International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Integration of Electrical Vehicle in Power Grid with Vehicle to Grid Technology

[1]Makireddy Mahesh, [2]Potnuru Mounika, [3]Sornapudi Sai Karthik, [4]Vempadapu Gowthami, [5]Ponduru Sravan

[1,2,3,4,5]*UG Student, GMR Institute of Technology, Rajam, Andhra Pradesh, India.*

ABSTRACT

The function of vehicle to grid (V2G) integration in frequency management of renewable-based microgrid is presented in this paper. The intermittent solar photovoltaic and wind sources make up the renewable-based micro grid, while backup diesel generators are used to supply residential and commercial loads. The MATLAB/Simulink environment is used to model and simulate the whole system. For the purposes of simulation, several vehicle profiles are taken into consideration. Simulated operating situations include partial shade of solar photovoltaic panels, the cessation of wind farm generation owing to high wind speeds, and an abrupt shift in load demand. The usefulness of V2G integration in power control and grid frequency management under jarring situations is shown by simulation results.

Keywords: Electrical Vehicles, Vehicle to Grid, Matlab, Power grid, Generators.

Introduction:

Nowadays, domestic transportation with electric vehicles (EV) is becoming more and more promising. EVs have the key

benefits of being noiseless, clean, and energy efficient. Free of polluting transportation. Possession of the EVs is growing, reaching 10% globally by the year 2030. By the end of the year, manufacturing and sales will reach 20 million. Electric vehicles (EVs) will be used for domestic travel by 2030 [1]. The main risks come from the use of fossil fuels and the emission of pollutants like carbon monoxide, nitrogen oxides, and others that cause ground level ozone, human health risks from CO- containing exhaust, and greenhouse gases like carbon dioxide that cause global warming. These pollutants are produced when hydrocarbons and nitrogen oxides react in the presence of sunlight to increase ground-level ozone. Building more charging stations is essential given the growing number of electric vehicles (EVs). Present day researchers and businesses are concentrating more on EV and their access to the grid. EVs have the ability to store energy, can also be used in other applications, like as improvement in stability and dependability, including voltage, frequency control, etc. Electric vehicles (EVs) can function as a distributed power storage device for grid input electricity in addition to being a controllable load (vehicle-to-grid, V2G). Therefore, according to theory, EVs will give the grid auxiliary resources like frequency control. EVs can be charged at home, in public areas, or in parking lots that feature quick charging stations[2]. The current power system grid does not already have enough loads. The growing number of EVs will place a significant stress on the electric system due to their high electricity usage. In order to meet future demand without harming the environment and produce clean energy to fill required loads, renewable energy sources (RES) are essential. The majority of research claimed that solar and wind energy are the most promising sources of clean energy out of all RES.00

2. System Configurations:

A photovoltaic (PV) array serving as a solar PV plant, a wind farm, and a diesel generator serving as a power reserve are all components of the planned microgrid depicted in Figure 1[2]. Three phase step-down transformers are linked to a common bus that contains three source connections. The load is linked to the same bus as the V2G system at the secondary side of the transformer. Residential and industrial loads make up the total load. Asynchronous machines are the main type of industrial load employed here. In Table I, all sources' power capacities and the needs of all loads are listed[2].

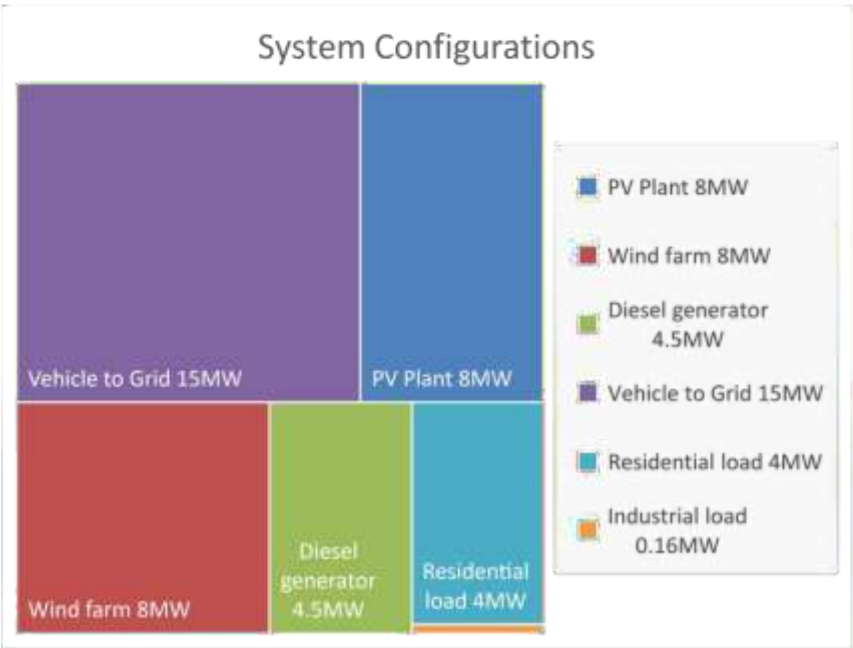

Fig 1: System Configurations.

