ISSN: 2583-5637 (Online)

International Journal of Inventive Research in Science and Technology Volume 2, Issue 8, August 2023

Simulation of 24 HOURS V2G System- A Review

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Abstract As the natural resources are going toward an extinction the world is now running toward renewable resources like sun, water and wind energy resources. An electric vehicle can be operated and charged by the energy generated from these renewable resources also. Therefore, the world is now moving toward the future that is electrical vehicles. Besides having benefits to the growth, transportation and road efficiency, electric vehicles can also be used to provide power to the utility systems and benefits to car owners, as they are able to provide ancillary services by their cars. Electric vehicle connected to the grid can behave either as a load or as a power source and this system on whole is called as vehicle-to-grid (V2G) when it is operated as power source. This paper discusses about the services provided by the vehicle owners after the implementation of the V2G system to the grid and also a case study on 24-h model of V2G system is done. The impact of solar shading on the services provided by the vehicles is studied. This analyzed system consists of actual power generation from a diesel power generator, base load, peak load, EV aggregator and the renewable energy resources (solar and wind). For different renewable energy generation in the grid that is by changing the shading of the solar plant, different scenarios are analyzed.

Keywords Vehicle-to-grid · EV aggregator · Solar shading · Micro-grid · Shading factor

1 Introduction

As the natural resources on the earth are diminishing day by day, the world is now running toward renewable sources like solar, wind, water, etc., and at the same time due to lack of natural energy resources, the fuels for the vehicles is going on the verge of extinction. So, now the future of vehicles is in electric domain, we can get as much of electricity from the solar, wind plants and thus these and never going to diminish and due to this reason only the energy services from these are in spotlight nowadays, and hence the energy from these plants can be used to feed electric vehicles. Now these electric vehicles can take power from any source that is from grid, micro-solar plants that can be established at any place and can also be used to fed power back to the grid in case of any kind of shortage due to increase in loads, thus, providing some kind of stability to the system.

Electrical vehicles have always been advantageous over normal internal combustion engines and there are lots of reasons why they are gaining attention of people over the IC engine vehicle and some of them are, as the fossil fuels which are required to run the internal combustion engines are diminishing, the prices of the fuels are reaching heights, and hence affording and using a conventional vehicle is becoming difficult for the people, combustion of fuel in the conventional vehicles leads to emission of harmful substances like carbon monoxide—CO, hydrocarbons—HC, particulate matter—PM and nitrogen oxides—NO_X , which obviously you know is not at all good for the environment and also as production of noise from the elec-tric vehicle is very less as compared to the conventional vehicles as the number of moving parts in the electrical vehicles are very less against the IC engine vehicle, which makes the efficiency of the electrical vehicle three times as of the conventional IC engine vehicles. Recently, the market of the electric vehicles in Asian countries and also the rest of the world have been growing rapidly as the maintenance and the running cost of these vehicles are low against the normal conventional vehicles and as these vehicles are electrical they can be charged anywhere where electrical power is available against the headache of refueling the conventional vehicle from the fuel station time to time. The countries are also bending their policies to attract people toward the electrical vehicles and benefiting them by introducing different benefits like ownership benefits, subsidy on purchasing, free EVs charging at the charging stations, etc. The electric vehicle in the grid acts as a source and as well as load but one at a time. The increase in number of EVs reduces the generation requirement in a grid. The battery of EV charges at the time when the demand is low which is most likely to be at night. The impact of increase in number of EVs in a grid during peak demand is studied in [1].

In [2], a solution has been described to provide enough energy to charge the battery in the discounted parking service. Electric vehicles are often referred to as "prosumers" because they deliver and consume electricity. It is estimated that electric vehicles use only 10% of their life, leaving 90% of idle time [3]. In this case, the energy stored in the battery can be fed back into the grid. The best penetration of electric vehicles requires not only the battery charging program on the swing market, but also the occasional discharge in times of high power. This is often referred as a "network vehicle system" referred to as V2G [4]. First, the term V2G is used to describe a particular type of system that allows power between the network and an electric vehicle on both sides. The concept here with V2G is that the power is supplied to the grid when the electrical vehicles are parked at their location or at the charging stations. This collaboration of electrical vehicle in grid helps to shed out the peak load demands and provide stabilization and increase the efficiency of the grid. Active and reactive power support has been provided by the electrical vehicles which are working in V2G mode. A comprehensive summary of diverse V2G systems is studied in [5, 6], When the fleet of EV provides power to the grid simultaneously for truly extracting the meaning of electrical vehicle and providing benefits of transportation, then the

