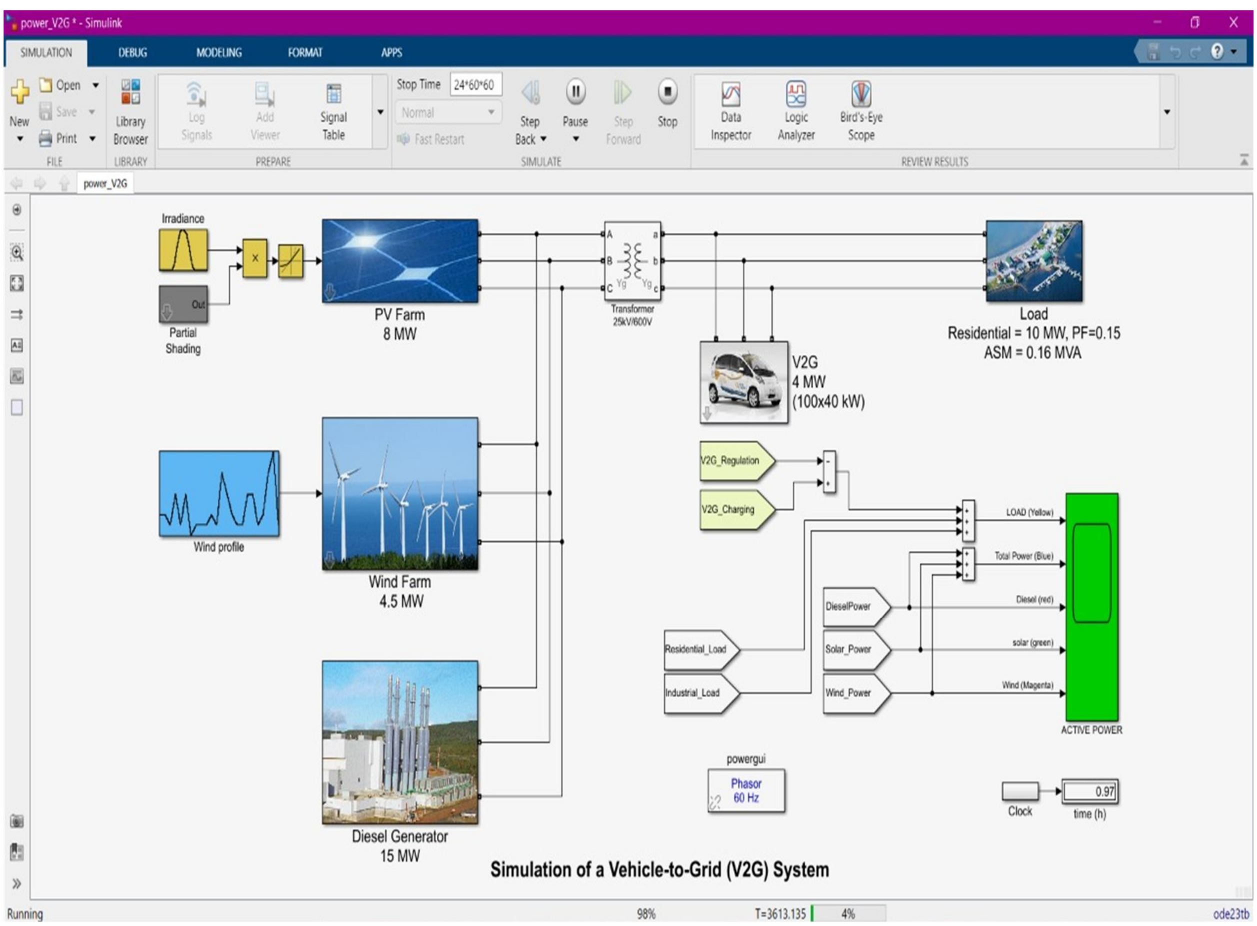

Figure 6 MATLAB/Simulation Model of a V2G implementation

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VII. RESULT ANALYSIS

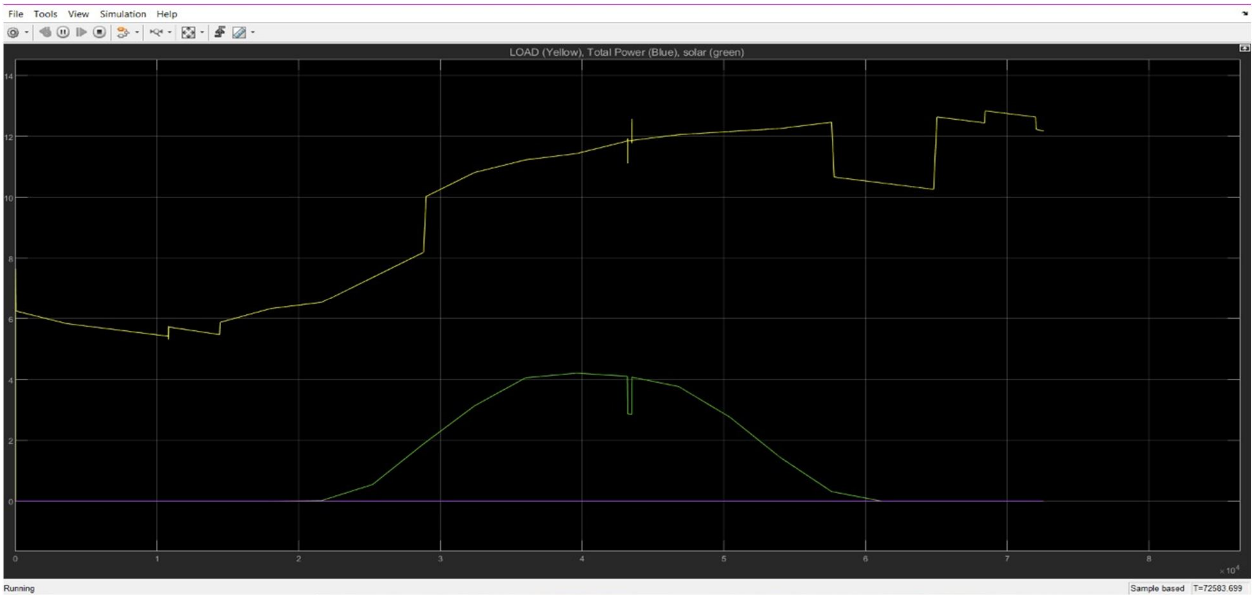

Figure 7 Variation in Load and Solar farm output

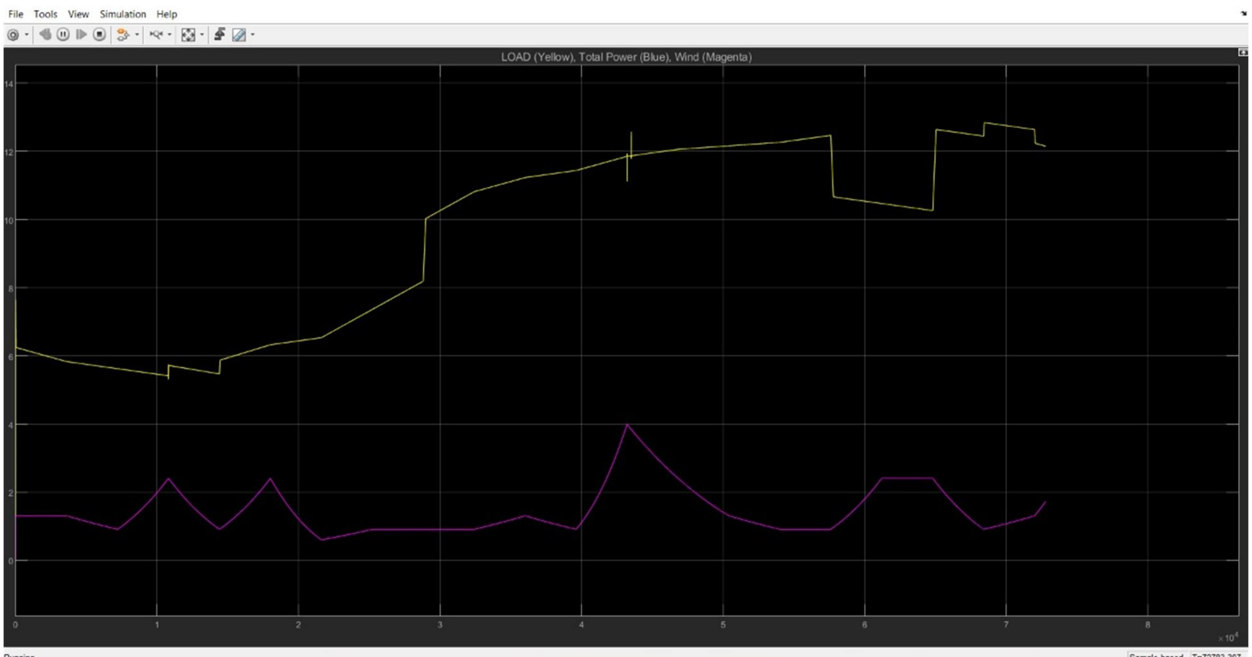

Figure 8 Variation in Load and Wind farm output

The proposed Model was designed in MATALB and simulation results are shown in Figure 7, 8, 9,10 and 11.Figure 7 shows the variation in Load and output due to PV farm. In the Figure Yellow line represents the load variation and Green line represent output of PV farm. It can be concluded from the figure that initially the load demand and solar power is low but at the peak time the load demand increases but at the same time there will also be increase in output of PV farm. At evening output of PV farm decreases but load demand is high so to fulfill this load requirement we can use the extra energy stored in EV's battery through V2G system. Figure 8 shows the variation in Load and output due to Wind farm. In the figure the load variation is represented by yellow line and Magenta line is represented the output variation due to wind farm. It can be observed from the graph that wind power is fluctuating. Initially load is low but with time it increases so to fulfill this gap in demand we use V2G concept.