The variation in sun irradiation, solar panel efficiency, and PV plant area all affect how much power is produced. Wind farms generate electricity in a straight line with wind speed. Wind farms only produce nominal electricity when the wind speed reaches its nominal value.

Wind farms are shut down until the wind speed returns to its nominal value if the wind speed exceeds the maximum wind speed value. A reserve in the system, the diesel generator balances the electricity generated by the wind farm and PV plant with the power needed by the load.

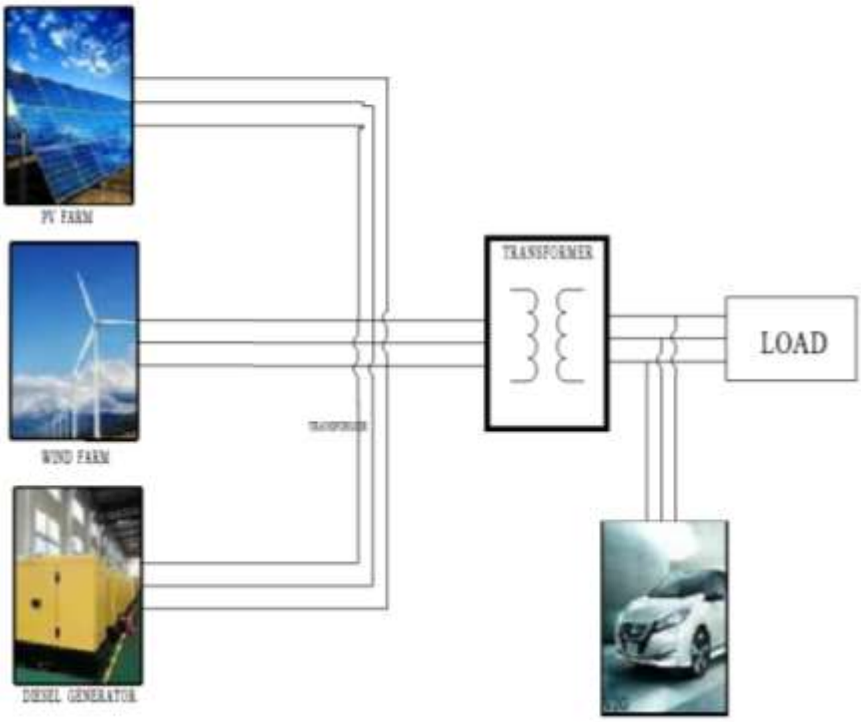

Fig 2: Micro Grid with V2G technology.

Diesel Generator Model:

The fuel consumption of the diesel generator is given by the following expression:

$FC = \eta_{fuel} (P_{diesel} - P_{diesel\_rated}) + FC_{rated}$

Where:

- FC(l/h) is the fuel consumption.
- P_{diesel} l(W) is the actual power of the diesel generator.
- *Pdiesel _ rated* (W) is the rated power of the diesel generator.
- $^{\eta}$fuel is the fuel consumption efficiency.
- *FCrated* is the diesel generator fuel consumption at rated power.

Photovoltaic Generator Model:

PV cell combinations that are coupled in series, parallel, or both make up photovoltaic (PV) generators. This generator allows solar energy to be transformed into electric energy, which produces a clean, renewable source of electricity. The result below is a function of solar radiation for electric power.

Wind Turbine Model:

The wind generator is composed of a turbine and a p00000ermanent magnet synchronous machine. The produced wind powe [3].

Load Model:

The following equation illustrates how the total amount of electric power used by all of the different loads in the micro-grid is equal to the sum of their individual powers.

In accordance with consumer demands, the power demand from these loads changes throughout the day and may be divided into three groups based on duration and intensity:

- Permanent loads: A portion of the activities of residential or industrial loads consist of ongoing or regular actions that require a steady supply of electricity.
- Consumption peaks: On occasion, a large quantity of power is needed in a brief period of time, leading to consumption peaks.
- Different loads: Depending on the duration and season of employment, there are additional power requirements that do not fit into any of the aforementioned categories.

Electric Vehicle Model:

The electric vehicles (EVs) employed in this simulation are categorized as plug-in-EVs, or battery-only electric vehicles, because they only have an electric motor for propulsion. To make the study easier to understand, these EVs are roughly represented by a battery pack with a rated charge of 85 kWh and a rated power of 40 kW.

PEV is classified as PEV+ and PEV-. Where:

PEV+ is EV discharging. PEV- is EV charging.

The suggested model and control for these vehicles is shown in Fig.2 and was created specifically for a V2G application to make it feasible to manage modes of optimal operation.

