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Vehicle-Building Technology In EV For Emergency Military Power Supply In Remote Locations

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Abstract:
In Today's World, There Is A Need Of Verge Of Significant Transformation In Electrical Power System. The Vehicle-To-Gird (V2G) Concept Optimizes This Transformation. The PEV Typically Has A Higher Capacity Energy Storage System (ESS). Each PEV Stores Approximately 5-40kwh Of Energy. This Energy Can Be Transferred To The Vehicle-To-Grid (V2G), Vehicle-To-Home (V2H) And Vehicle-To-Building (V2B) As Most Of The Time The Vehicle Is Kept In Parking As Idle. Plug In Hybrid Electric Vehicles Have Vast Scope And Capabilities Of Energy Storage. This Feature Of EV Can Be Utilized For Energy Storage Along With Distribute/Sell It During Peak Demand. In [4] The Various Features Of V2G, Its Applications, Advantages Along With Its Challenges To Implement It, Is Presented. A Precise And Comprehensive Literature Review Is Analyzed In [5] To Consider All Aspects Of Implementing Electric Vehicles As Supporting Role For The Grid (V2G) System. Integration Of Electric Vehicles Along With Other Renewable Energy Sources In Smart Grid And Their Impacts On Power Networks Is Also Studied. This Paper Presents The Concept Of V2G Technology, And Military Applications For Vehicle To Building And Vehicle To Home Concept To Cater For Emergency Demands In Remote Locations.

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I. INTRODUCTION:

With increasing economy all over the world, the environmental issues are major concern for all nations. Recent studies done by researchers show that the biggest sources of emission are transportation fleets. The climate crisis can be solved by decarbonization, energy efficiency and electrification. Decarbonization in energy production can be done by deployment of more and more renewable energy sources such as wind and solar. However solar, wind etc energy sources being intermittent introduces the problem of energy storage. Therefore, the growth of renewable energy sources is making the energy sector kore volatile as energy should be either used where it is produced or should be stored for further usage. The transportation sector can contribute towards the carbon reduction as it is inducting more and more electric vehicles. Electric vehicle batteries can be a good source of energy storage and can be integrated along with renewable energy sources for supporting the grid for energy balance. A technology called as V2G which stands for vehicle to Grid technology enables power to be pushed back to grid from the battery of electric vehicles. Penetration of more and more electric vehicles is causing the problem of electric supply fluctuations, hence integration of vehicle with RES can solve this problem to a certain extent. During the peak demand of energy, ancillary generators are used along with RES to meet the peak demand of energy. The peak demand of energy can also be met by stored energy is the batteries of EVs and during off peak hours the generated energy in the grid can be used to charge the EVs. Vehicle to Grid technology is similar to smart charging which enables controlled charging of electric vehicles such that the charged power can be momentarily pushed back to the grid to balance variations in energy production.

In recent years lot of transformation is taking place in electrical power system, one of the reasons being increase use of Electric Vehicle (EV). Most of the electric vehicles use battery as energy storage system, which can store approximately 5-40kWh of energy. In [3] the concept of vehicle to grid (V2G), vehicle to home (V2H) and vehicle to building (V2B), their classification etc. has been explained. Plug in Hybrid electric vehicles have vast scope and capabilities of energy storage. This feature of EV can be utilized for energy storage along with distribute/sell it during peak demand. In [4] the various features of V2G, its applications, advantages along with its challenges to implement it, is presented. A precise and comprehensive literature review is analyzed in [5] to consider all aspects of implementing Electric Vehicles as supporting role for the grid (V2G) system. Integration of electric vehicles along with other renewable energy sources in smart grid and their impacts on power networks is also studied. The effect of reactive power operation on the design and operation of single-phase on-board chargers that are suitable for reactive power support has been studied in [6]. It also classifies single phase as-dc converters that can be used in on-board plug-in hybrid electric vehicles based on their power transfer capabilities. A prototype on a smaller level on integrating vehicle to grid technology at the residential and