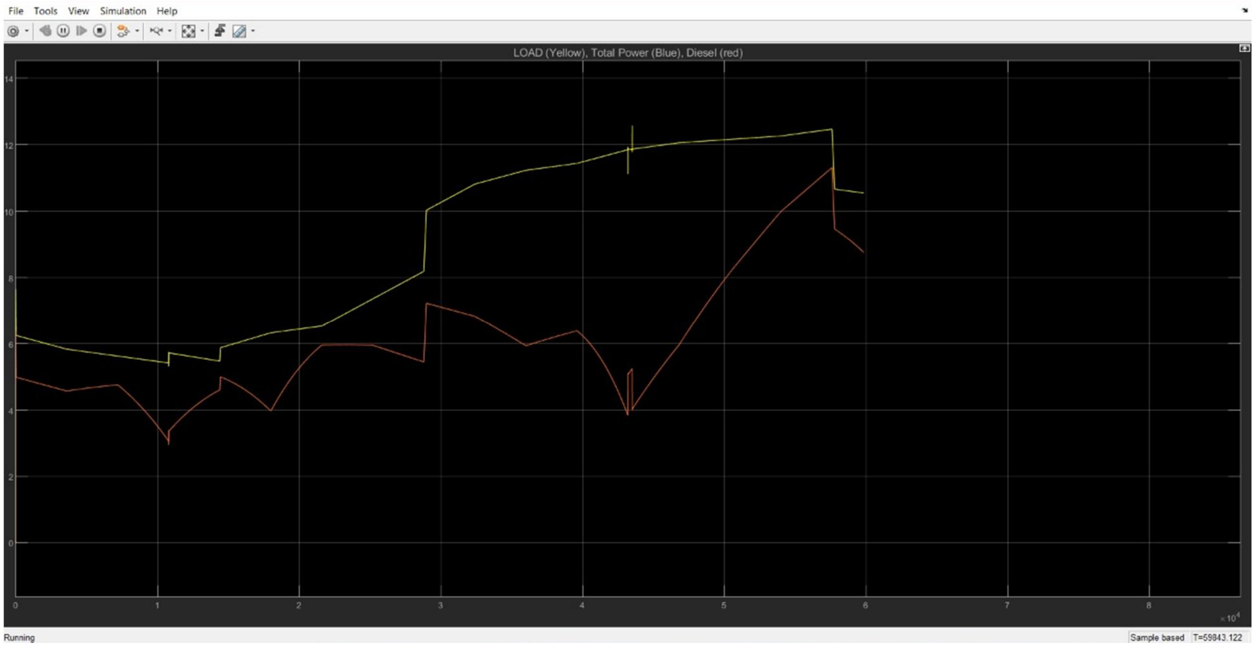

Figure 9 Variation in load and Diesel generator output

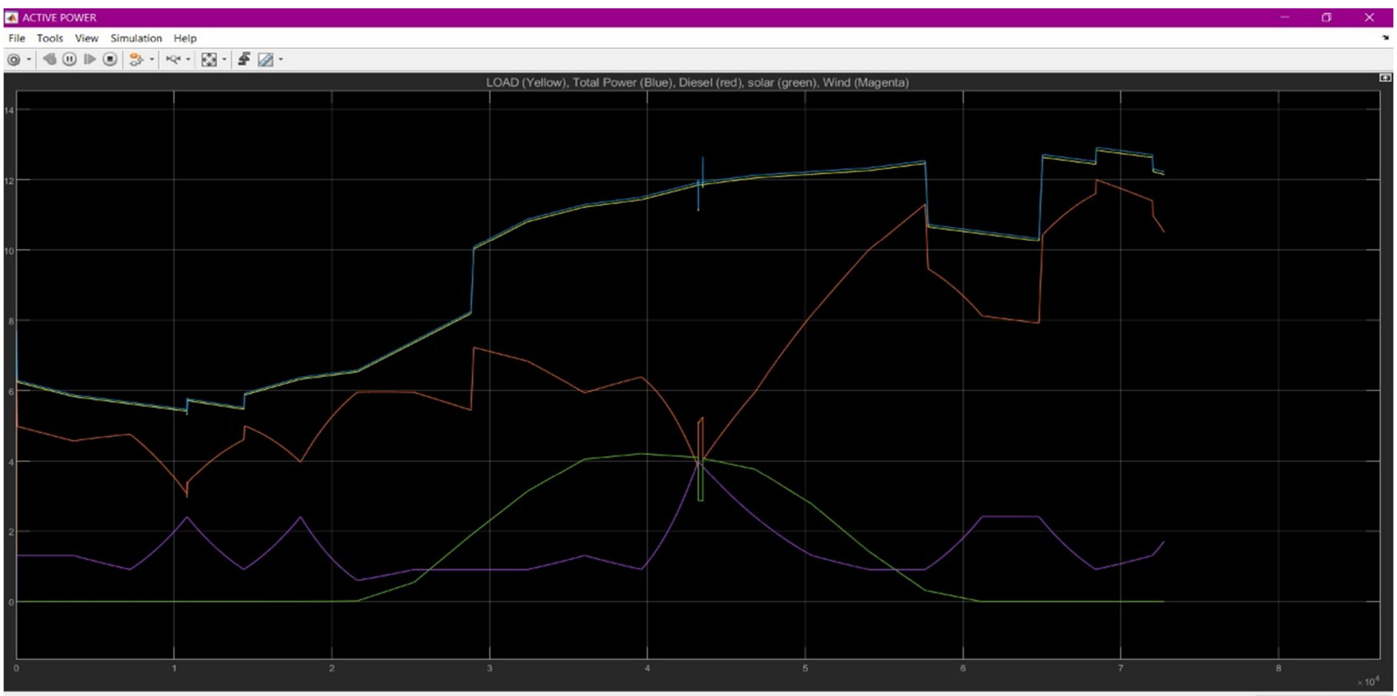

Figure 10 Comparative Analysis

Figure 9 shows the variation in Load and output due to Diesel generator. In the figure the load variation is represented by Yellow line and Red line is represented the output variation due to Diesel generator. It can be concluded from the graph that as the load is continuously increasing while at some time Diesel generator output decreases. Figure 10 shows the comparative analysis of V2G implementation.

The proposed model of V2G has been simulated in MATLAB as shown in figure 6.The simulation result is shown in Figure 11. Which shows the 24-hour simulation of a Vehicle-to-Grid (V2G) System. The yellow line represents the load variation. Blue line represents output variation in case of EV implemented to Grid respectively. The trend of charge data also changed as the time of charging (or discharging) for each corresponding transfer of energy increased because of the gradual variations.

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Figure 11 Variation when EV implemented with Grid.

VIII. CONCLUSION

Energy efficiency is the main concern in V2G implementation.Since the power consumption required is very high. In this paper review on electric vehicles are discussed in detail. Furthermore, analysis, challenges, advantages is discussed as well.The concept of V2G framework, power flow between the vehicle and the power grid, types of V2G technology and their advantages and disadvantages are on paper.In future different parameters except energy consumption can be discussed. The impact on grid, key technologies, financial & environment benefits are reviewed and analyzed. We still need to make progress in current technology for future work.