The V2G does two tasks: managing the charge of the batteries that are linked to it and managing the grid whenever an event occurs during the day by using the electricity that is obtained. Five fully separate car-user profiles are implemented by the block v2g:

Profile #1: People who go to work with a facility to charge their cars at work.

Profile #2: People who go to work with a facility to charge their cars at work however with a longer ride.

Profile #3: People who go to work without any facility to charge their cars at work.

Profile #4: People who stay at home all day.

Profile #5: People who go to work on a night shift.

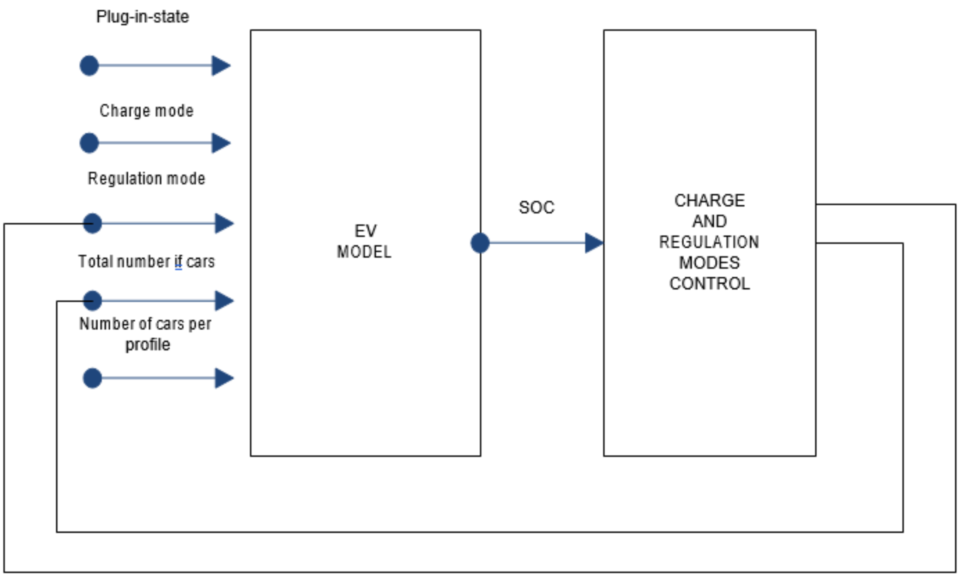

Fig 3: V2G model

To make the changes gradual, the State of charge (SOC) of every automobile profile was changed. SOCs were dropping at a rate of 0.1 hours per unit when in motion i.e. plug state 0. When the vehicle wasn't in operation, and if the plug stayed 0, the SOCs were unaffected; otherwise, if the plug state was 1, and the SOCs raised until they reached a maximum of 0.95, post which it provides charge to the grid at times of excess consumption or sudden closure of any energy farm. Further, the A modified SOC calculation control block now has a variable SOC during the time when plug state for the certain HEV is zero, which relates to a reduction in SOC of the employed HEV [4].

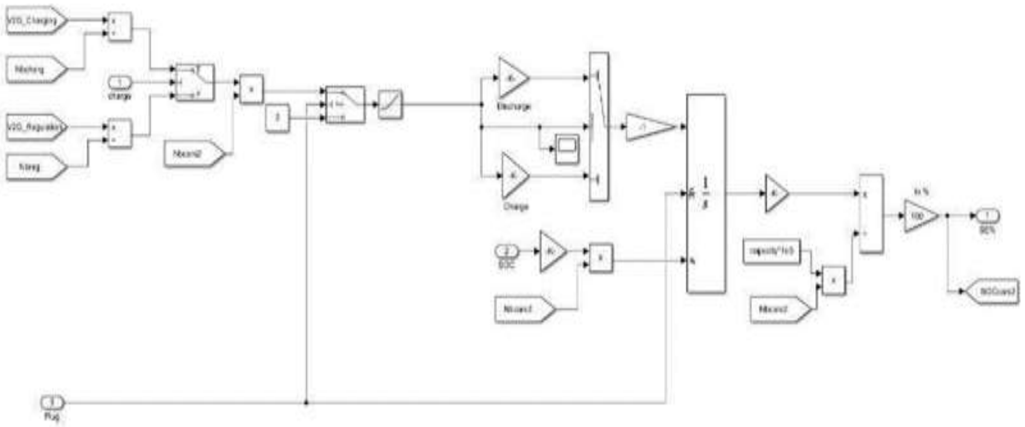

FIG 4: Conventional control

Profile 1: The 20 automobiles in this profile represented persons who commute to work and have access to a charging station. When the automobile is unplugged, the maximum SOC of 0.9 goes to -1, and when it is connected back in, a lower value of

0.8 rises.

