Demand Side Management (DSM) Through (V2H) Vehicle to Home and (H2V) Home to Vehicle System

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Abstract:* *Electric vehicle batteries have good potential for energy storage capacity and it can potentially utilize also as backup power supply for home loads during peak load, load shedding or blackout. Additionally, solar energy can be utilized to charge plug-in electric vehicles (PEVs) to further enhance the backup power for home loads. In this work, a microcontroller is utilized for efficient power management and utilization of V2H and H2V. It imitates the decision-making process of charging/discharging of the PEV battery through priority decision making of power management and emergency backup power supply of a typical home in developing countries like India.

Index Terms* *- Electric Vehicle; Load Shedding; V2H; H2V; Emergency Backup Power; Demand Side Management

I. INTRODUCTION

There is a global interest in decreasing CO2 emissions and in understanding the strategy of providing cleaner energy with low cost. According to India Environmental Protection Agency, in 2014, the transportation sector represents 26% of greenhouse gasses (GHG) emissions all over the India. These challenges have directed the automotive industry towards bringing forward the plug-in electric vehicle (PEV) into the market. The use of electric vehicles is an initial step towards the reduction of CO2 emission. The U.S. Department of Energy report shows that there were more than 1.2 million electric vehicles at the end of 2015 and they had estimated that there would be 15 million electric cars by 2020 and 100 million by 2030. Moreover, PEVs have enormous energy storage capacity. Thus they can also act as residential battery storage systems when a grid outage or load shedding happens. The vehicle to home (V2H) capability describes a scenario that PEVs not only take power from the grid to charge the vehicle but also give backup power to the home and other islanded load during an interruption load shading, similar to a stand-alone power emergency generator. Utilizing a PEV means that the vehicle energy is supplied from the grid to charge the battery. Thus, it increases the extra load on the grid, therefore increasing the number of conventional power plants to feed this new demand. This creates another problem which adds to, not minimizes the problem of pollution or fossil fuel depletion. Therefore charging the PEVs by grid due to the uncertain period of charging causes a sudden pressure on the power grid. This type of energy consumption on a local scale can lead to network instability. Therefore, reducing the power fatality and optimizing the main power grid load factor are the new interests of researchers Thus, optimizing the utilization of PEVs and smart charging become the most common goal of researchers. In India over 85% of the households in five of the six states (Bihar, Jharkhand, Madhya Pradesh, Uttar Pradesh, West Bengal, and Odisha) considered in the had electric Power for less than 8 h (even for less than 50 W load) or no electrical energy at all for all for the whole day. In general Lead-acid battery based UPS/inverter system is used at home as a standby the power supply in developing and under developing countries. It has low power/energy capacity (2 kWh to 5 kWh). Typically, one or two lead-acid batteries are used for this purpose (12 V, 150 Ah-200 Ah). In comparison to that system, the batteries of PEV has enormous energy storage capacity (above 35 – 40 kWh). This capacity can be easily utilized during load shedding and blackout. Typical drive patterns according to the vehicle usage are also used to access its availability. Proposed V2H also introduces the solar PV based charging of vehicle. Slow DC charging and fast DC charging regimes are applied besides constant voltage and constant current charging modes during the daytime to reduce the dependency of EV to the electric power grid. Thus low power demand from the electric power grid reduces the CO2 emission of the conventional power plant. To reduce the CO2 emission and to achieve maximum cost benefit

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The National Electric Mobility Mission Plan 2020

The National Electric Mobility Mission Plan 2020 is one of the most important and ambitious initiatives undertaken by the Government of India that has the potential to bring about a transformational paradigm shift in the automotive and transportation industry in the country. This is a culmination of a comprehensive collaborative planning for promotion of hybrid and electric mobility in India through a combination of policies aimed at gradually ensuring a vehicle population of about 6-7 million electric/hybrid vehicles in India by the year 2020 along with a certain level of indigenization of technology ensuring India's global leadership in some vehicle segments. It is a composite scheme using different policy-levers such as:

1. Demand side incentives to facilitate acquisition of hybrid/electric vehicles
2. Promoting R&D in technology including battery technology, power electronics, motors, systems integration, battery management system, testing infrastructure, and ensuring industry participation in the same
3. Promoting charging infrastructure
4. Supply side incentives
5. Encouraging retro-fitment of on-road vehicles with hybrid kit

II. ELECTRIC VEHICLES

An electric vehicle, also called an electric drive vehicle, uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels or an electric generator to convert fuel to electricity. EVs include road and rail vehicles, surface and underwater vessels,