V2G operation is said to function properly. The EVs are under an aggregator agent who takes the regulation charges from the grid for every unit of power sent to the system at the hour of need. An aggregator has a fleet of EVs under him and provides the ancillary services with the help of the EV fleet. The term EV aggregator is used to define the subject of controlling battery charging of the electrical vehicle and may include many electric vehicles. In the grid scenario, the aggregator acts as a large controlled weight or generation source that can be used as an add-on service.

The objective of this paper is to evaluate the impact of electric vehicles (EV) to provide better micro-grid services. The second part briefly describes the upcoming electrical vehicles technology. In Sect. 3, the impact of solar shading on the power output of the system is studied and analyzed.

2 EV's as Supplementary Reserve in the Grid

Large admissions of electrical vehicles in the grid will soon change the future of the traditional grid. EVs have many applications as they provide transportation services and energy storage optionsIn V2G operating mode, the EV acts as a storage unit. The most commonly reported services are micro-operations, voltage control and peak shaving [5, 6]. At any instant of time, the operation of grid is based on generation management and the load at that instant. At any instant, the grid basically main-tains the balance between the generated power and the demand of the loads which basically makes the grid to work normally. Every imbalance between demand and production generates a frequency fluctuation in the system. From these points of view, the constant speed of the synchronous generator can be compromised, making the power supply system unstable and adversely affecting the accuracy of the clock. In order to maintain the balance between load and production, the system manager must obtain various services from the electricity market from other production units. The viability of V2G system is to support a variety of services. Spinning reserve and peak power are the features that V2G can support.

3 Simulation Model Description

The simulation model is an example present in the MATLAB [7] library and it consists of various power generating plants. It consists of a 15 MW diesel generator, a wind farm, a solar farm with its shading control, load at the end and an EV aggregator, which communicates with all the electrical vehicles to provide the ancillary services to the grid in the time of need. The model is an isolated power system.

The diesel generator, which is capable of generating 15 MW of power, is the only dependable sources here, which means that it is not affected by any kind of weather conditions and is totally independent of the wind, rain and all. There are two renewable energy sources present in the system or you can call the combination as a micro-grid. Photovoltaic cell-based solar panels which makes a solar plant which generate energy from solar radiation at the time sun is shining, and a wind farm which has a wind turbine, that is it generates energy from the wind, the more is the velocity of the wind the more is the power generated by the wind turbine, also rated capacity of PV farm is taken as 4.5 MW, and that of wind turbines is 8 MW.

EVs are used to deliver the extra burden on the grid at peak hours and that is called peak shaving. The energy stored in the battery of electrical vehicles which are parked somewhere and connected to grid is used in the peak load time that is at the time of high demand. It helps us to reduce the investment of incorporating new conventional

ISSN: 2583-5637 (Online)

International Journal of Inventive Research in Science and Technology Volume 2, Issue 8, August 2023

generators at the time of high demand. Thus, also for the control of voltage and the congestion management, the battery energy of the electrical vehicles ID fed back to the grid. And also it can provide frequency regulation services.In this simulated model, the number of aggregated EVs is taken to be 200 and they operate in different profiles that is an amount of electrical vehicles will provide the ancillary services at a particular period of time and on the basis of these they are divided into different profiles and different time periods. The required rated power for charging for the EVs which are 200 in number is 200 × 16 kW [8]. The required charging power 16 kW for each EV resembles to the level two chargers, this type of chargers offer charging from 230 V AC plug directly and also it can be used anywhere to charge where the 230 V AC charging sockets are available. Further, these level two chargers can be used to charge any type of EV and PHEV. It is assumed that the charging facilities are available at every household and offices and thus they are divided into five different scenarios which are listed below. The characteristics profile of each user is as follows,

Profile 1: People who work at offices from 9 to 5 pm, and use their vehicles for 3 h in this period with availability of charging facilities near offices and homes represents 17.5% of the total EVs.