SOC: [0.9 0.9 0.9 0.9 0.9 0.9 -1 0.8 0.8 0.9 0.9 0.9 0.9 0.9 0.9 0.9 -1 0.8 0.8 0.9 0.9 0.9 0.9 0.9]

Plug State: [1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1]

Profile 2: The 20 automobiles in this profile stand in for those who commute to work without access to a charging station.

SOC: [0.9 0.9 0.9 0.9 0.9 0.9 -1 0.8 0.8 0.9 0.9 0.9 0.9 0.9 0.9 0.9 -1 0.8 0.6 0.9 0.9 0.9 0.9 0.9]

Plug State: [1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1]

Profile 3: The 20 automobiles in this profile indicate individuals who commute to work with the potential to charge while there, but who also have a lengthier ride.

SOC: [0.9 0.9 0.9 0.9 0.9 -1 -1 0.7 0.7 0.9 0.9 0.9 0.9 0.9 0.9 0.9 -1 0.8 0.7 0.9 0.9 0.9 0.9 0.9]

Plug State: [1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1]

Profile 4: The 20 automobiles in this profile are for the individuals who like to stay at home and who can help other profiles out when necessary.

SOC: [0.9 0.9 0.9 0.9 0.9 0.9 0.8 0.8 0.8 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.8 0.8 0.8 0.9 0.9 0.9 0.9 0.9]

Plug State: [1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1]

Profile 5: The 20 automobiles in this profile stand in for those who work the night shift and spend the day at home.

SOC: [-1 0.9 0.7 0.7 0.7 0.8 0.8 0.8 0.8 0.8 0.9 0.9 0.9 0.9 0.9 0.9 0.8 0.8 0.8 0.9 -1 0.9 0.9 0.9]

Plug State: [0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0]

3. MANAGEMENT STRATEGIES:

In this specific application, where charging is not regulated and discharging is controlled, management measures have been put in place to guarantee that the micro-grid operates as intended. When there are abrupt spikes in demand, the discharged power must be used to meet the need for mixed production.

Charging Strategy:

The scale of the suggested simulation is designed to meet all customer demands, whether they are domestic or industrial. Additionally, it incorporates a sizable number of renewable energy sources within the confines of the 24-hour simulation period's consumption and production levels.

According to the charging profiles of each segment of the fleet, the EV fleet has been given a primary charging function in this simulation environment and is largely regarded as another load with consistent power consumption during many hours of the day.

When an electric vehicle (EV) is hooked into the grid and its State of Charge (SOC) falls below a threshold set by the charging management parameters, the charging procedure is initiated. These settings dictate that EVs only charge when their SOC is below 85%. The charge mode, or charge state, is produced by the management system as a Boolean variable and used to instruct the EVs to either charge (value equal to 1) or not (value equal to 0). (Value equal to 0)[4].

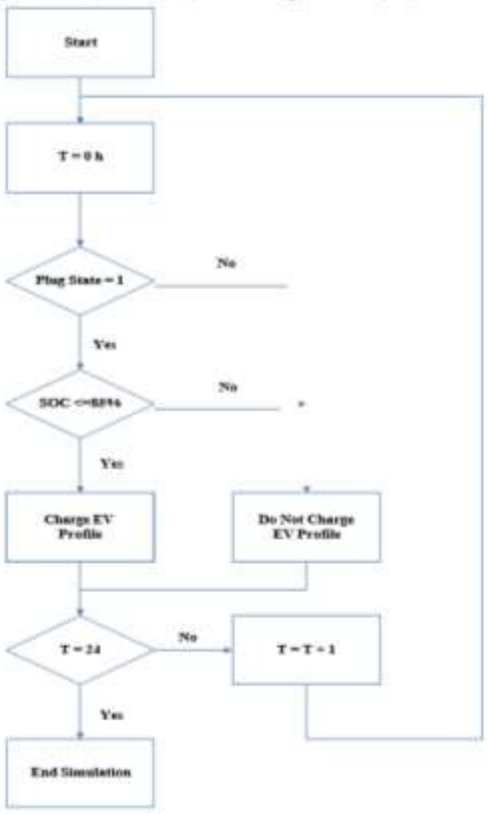

Fig 5: Charging process flowchart

Discharging strategy:

In order to verify the simulation's resilience, several situations have been included as a few interruptions to the system's regular processes. The following list provides examples of these situations:

- The launch of an asynchronous machine reflecting the industrial load at 3 AM significantly and abruptly raises the overall load.
- A partial shadowing of the PV farm around 12 AM produces a considerable and rapid fall in the micro-total grid's power generation, forcing the diesel generator to adjust.
- At 10 p.m., the wind speed surpasses the maximum permissible speed for the wind turbine, necessitating its shutdown owing to safety rules, and forcing the diesel generator to compensate for the power imbalance during that time of severe winds. Figure 12 depicts the wind speed for the EVs have been enlisted as an instrument of regulation to assist decrease the consequences of these circumstances. As a result, EVs may now only release modest, controlled quantities of energy in order to comply with government regulations. The SOC score and plug-in state of the EVs are requirements for this functionality. These circumstances come together to create the regulatory mode, which displays the EVs' readiness for discharge. Users are unable to manage discharge capabilities. Only when the grid requires their assistance in responding to sudden, severe power outages that the diesel generator is unable to handle on its own can electric vehicles (EVs) discharge. They also perform the function of a tiny supporting energy source, releasing quick bursts of energy to assist the slower power infrastructure in controlling power in a fast- changing environment [3].