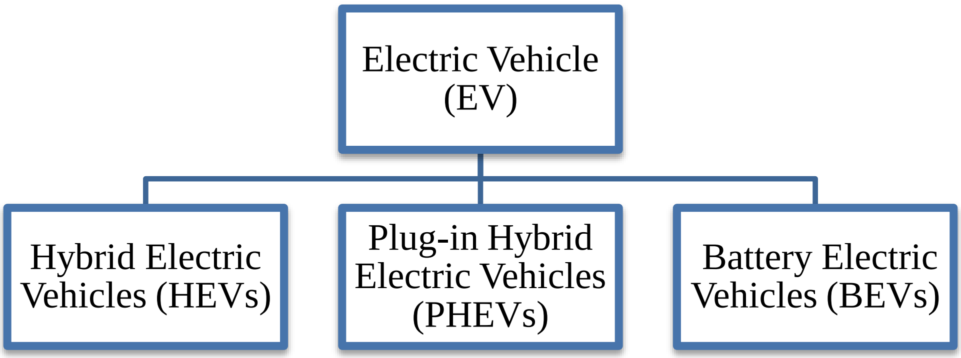

Fig 1 Electric Vehicle Classification

III. DEMAND SIDE MANAGEMENT USING ELECTRICAL VEHICLES

A. Demand Side Management

For electric utility, Demand Side Management is defined as "the planning, implementation, and monitoring of distribution network utility activities designed to influence customer use of electricity in ways that will produce desired changes in the load shape", which includes peak clipping, valley filling, load shifting, strategic conservation, strategic load growth, and flexible load shape. There are two components included in Demand Side Management: Energy Efficiency (EE) and Demand Response (DR). EE is designed to reduce electricity consumption during all hours of the year; DR is designed to change on-site demand for energy in intervals and associated timing of electric demand by transmitting changes in prices, load control signals or other incentives to end-users to reflect existing production and delivery costs . The utility and customer cooperatively participating in DSM will provide the benefits to the customer, utility, and society as a whole. It was implemented by changing on-site demand for energy in intervals and associated timing of electric demand by transmitting changes in prices, load control signals or other incentives to end-users to reflect existing production and delivery costs.

Table 1: DSM Benefits to Customer, Utility and Society

Customer Benefits	*Societal Benefits*	*Utility Benefit*
Satisfy electricity demands	Reduce environmental degradation	Lower cost of service
Reduce/stabilize cost	Conserves recourses	Improve operating efficiency
Improve value of service	Protect global environment	Flexibility of operation
Maintain/ improves life style	Maximize customer welfare	Reduce Capital needs

B. Framework of using Electrical Vehicle for DSM

Demand side management based on eclectic vehicles considers batteries in EVs as either generation resources or regular load for the buildings via bidirectional power transfer through energy exchange stations, such as smart garages, at certain periods of time. It could increase the flexibility of the electrical distribution system operation. Demand side management operation in customer side will improve the reliability of the distribution system, provide extra economic benefits to the vehicle owners, and reduce the home or building electricity purchase cost. Especially, when renewable energy resources, such as wind or solar, are integrated in smart grid, the batteries in EVs can function as energy storage system to reduce the influence of weather conditions.