commercial level is developed in [7]. It is depicted in this prototype that with the help of TP charging module and embedded system i.eAurdino it is possible to have energy exchange between vehicle and grid optimally. During peak demand EVs can be used to return stored energy back to the grid. However, in doing so, it is necessary to determine the best charging and discharging strategy for optimum transfer of energy. Along with this issue there are other issues also like security, scalability and real time data accessibility of EVs to be addressed. The work carried out in [8] has proposed a secure V2G energy trading scheme using deep reinforcement learning and Ethereumblockchain technology which employs a deep Q network for EVs scheduling for charging/discharging. The efficacy of the proposed technique has been studied and it shows saving in EV charging cost, low ET data storage cost and increased EV owner's profit. The work carried out in [9] has represented the current challenges, prospects in V2G implementation worldwide, types, current ratings and policies related to V2G and business model. A review of Battery Management System (BMS) which is a critical component of electric and hybrid electric vehicles is presented in [10]. The aim of battery management system is to maintain the safety and reliability of the battery by state monitoring and evaluation, charge control and cell balancing.

The scope of this paper encompasses the study of usage of Electric Vehicles recently been inducted in various Units of Army for supply of power, back to Units (living accommodations, offices etc.) based on availability of number of EVs and required amount of energy replacing the usage of Diesel Generators specially in remote locations where in power cut from the Grid is on frequent basis specially during winters. And the overall saving of FOL and spare parts been used for running these Diesel Generators.

II. VEHICLE TO GRID CONCEPT:

Vehicle to Grid Technology:

Vehicle to Grid technology is a technology which has the capability to control the bidirectional energy flow between the vehicle and the electrical grid. The integration of batteries of electric vehicle into the electrical grid is called the vehicle to grid system. Any electric vehicle has battery along with power electronics making it capable to drive power requirement of home and offices to a certain extent. It has been shown by researchers that even during peak hours 92% of the total electric vehicle remain parked. During this period, on board batteries of the electric vehicles can be connected to the grid through appropriate communication devices. This can avoid load shedding and peak shaving during peak hours. The vehicle batteries can be fully charged during low demand hours. Thus, the direction of power flow between the electric vehicle and grid can be reversed as per the requirement using the smart grid technology. V2X means vehicle to everything, which includes vehicle to home (V2H), vehicle to building (V2B) and vehicle to grid services.

Concept of V2G:

V2G technology usually refers to "mobile energy", "smart energy" or "virtual power plant (VPP)", which plays an influential role in power demand adjustment of electrical grid.The V2G technology that usually refers to "mobile energy", "smart energy" or "virtual power plant (VPP)" is a new term that plays an influential role in demand adjustment

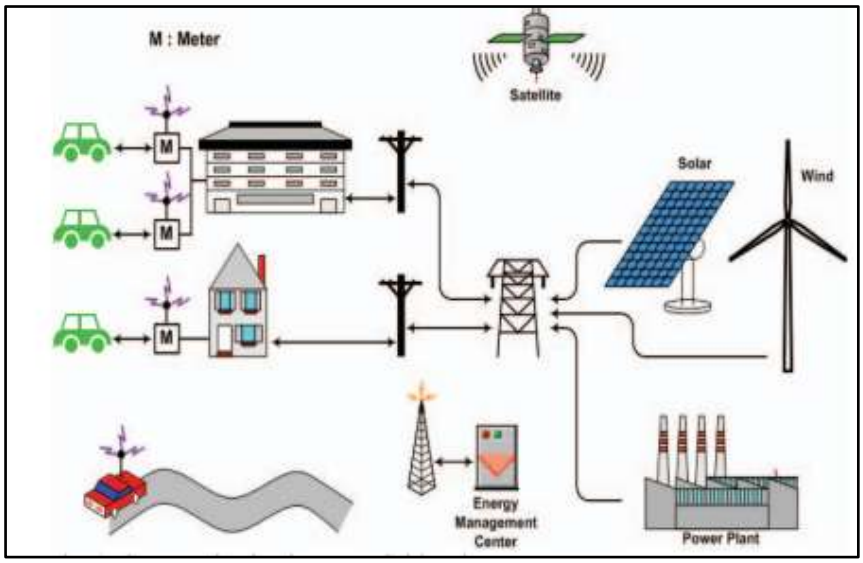

Fig. 1 Communication between Grid and PHEV [1]