Profile 2: People who work at offices from 9 to 5 pm, and drive their vehicles for 4 h in this period with availability of charging facilities near offices and homes represents 12.5% of the total EVs.

Profile 3: People work at offices from 9 to 5 pm, and drive their vehicles for 3 h during this period without availability of charging facilities near their offices do represents 10% of the total EVs.

Profile 4: People who does not even drive their vehicles the whole day and their cars are connected to the grid all the time represents 30% of total EVs.

Profile 5: People work at offices from 20 pm to 4 am, and drive their vehicles for 2 h in this period without availability of charging stations near offices at all represents 17.5% of the total EVs (Fig. 1).

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International Journal of Inventive Research in Science and Technology Volume 2, Issue 8, August 2023

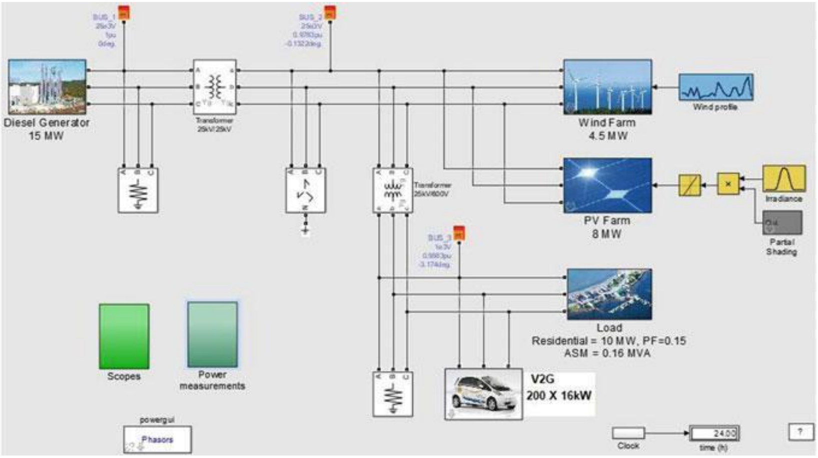

Fig. 1 24-h simulation of V2G system

3.1 Simulation Description and Different Scenarios

This simulated model is simulated for the whole of 24-h. Solar plant being the most uncertain one for generation of power as there is no guarantee of when the shading of solar plant will occur that means the solar plant will not be able to produce a constant power when needed thus the solar shading (shading factor) is being considered here and is used to see the performance of the system. At the time of noon, there is significant amount of shading which will distress the power output from the solar plant. Shading factor represents the amount of solar plant is shaded in ratio to the total area of the solar plant. There is an impact on power generation due to the solar shading of the PV farm and also when different number of EVs used in the system. Also, the impact of shading is being studied on the different factors of the grid like the power generation and the frequency of the system. The main here is to maintain the stability between demand and generation.

Figure 2 represents the 24-h simulation model of a micro-grid along with the declined output of PV panels which occurs during the noon that is at 12:00 pm and remains for 10 min when the shading factor is considered to be 0.5 [9]. By changing the shading factor or the time of shading, the output of the total PV panel varies and hence the total output varies. Thus, the EV fleet connected to the grid will have to transfer the excess power, as the output of the wind would be constant and load being the same; therefore, the EV fleet or electrical vehicle in general can be used to provide the regulation services or the excess demand.