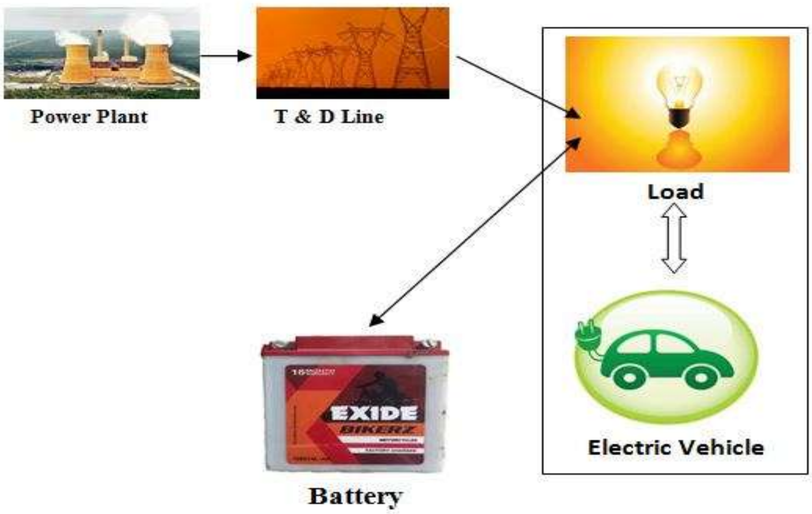

Fig 2 : Framework of using EVs for DSM

IV. IMPLEMENTATION OF DSM:

A. G2V Option

Without availability of significant and reliable storage of energy, maintaining grid stability and reliability under the growing electricity demand is a complex problem. Thus energy storage system is one of the major applications in support of DERs. Utilities typically use batteries to provide an uninterruptible supply of electricity to power substation switchgear and to maintain backup power systems. However, there is an interest that goes beyond these applications by performing load leveling and peak shaving with battery systems that can store and dispatch power over a period of many hours. G2V provides the option to utilize EV's usefulness as an energy storage system. The G2V option can be used to charge electric vehicles at reduced cost when the power system load is reduced and generation capacity is abundant, such as during night time. The development of smart charging makes it feasible to implement the optimal charging to level or shift load profile curve as needed.

B. V2H Option

From the discussion above, recent research on the feasibility of V2G is based on the assumption of large-scale penetration of EVs, which is envisioned on a 15-30 year time horizon in the most optimistic scenarios. As a more near-term application of V2G, Vehicle-to-home (V2H) operation is defined as the option of exporting electrical power from a vehicle battery into a building connected to the distribution system to support loads. Due to early adopters, the availability of electrical vehicles in major cities may create a critical mass of vehicles for aggregated use to be available 5-10 years from now. With the introduction of smart garage, which represents an interface between the transportation network and electric power system, the vehicle charging/discharging infrastructure and control system can be available widely making the proposed V2H idea viable and economically attractive.

V. SYSTEM ARCHITECTURE

A. Hardware Description

Hardware is prototype model which consist of following circuits

i. Rectifier and controller circuit
ii. Inverter circuit
iii. Synchronising circuit
iv. Batteries as Electric vehicle and Emergency Back up

Proto type hardware model is shown in figure 3 and circuit diagram is shown in figure 4 and figure 5 describes Block diagram of Proto type hardware model.

Demand side management is implemented by means of V2H / G2V using this proto type in following modes of operation (operation modes of proto type)

Mode I - Grid to Home (G2H)

This is normal operating mode in which supply is taken from utility and supplied to home load includes Charging of Vehicle battery, Emergency battery and home load during off peak condition

Mode II - Vehicle to Home (V2H)

In event of peak load condition supply from grid is cut off automatically (in this proto type it is done manually using Switch) and demand is fulfilled by Vehicle battery.

Mode III - Home to Vehicle (H2V)

During off peak period vehicle is charged.

Mode IV - Emergency Back Up

In this mode, supply from grid is not available or during peak load duration and electric vehicle is not present in parking lot or discharged, emergency battery fulfils the required load.