According to the chosen parameters for the discharge strategy, EVs are discharging whenever the following conditions are met:

- EVs are plugged into the power grid.
- EVs have a SOC higher than 95%.
- The diesel generator requires help with regulating the power grid when confronted with a sudden event for a specific period of time.

When the difference between the reference angular velocity (ωref= 1 p.u.) and the angular velocity of the diesel generator reaches $\pm 5.10^{-4}$ p.u., the discharge strategy's specifications call for EVs to assist in regulating the power imbalance. Given that the diesel generator has a slower reaction time than Li-ion batteries, the grid may need to use a V2G application. The quantity of power released by EVs is shown in Fig. 13, which also shows the power bursts that occur at times of abrupt and large disruptions. The flowchart of the discharging process is shown in Fig. 14, where T (days) stands for time.

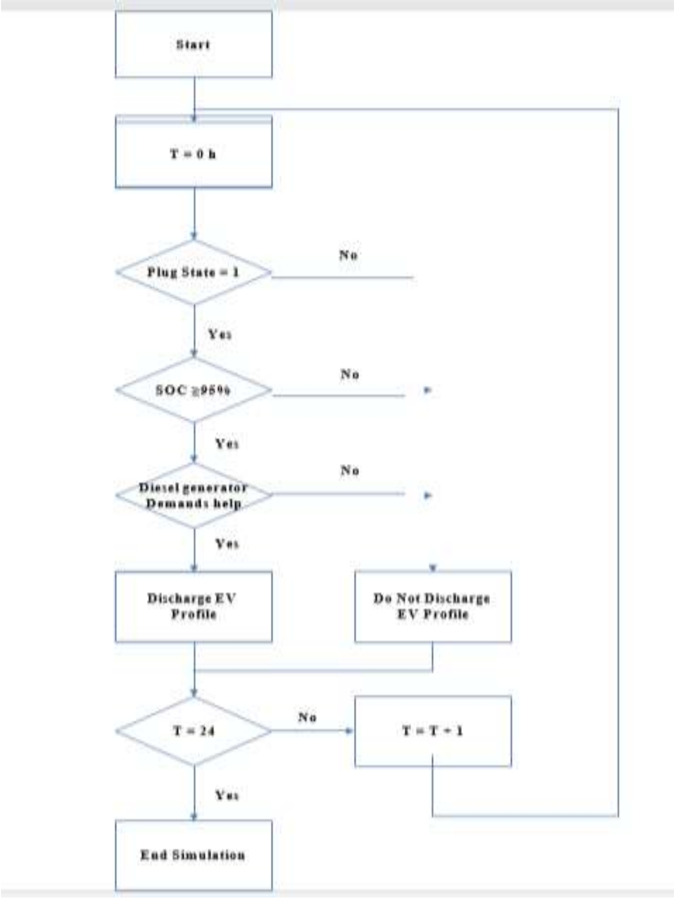

Fig 6: The flowchart of the discharging process.

4. Simulation Results and Discussion:

In this research, a 24-hour scenario is simulated for the model. The peak of the sun intensity, which has a typical distribution, occurs at noon. The wind has several peaks and valleys during the course of the day. A typical household's consumption pattern is comparable to how the residential load is distributed. The consumption is modest throughout the day, peaks in the evening, and then gradually declines during the night. Two partial shedding effects are taken into account in this case study; further information is provided in Table 1. At 3 hours, the industrial load is switched on. Chart 2 displays the car profile that was picked for this scenario. The findings of the simulations are explained in more detail below.

Table 1: Partial shedding effect of the PV farm.