In the future, the integration of EVs and RESs requires a smarter grid,a more energy efficient system and a better business framework. It is hoped that this review will help researchers gain a clear understanding of EV implementation and contribute more to the field..

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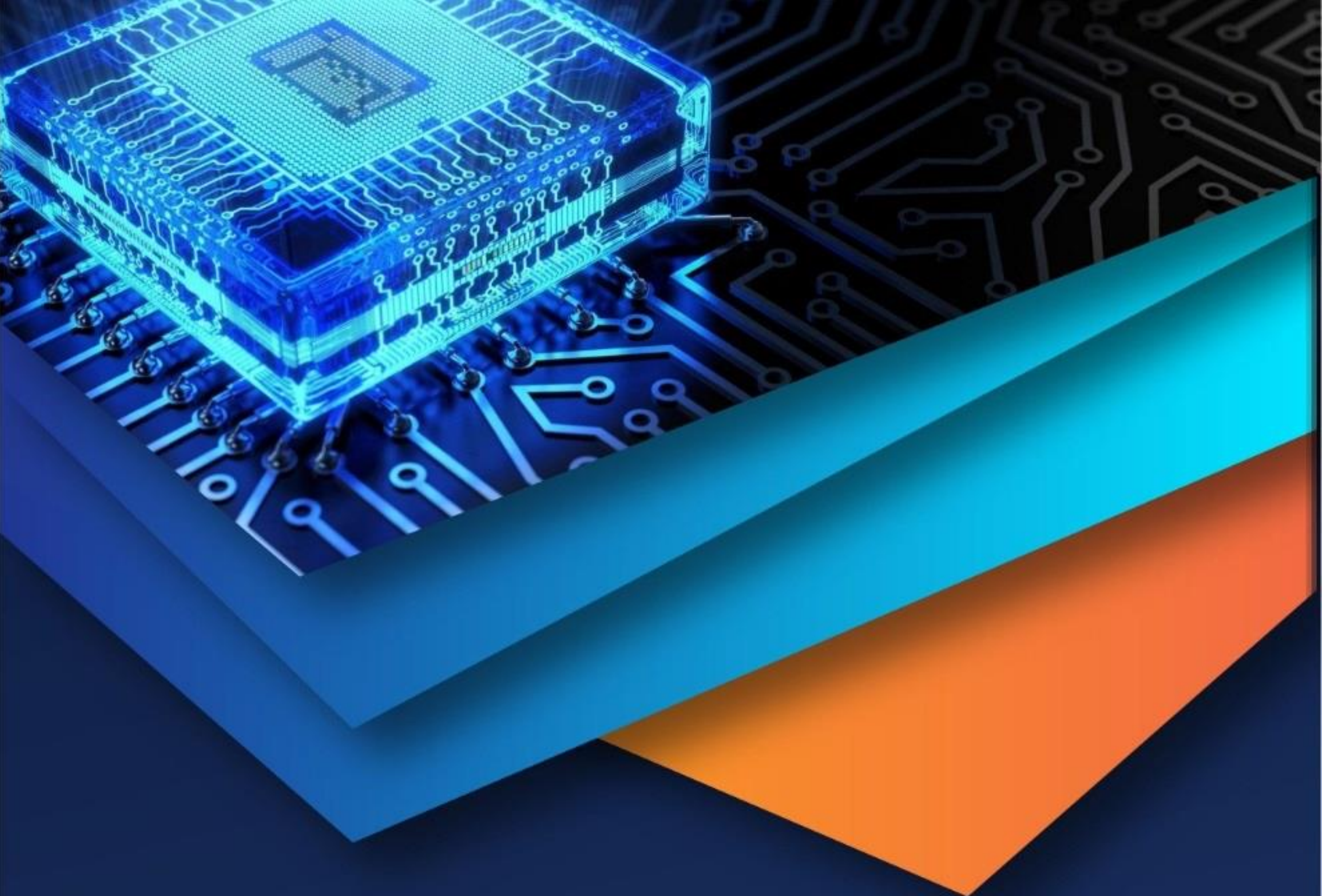

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