The latest version of Electric vehicle ate Plug-in Hybrid Electric Vehicles (PHEV) which can be considered as a mixture of Battery Electric Vehicle (BEVs) and IC automobiles technology. This kind of electric vehicle consists of one internal combustion engine that will consume fuel as base mode and an electric engine that consumes stored electric power from rechargeable battery. Depending on the road condition the PHEV's can be switched between the electric to fuel or reverse accordingly. The on-board charger for electrical energy storage system (ESS) in PHEV's can be modified to provide additional functionalities. It is observed that most of the customer owned PHEVs remain parked during the peak load hours. This offers the opportunity to utilize their stored energy to meet peak demand while they are idle. The ESS on board can be modified to allow power flow in both direction either from the grid for charging the batteries or to supply power to the connected grid. The V2G concept stands on this principle. As shown in fig.1 V2G is a system in which PHEVs communicate with power grid to exchange power between the batteries of PHEVs and connected grid as per the situation and requirement to benefit both PHEVs and connected grid. Depending on the grid demand and charging stations locations, PHEVs coordinate this process and release their energy to the grid. In smart grid the coordinated PHEVs send signal to all vehicles one by one, send signal to the central controller that could manage the PHEVs in a facility like parking lot and a third-party aggregator to manage the located vehicle. The effects and role of a single PHEV is negligible; hence aggregators are installed which are central units used to make a chain of EVs to monitor, control and support the grid by providing the ancillary services. The aggregators satisfy the driving demand, frequency regulation and making profit by following a set of dispatching strategies.

Principle of Operation:

The overall operation of bidirectional power interface for V2G technology can be divided into two modes, namely charging and discharging mode. The structure for charging and discharging is same because the topology is bidirectional.

Fig. 2 Schematic of power interface in Charging mode [2]

Charging mode:

When the battery of vehicle gets charged, power flows from grid to battery of vehicle. Figure 2 shows the block diagram of control strategy used in charging mode. The circuit used for charging the battery consists of bridgeless Power Factor Correction (PFC) circuit to increase the power supply efficiency and it operates without input rectifier bridge. It also consists of Phase Shift Full Bridge (PSFB) converter circuit used for DC-DC conversion to convert a high voltage bus to an intermediate distribution voltage. The operation principle of bridgeless PFC is similar to that of the boost Power Factor Correction circuit. However, in bridgeless PFC low common mode (CM) noise interference and very high efficiency can be achieved as compared to conventional PFC.

For PSFB converter, a two-loop control method consisting of inner current loop and outer voltage loop is used so as to charge the battery by constant current mode and constant voltage mode.

Discharging Mode:

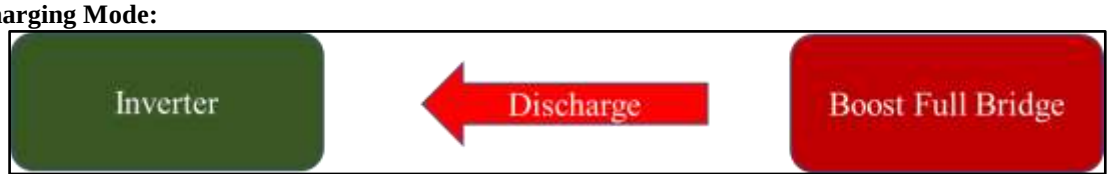

Fig. 3 Schematic of power interface in Discharging mode [2]