Partial Shedding No	Event Occur at	Duration	Factor
1	12Hrs	10mins	0.7

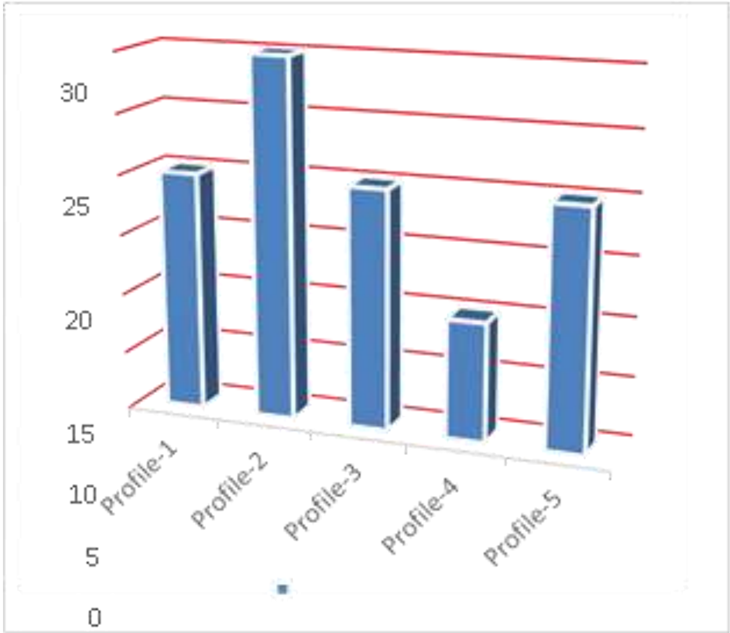

Fig 7: Number of cars in the particular profile.

The simulation results for irradiance, power of PV farm is shown in Figure 3. The figure shows that electricity generation peaks around noon. PV farm generation fluctuates based on solar irradiation. The PV farm's maximum electricity output is 4 MW. Current reaches a high of roughly 145 Amp. At 10 hours and 12 hours, with durations of 10 minutes and 15 minutes, respectively, the partial shedding effect may be observed clearly.

The simulation results for wind speed, power of wind plant is shown in Figure 16. The highest wind speed in this situation is 14 m/s. The graphic illustrates how wind is erratic in nature. The wind farm's peak electricity output is 4.5 MW. Wind farms are protected from strong winds, so they are alerted when the wind speed exceeds the maximum wind speed restriction. Figure 16 shows that this interruption occurrence happens at 21:45 hours.

Figure 17 displays the power simulation results for diesel generators. The power demand is controlled by a diesel generator. The diesel generator's peak output is 14 MW.

The analysis takes into account a total residential load of 10 MW and a total industrial load of 0.16 MVA. Figure 19 displays the power measurements for a residential load. At 3 hours, industrial load is activated. Figure 18 displays the power measurements for industrial loads. Figure 20 displays the Asynchronous machine simulation results for an industrial load, rotor speed, including power, and mechanical torque.

Each 40 kW is linked to 100 automobiles. 4 MW is the total V2G load. As shown in Chart 2, 100 automobiles are split into a total of five categories of profile. The number of vehicles in charging mode and the number of vehicles in regulation mode are shown in Figure 21.