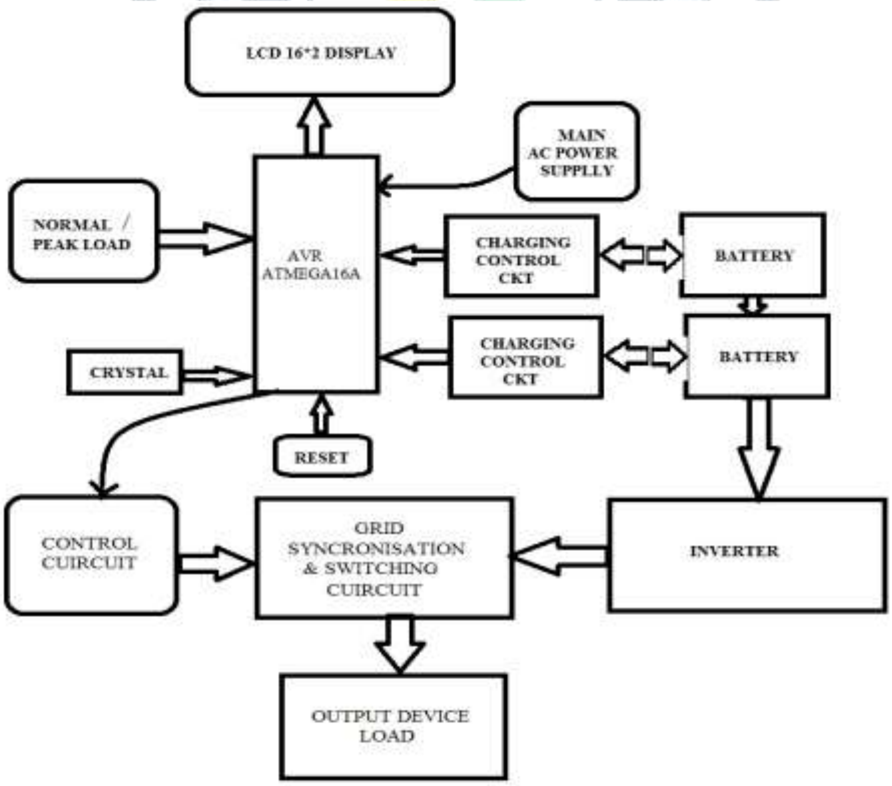

Fig 3 Block diagram of Proto type hardware model

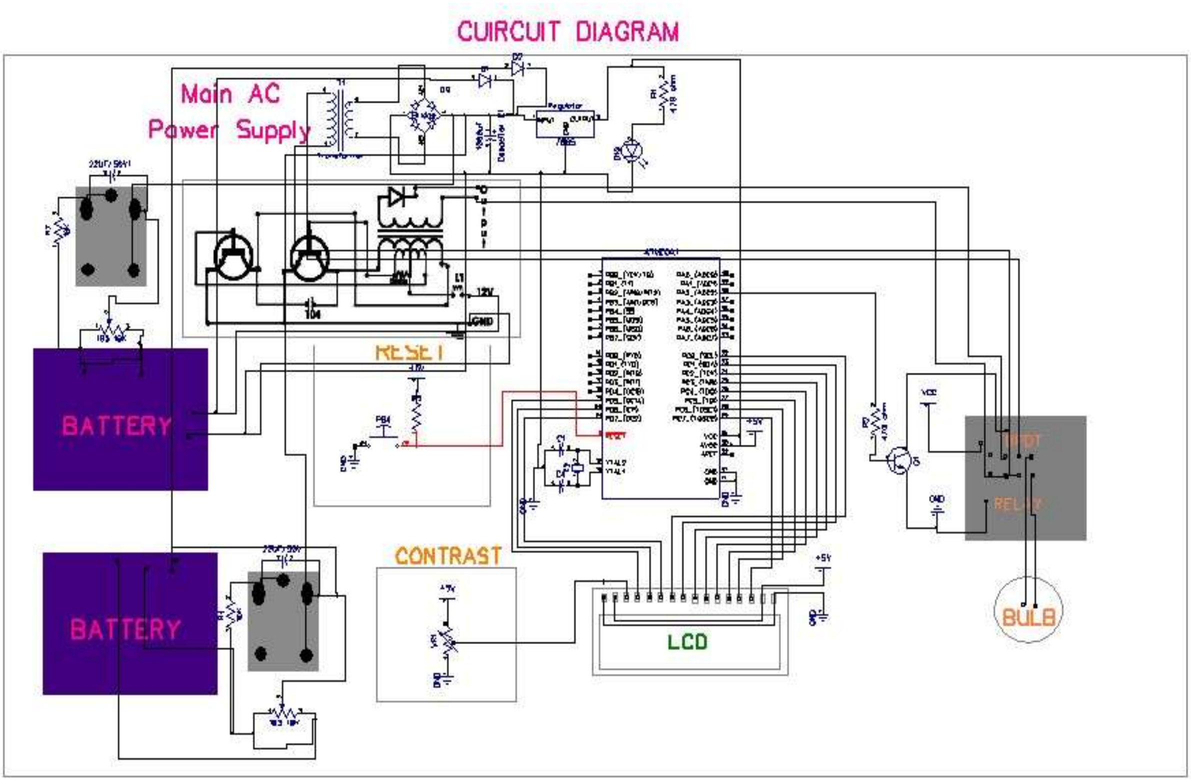

Fig 4 Circuit Diagram of Proto type hardware model

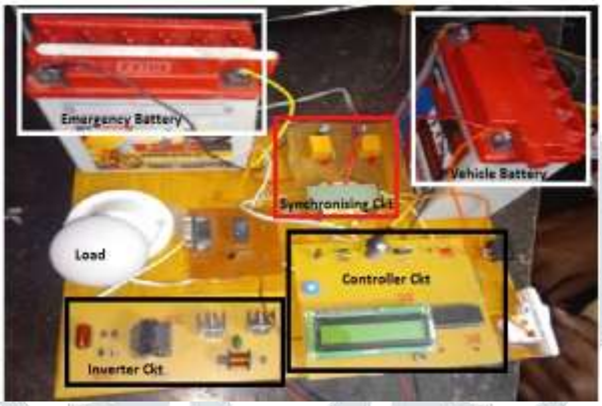

Fig 5 Proto type hardware model

VI. CONCLUSION

This paper has proposed a V2H/V2G system that can be implemented for Demand Side Management. Hardware for this work is proto type which is analogues to actual Electric vehicle Operation for V2H & H2V concept. Proto type is operated in four modes which fulfils the objective of implementation Demand Side Management

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