In discharging mode, electrical energy flows from battery of vehicle to grid/home/office. The discharging circuit consists of a full bridge boost circuit to boost the battery voltage to bus voltage. This bus voltage is connected to the grid through single phase inverter circuit as shown in fig.3 thus feeding back the energy to the grid. A single loop control method is used in DC-DC converter stage with voltage loop adopted to ensure it works in full bridge boost mode. Phase Locked Loop (PLL) is used in single phase inverter to obtain current reference of the grid voltage. The PI compensator of the current loop produces the required PWM pulses for the switches connected in single phase inverter.

III. BATTERIES USED IN EV:

Batteries and BMS used in EV:

With the emergence of vehicle to grid technologies, there is a need to standardize batteries and EV recharge infrastructure to facilitate safe transition of electrical energy with economically, efficient and environmental abiding. Various researchers are trying to optimize energy management in electrical vehicles to improve their performance. One of the energy storage management systems in hybrid electric vehicle (HEV) or EV is battery. While accelerating the vehicle receives power from battery and while brakes are applied the battery absorbs power, thus the cruse range and acceleration of vehicle depends on the battery performance. Lead acid, nickel metal hydride and lithium-ion batteries are durable, safe, high energy and cost effective. The battery energy density has been improved from 60Wh/L to 150Wh/L. The improvement in battery technologies is leading to the reduction in its cost. Lithium-ion batteries are more commonly used by various EV manufacturers because of its long range, higher density, lower cost, less charging time and non-toxicbehavior.

The battery degradation parameter is very important if the vehicle is used for travel as well as to transfer energy. Cycling and calendar aging are two main factors responsible for aging of battery. Lithium-ion batteries can be used for medium-long term application;however, lithium Sulphur has high energy density of 300Wh/L but it has low battery life. This problem can be solved by use of graphene to some extent. Still research is going on with lithium air batteries which can give energy density of 1500Wh/L.

Battery Management System (BMS) plays a vital role in HEV and EV for maintaining the battery's life. The BMS monitors the various performance parameters of the battery, it communicates with the vehicle control unit (VCU) so that the battery is not abused, overcharged, over discharged etc.

A battery management system ensures optimum use of battery energy and minimizes the risk of damage to the battery. Battery management system continuously monitors and controls the charging and discharging of the battery along with its temperature. The various tasks performed by the battery management system in electrical vehicle are data acquisition, battery state determination, electrical management, thermal management, safety management and communication.

IV. VEHICLE TO HOME:

Vehicle to Home (V2H):

The objective of vehicle to home is to deliver the energy stored in its battery through various renewable sources to home loads. This will lead to reduction in energy bills and also provide power back up as and when required. V2H composes of on Plug in Hybrid electric vehicle, bidirectional charger, home loads, small scale distributed generation, smart meter, home grid and home energy management system. This all components can be integrated into smart home concept. Smart meter in V2H concept will register data about system consumption, along with providing interface to send and receive information from utilities. V2H system can be integrated into large control system thus reducing burden on state distribution grids. In V2H concept the vehicle battery effectively transfers energy to home loads during non-travelling hours.