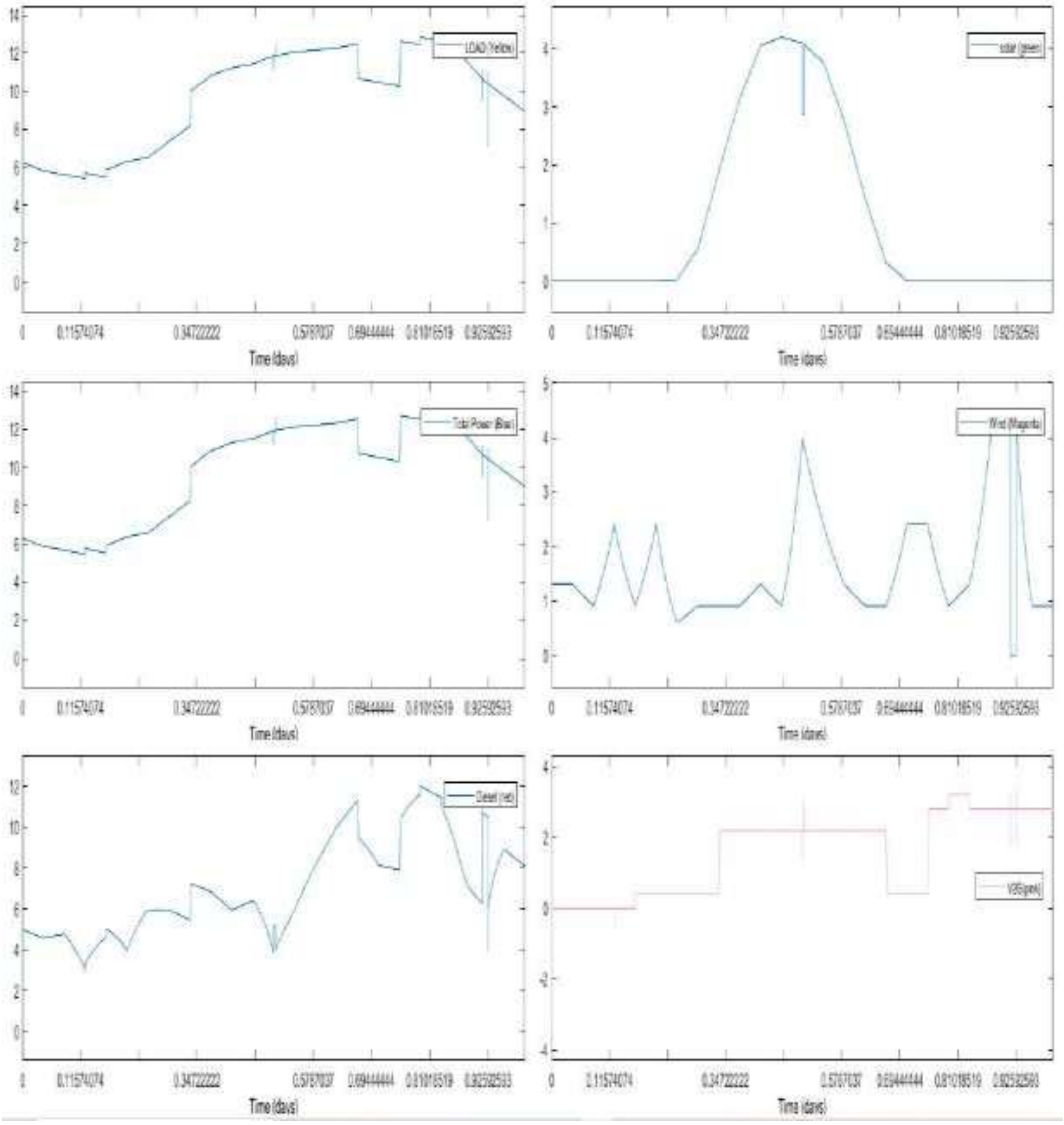

Fig 8: The combined plot of electricity from a PV farm, a wind farm, a diesel generator, total power, EV power, and load power.

The PV farm produces no electricity between the hours of 12 and 6, and less than 3 MW of power is produced by the wind. As shown by the load line, load demand grows at this time, making it impossible for the wind farm to meet that need alone. In this case, diesel generators support the load demand and provide the additional electricity needed by the load.

A partial shedding effect occurs around 10 and 14 hours. In order to make up for the decreased power during this shedding effect, diesel power generates extra power[7].

As wind speed surpasses the maximum wind value by roughly 21.45 hours, wind farms experience excursions, as seen by the wind line in figure 23. At three hours, the industrial load begins.

The grid frequency response is seen in Figure 13. Several things happen throughout the course of the 24-hour simulation. The industrial load is switched on first at three hours. Additionally, partial shading effect 1 begins at 10 hours. The second partial shade effect begins at 14 hours. Fourth, the stoppage of the wind farm begins at 21.45 and ends at 22.21. The automobiles that are in regulator mode control the frequency of the grid.