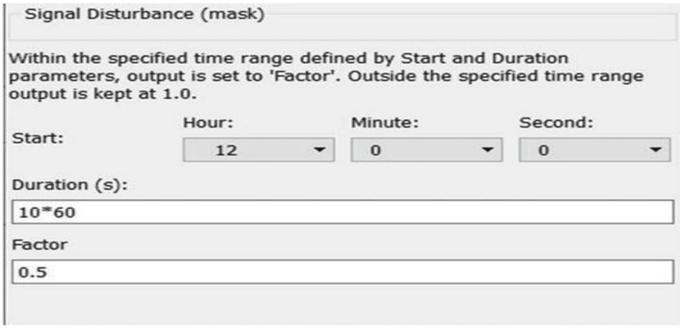

Fig. 2 Solar shading and its duration

4 Simulation Results

The power outputs of the different plants that is the solar, wind, diesel generator are obtained from the simulation and are displayed below at shading factor equal to 0.5. By changing the shading factor only, the output of the PV farm changes and hence the total output of the grid changes. Also, the SOC of the electrical vehicles, regulation and charge parameters have been monitored at the same shading factor. Also, by changing the shading factor, the behavior of the grid can also be studied, which basically means that the total power output variation with respect to the shading factor, as shading factor only changes the power out of the PV farm and rest producing the same output (Fig. 3).

This plot shows the power produced by all the power-producing elements in the grid. The first plot is the total power produced by all the components of the grid. The red-colored one that is the second graph is the power generated from the diesel generator. The blue graph is the output of the wind farm, whose output totally depends on the profile of the wind of the area. The last one that is magenta graph is the out of the solar farm which clearly shows a dip at the time of shading of the PV farm. The output of the PV farm clearly drops to almost a half when the half of the PV farm is shaded that is when the shading factor is equal to 0.5.

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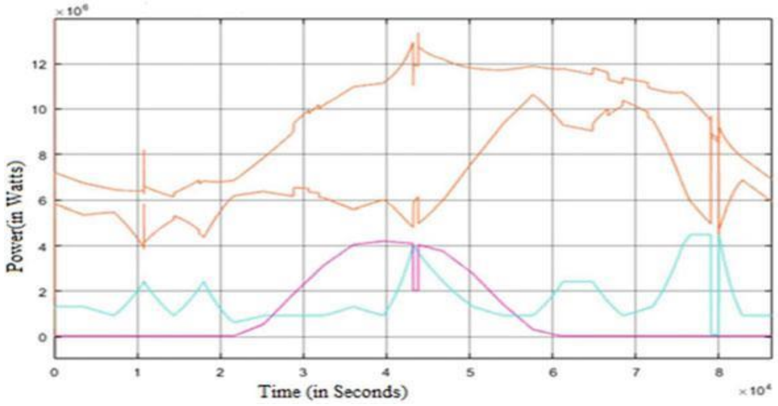

Fig. 3 Power generated by different plants and total power

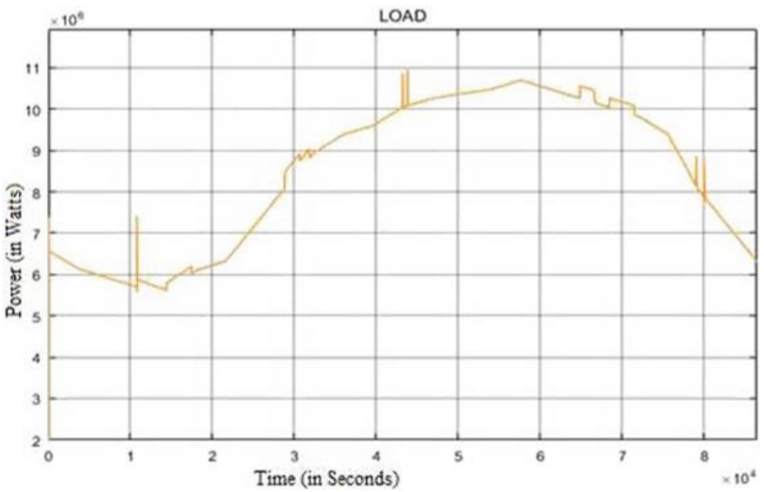

Figure 4 load curve

ISSN: 2583-5637 (Online)

International Journal of Inventive Research in Science and Technology Volume 2, Issue 8, August 2023

Figure 4 is the load curve which resembles the output of the grid that is, the graph of total power generated in the micro-grid and this should also be the case as the demand should be equal to the supply. The power produced should be equal to the power needed and at the time of dip in the output of the solar farm or the shading of the PV Farm, the EV fleet that is the EV aggregator is doing is work that is providing the regulatory power services to the grid and thus maintaining stability in the system, which means that the vehicles are charging and discharging the whole time but thevehicles connected to the grid at the time of power dip would be providing the power, thus, the state of charge of the vehicles should be the thing to monitor here and the same is shown for the different profile in the EV fleet. Figure 5 shows the state of charge of the different profiles of the EV fleet under the EV aggregator. The state of charge varies between −ve 100% and +ve 100%, where negative value of SOC shows that the EV fleet is doing the vehicle-to-grid operation and otherwise G2V. Figure 6 shows different parameters like voltage, current and different powers of an EV fleet.