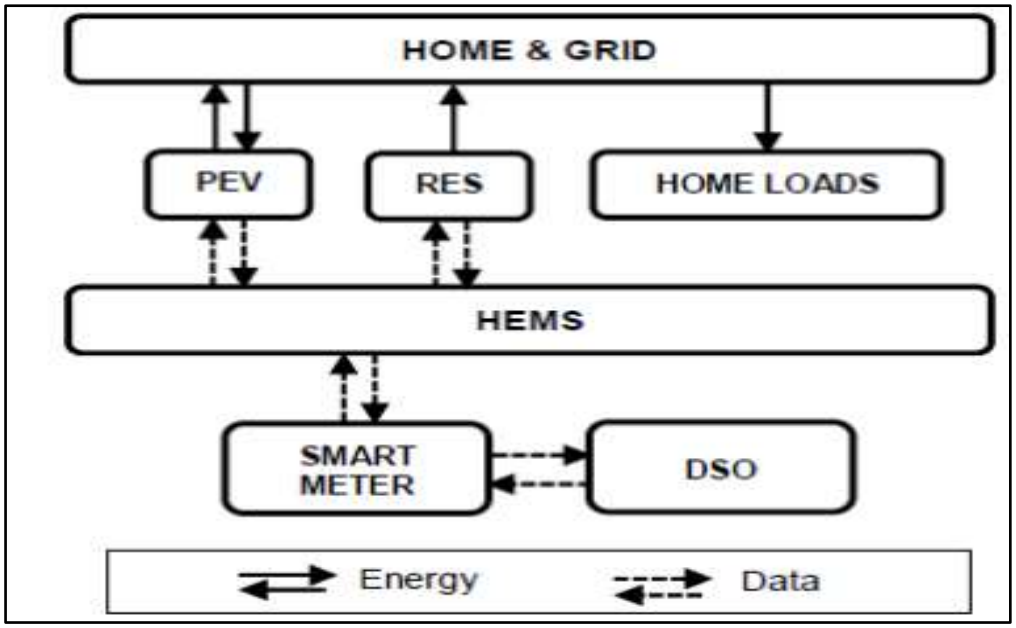

Fig. 4 Vehicle to Home Technology

Fig 4 shows the concept of vehicle to home technology which used renewable energy sources along with plug in hybrid electric vehicle to provide power to home loads through smart meter and Hybrid energy management system.

V. VEHICLE TO BUILDING:

Vehicle to Building (V2B):

Research is also going on for Vehicle to Building (V2B) technology, which is an intermediate technology between V2H and V2G, as it provides various advantages for Plug in Hybrid Electric vehicles and building owners. This technology can lead to overall saving in energy bills as the arrival and departure timings of the workers are known. V2B technology can transfer power to hospitals, hotels, universities, office buildings, shopping centers and various other critical loads. In hospitals where there are frequent power failures and DG sets also fails to supply the required power, V2B technology can help to save the life of various critical patients in ICU. The Building Energy Management system (BEMS) can play a vital role in calculating the set point of different sub systems, maintain charging and discharging rate of batteries used in EV by executing optimum algorithms