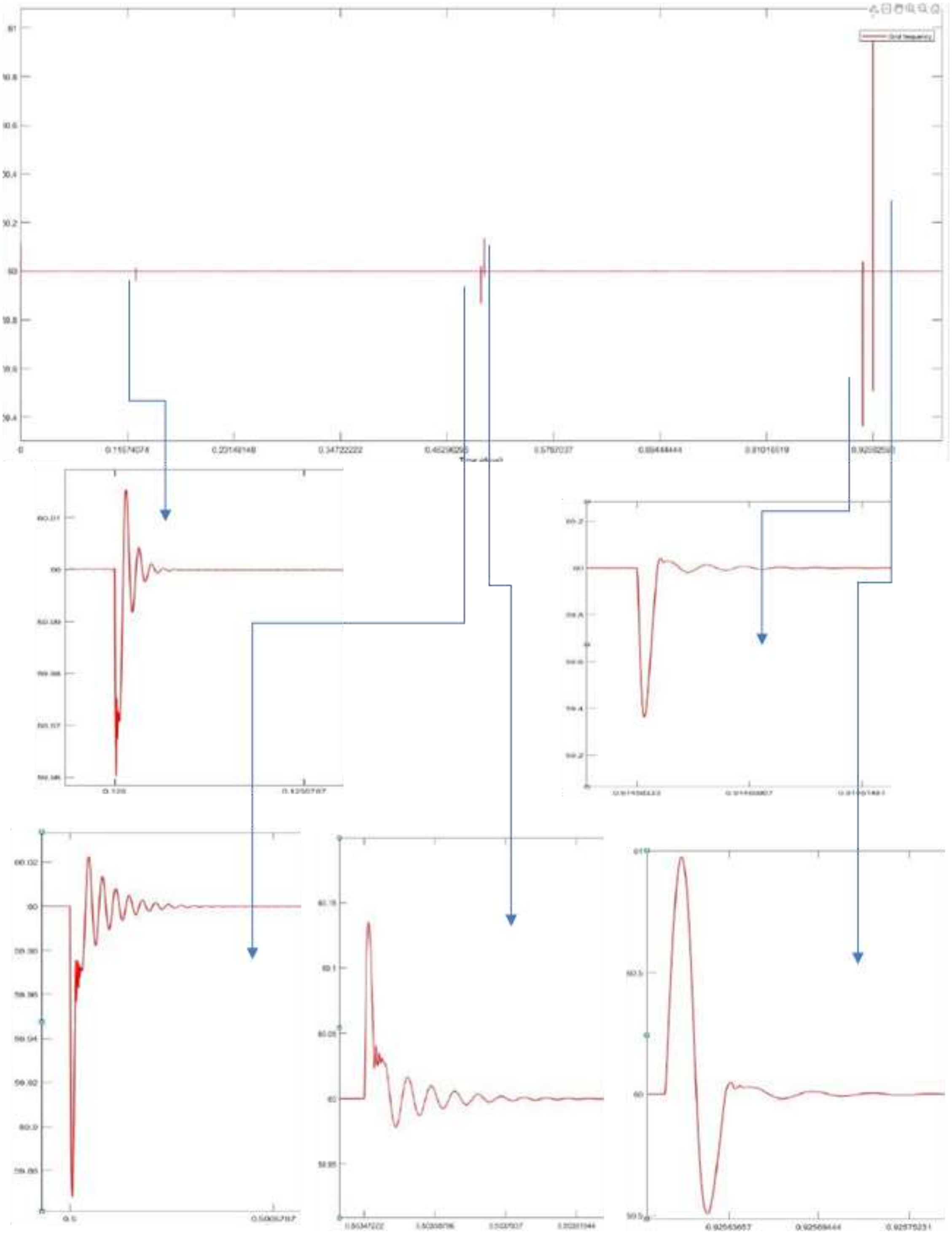

Fig 24: Grid frequency response.

5. Conclusion:

An environment for simulating a planned micro-grid has been researched. Its power balance simulation has been discussed. The charging techniques that were picked as potential representations of different lifestyles have been described. Investigations have been done into the management techniques employed to control the power levels in various situations. Understanding power regulation and the impact of natural events on a grid that runs on renewable energy is greatly aided by this simulated environment. Allowing users to discharge at will or directing vehicles individually rather than as a group sharing a single profile are examples of potential upgrades.

References

[1]. Pillai, Jayakrishnan Radhakrishna, and Bilrgitte Bak-Jensen. "Integration of vehicle-to-grid in the western Danish power system." IEEE transactions on sustainable energy 2, no. 1 (2010): 12-19.

[2]. Ma, Yuchao, Tom Houghton, Andrew Cruden, and David Infield. "Modeling the benefits of vehicle-to-grid technology to a power system." IEEE Transactions on power systems 27, no. 2 (2012): 1012-1020.

[3]. D. Danalakshmi, S. Kannan and V. Thiruppathy Kesavan, Reactive power pricing using cloud service considering wind energy, Cluster computing- The Journal of Networks Software Tools and Application, Springer, pp.1-11, 18 May 2017, doi: 10.1007/s10586-017-0896-2. (Indexed in: SCI, Impact factor: 2.040).

[4]. Danko, Matúš, Juraj Adamec, Michal Taraba, and Peter Drgona. "Overview of batteries State of Charge estimation methods." Transportation Research Procedia 40 (2019): 186-192.

[5]. Liu, Hui, Zechun Hu, Yonghua Song, Jianhui Wang, and Xu Xie. "Vehicle-to-grid control for supplementary frequency regulation considering charging demands." IEEE Transactions on Power Systems 30, no. 6 (2014): 3110-3119.

[6]. Qays, Md Ohirul, Yonis Buswig, Md Liton Hossain, and Ahmed Abu-Siada. "Recent progress and future trends on the state of charge estimation methods to improve battery-storage efficiency: A review." CSEE Journal of Power and Energy Systems 8, no. 1 (2020): 105-114.

[7]. Han, Sekyung, Soohee Han, and Kaoru Sezaki. "Development of an optimal vehicle-to-grid aggregator for frequency regulation." IEEE Transactions on smart grid 1, no. 1 (2010): 65-72.

[8]. Gupta, Aditi, Hari Om Bansal, Pavni Jaiswal, and Ravinder Kumar. "Modeling and Analysis of a V2G Scheme: A Concept in Smart Grid." In 2020 International Conference on Emerging Trends in Communication, Control and Computing (ICONC3), pp. 1-6. IEEE, 2020.

[9].] Misyris, George S., Dimitrios I. Doukas, Theofilos A. Papadopoulos, Dimitris P. Labridis, and Vassilios G. Agelidis. "State-of-charge estimation for li-ion batteries: A more accurate hybrid approach." IEEE Transactions on Energy Conversion 34, no. 1 (2018): 109-119.

[10]. TUMMALA, A. S. L. V., INAPAKURTHI, R., & RAMANARAO, P. V. (2018). Observer based sliding mode frequency control for multi-machine power systems with high renewable energy. Journal of Modern Power Systems and Clean Energy, 6(3), 473–481. doi:10.1007/s40565-017-0363-3.