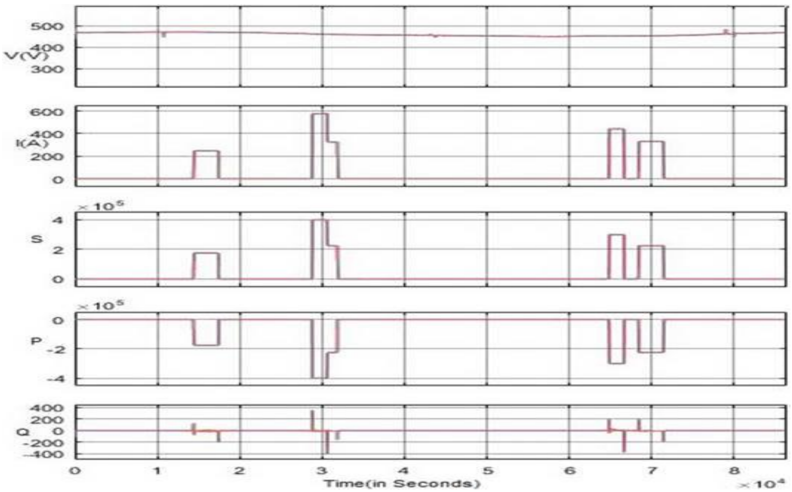

Fig. 5 SOC of different EV profiles

ISSN: 2583-5637 (Online)

International Journal of Inventive Research in Science and Technology Volume 2, Issue 8, August 2023

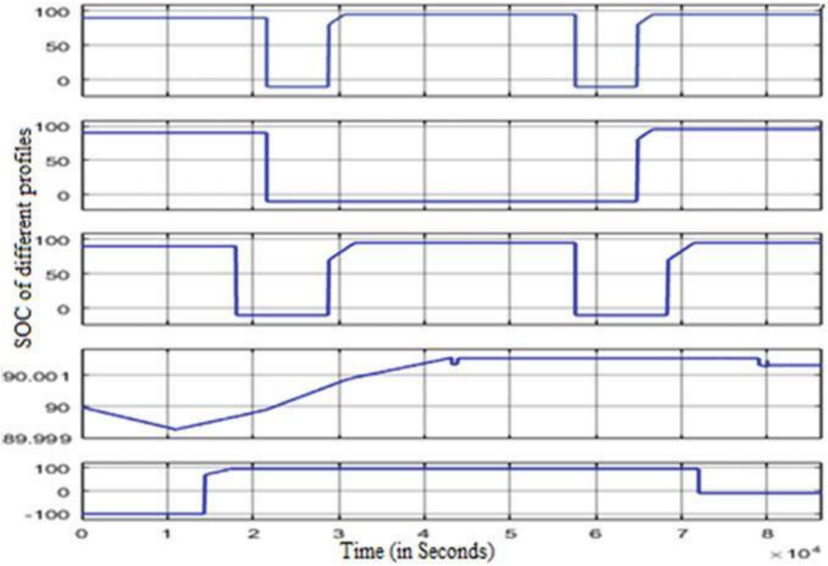

Fig. 6 Voltage current and power profile of EV fleet

5 Conclusion

A successful study of a 24-h simulation of vehicle-to-grid system is done and how the different parameters of the grid vary by changing the different parameters like solar shading, number of electrical vehicle under an EV aggregator or in the EV fleet is analyzed and studied. The more the number of vehicles connected in the grid under a EV aggregator, more ease it will provide to the grid and the more it will help to shave out the peak load because we cannot be dependent on the output of wind plants and the output of the diesel generators does not vary a much

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