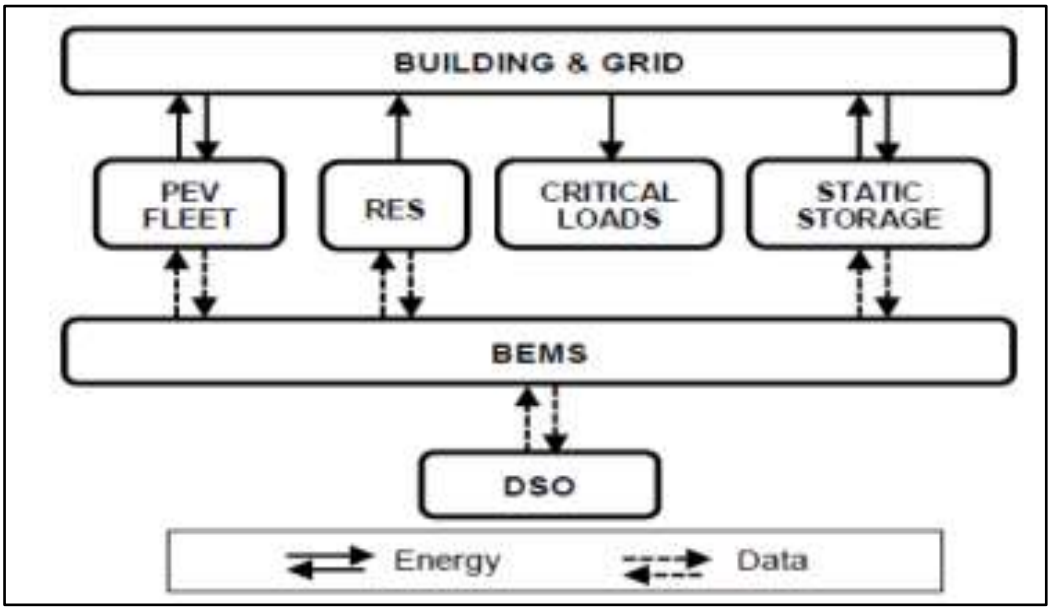

Fig. 5 Vehicle to Building Technology

Fig. 5 shows the concept of vehicle to building technology (V2B) which consists of Plug in Hybrid Electric vehicle, renewable energy source and static energy storage system. The intelligent building energy management system controls the energy exchange between loads and source.

VI. MILITARY APPLICATION:

Vehicle to Home and Building (V2H/V2B) Concept:

For the application of Vehicle to Building (V2B) concept in military stations, the main requirement would the load calculation of a military station/garrison and the availability of Plug in Hybrid vehicles. Case study for this paper has been taken as Military garrison which is not only a far-flung location but also severely affected during winters in terms of power cut due to heavy snowfall and intensive usage of Diesel Generators for a longer duration leading to excessive consumption of diesel etc.

The total average load of Military Garrison would be approx. 800 kWper day and at an average in a year the grid supply would be available for 16 hours and balance 8 hours would be catered by captive power supply i.e. using DG sets. Details of DG sets utilized under various roles with their consumption rate is tabulated below:

Table 1 DG Sets available at ZangliGarrison

S NO	GEN LOC	CAPACITY (IN KVA)	KPL (Ltrs/Hr)	CONSUMPTION FOR 8 HRS (in Ltrs/day)
(a)	MES COMPLEX	200	33	264
		125	21.5	172
		100	20	160
(b)	POWER HOUSE	125	22	176
		125	21	168
		100	19	152
		63	9.5	76
(c)	MI ROOM	82.5	12	96
(d)	UG OPS ROOM	63	12	96
(e)	MAIN OFFICE CHS	35	8	64
(f)	ASCON NODE	100	17.5	140
(g)	SIGNAL NODE	82.5	12	96
TOTAL KPL			**207.5**	**1660** **51,460 p.m.** **6,05,900 p.a.**

Calculation to identity requirement of Electric Vehicles

Based on the load that comes to be 800 kW * 8 (hours) = 6400 kWh for a day that would be2336 MWh for a year.

Tata Nexon, which is the latest launched electric vehicle uses single battery with capacity of 40.5 kWh. So, if the same vehicle of battery capacity is inducted into Indian Army, then to cater for the electric requirement at Military garrison for a period of 8 hours, 6400/ 40.5= 160 Nos of batteries would be required along with battery management system and internal supply sub station for respective loads inside the garrison. However, catering for such a large number of loads would not be possible demanding such large number of batteries, therefore identifying the critical loads are important.

Critical Loads. Some of the likely critical loads are as below:

Table 2 Critical loads at Zangli Garrison

S NO	CRTICAL LOADS	LOAD (in kWh)	NOS OF BATTERIES REQD	RATING OF DG SETS USED	CONSUMPTION FOR 8 HRS (in Ltrs/day)
(a)	UNDER GROUND OT	62.5	02	82.5	96
(b)	UNDER GROUND OPS ROOM	50.4	02	63	96
(c)	SECURITY LIs	73.5	02	125	172
TOTAL kWh		**186.4**	**06**		**364** **11,284 p.m.** **1,32,860 p.a.**

Based on table 2 above it can be seen that to cater for the critical loads for a short duration, battery of Electric Vehicles can be used in place of DG sets there by reducing not only the usage of fuel but also reducing the carbon emission. Moreover, if Electric Vehicles for 2.5 Ton, ALS and Tatra are inducted, since these vehicles will have larger size batteries i.e. batteries with more capacity thereby can cater forlarge number of loads further reducing the dependency on fuel.

Benefits of Vehicle to Garrison:

(a) Cost Reduction. It is associated with a reduction of the electricity bill and also with reduction in usage of fuels and maintenance associated with DG sets, taking advantage of the energy stored in the batteries, charged at free hours.

(b) Back-Up System. Electric Vehicles can act as a backup in the event of a power outage for critical loads. During those situations, the fleet could continue to supply the building with the most important services or to continue functioning of security lights/ security cameras until it returns to normal.

(c) Reduction of associated CO2 Emissions. By average, transportation and buildings represent about 75% of the total CO2 emissions in a service provider company and, therefore, Vehicle to Building technology can play a key role in reducing greenhouse gas emissions worldwide.

VII. Conclusion:

(a) Interest in Vehicle to Building technology has been growing and in recent years, it has become more important due to the numerous acquisitions of electric vehicles and its key paper in grid regulation, stability and carbon reduction.

(b) Technically it is possible to carry out these energy transfer processes; the possibilities of increasing growth are very promising and the benefits much greater. The new models and energy management structures must include Electric Vehicles as a very important element in energy dynamics and it is proved that is possible to apply Vehicle to Building concept.

References:

[1]. A. B. Rolufs, "Kansas City Plug-In Electric Vehicle Demonstration Project", Missouri Transportation Institute, Missouri University Of Science And Engineering.

[2]. ZiruiJia, Liyuan Chen, "Design Of A Bidirectional Power Interface For V2g Technology With Smaller Dc-Link Capacitance", International Journal Of Smart Grid And Clean Energy, Aug 2013, Pg 104-110.

[3]. Dr. G. Sree Lakshmi, G Divya, G Sravani, "V2g Transfer Of Energy To Various Applications", E3s Web Of Conference, Feb 2019, Pg. No 1-6.

[4]. PritishPani, Abhishek R Athreya, AishwaryaPanday And Hari Om Bansal, "Integration Of The Vehicle-To-Grid Technology", Conference Paper, March 2015, Pg. No 1-8.

[5]. BijanBibak, HaticeTekiner, "A Comprehensive Analysis Of Vehicle To Grid (V2g) Systems And Scholarly Literature On The Application Of Such System", Report, Focus October 2020, Pg No. 1-59.

[6]. Mithat Can Kisacikoglu, "Vehicle To Grid (V2g) Reactive Power Operation Analysis Of The Ev/ Phev Bidirectional Battery Charger", Dissertation Work, University Of Tennessee, Knoxville.

[7]. Bakul Vani, DevyaniChaturvedi, Preeti Yadav, "Grid Management Through Vehicle-To- Grid Technology", International Journal Of Recent Technology And Engineering (Ijrte), Vol. 10, Issue2, July 2021, Pg. No. 5-9.

[8]. AparnaKumari, Mihir Trivedi, SudeepTanwar, Gulshan Sharma, Ravi Sharma, "Sv2g-Et: A Secure Vehicle – To Grid Energy Trading Scheme Using Deep Reinforcement Learning", Research Article, Wiley Hindawi, 22 April 2022, Pg. No. 1-11.

[9]. Md Rayid Hasan Mojumder, Fahmida Ahmed Antara, Md Hasanuzzaman, BasemAlamri And Mohammad Alsharef, "Electric Vehicle -To- Grid Techologies: Impact On The Power Grid And Battery," Article, Mdpi, Sustainability, Oct 2022, Pg. No 1-53.

[10]. Omkar S Chitnis, "A Review On Battery Management System For Electric Vehicles", International Journal Of Scientific & Engineering Research, Vol 10, Issue 5, May 2019, Pg. No. 109-114.