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Efficient Consumption of Renewable Energy using Vehicle to Grid Technology.

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Abstract—An electric vehicle (EV) charge-discharge management framework for the effective utilization of photovoltaic (PV) output through coordination based on grid energy management system (GEMS). In this proposed framework, the GEMS determine an EV charge-discharge plan for reducing the residential operation cost and PV curtailment without disturbing EV usage for driving, on the basis of voltage constraint information in the grid provided by the GEMS and forecasted power profiles. Then, the GEMS controls the EV charge-discharge according to the determined plan and real-time monitored data, which is utilized for mitigating the negative effect caused by forecast errors of power profiles. The proposed framework was evaluated on the basis of the Japanese distribution system (DS) simulation model.The simulation results show the effectiveness of our proposed framework from the view point of reduction of the residential operation cost and PV curtailment

Keywords— Grid energy management system, Japanese distribution system, PV curtailment, Residential operation cost etc

I. INTRODUCTION

With environmental and climate change issues and legislation, rising energy costs, concerns about energy security and fossil energy reserves, and growing consumer expectations, plug-in electric and hybrid vehicles (PEVs) are appearing worldwide . Even though PEVs have not been widely adopted, in part because of technical limitations, social obstacles, and cost compared to conventional internal combustion engine (ICE) vehicles , PEVs have an advantage compared to self- contained hybrid electric vehicles (HEV) and ICE vehicles: a connection to the electric power grid. PEVs can serve in discharge mode as vehicle-to-grid (V2G) devices and in charge mode as grid to- vehicle (G2V) devices . The V2G concept has attracted attention from grid operators and vehicle owners. However, convenient recharging and available electricity supplies are necessary to realize the benefits of V2G capabilities.

Here reviews V2G/G2V technology and requirements, economic costs, challenges, and strategies for V2G interfaces of both individual PEVs and vehicle fleets. For purposes of the paper, “V2G” is used generically for both V2G and G2V energy flows. A range of proposed V2G concepts, services, benefits, components and power-flow technologies, individual and aggregated structures, and charging/recharging strategies are discussed. The context is PEVs whether purely electric or hybrid. It will be shown that V2G concepts that allow benefits to be shared among grid operators and vehicle owners are likely to accelerate PEV deployment. Controls and usage patterns must be evaluated for short-term and long-term impacts on battery life and utility distribution networks. PEVs can behave either as electric loads or as generators. The charging behavior of PEVs is affected by different factors such as the type of connection (unidirectional or bidirectional), geographical location, the number of PEVs being charged in a given vicinity, their charging voltage and current levels, battery status and capacity, charging duration, etc. Each vehicle can be contracted individually or as part of an aggregation.

Aggregators collect PEVs into a group to create a larger, more manageable load for the utility . These groups can act as distributed energy resources to realize ancillary services and spinning reserves. Cooperation between the grid operator and vehicle owners or aggregators is important to realize the highest possible net return. Many researchers have investigated potential benefits and costs issues of V2G concepts V2G- capable vehicles offer a possible backup for renewable power sources including wind and solar power, supporting efficient integration of intermittent power production .V2G systems can provide additional opportunities for grid operators, such as reactive power support , active power regulation, load balancing by valley filling , peak load shaving , and current harmonic filtering.

II. BLOCK DIAGRAM

The A virtual impedance based control strategy to reduce

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the SHC in the front- end dc–dc converter of the two-stage inverter. The mechanism of suppressing the SHC as well as the virtual impedance form is analyzed. Here, presents a closed-loop parameter design method which can determine the satisfactory region of the virtual resistor and the voltage loop crossover frequency for the case in which the virtual impedance is a resistor, indicating that adopting a virtual resistor is not beneficial to increasing the voltage loop crossover frequency.

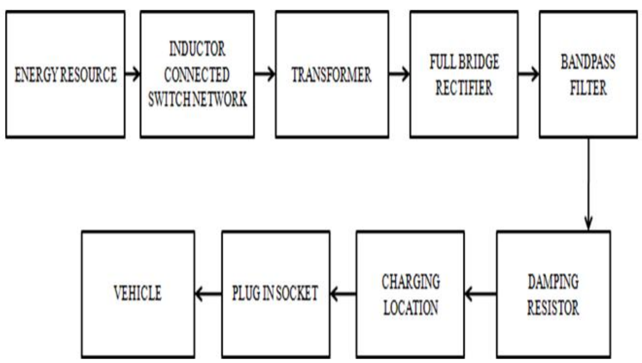


Fig 1 .Proposed System Block Diagram

To achieve a higher voltage loop crossover frequency, an inner inductor current feedback through the band pass filter (BPF) is put forward, and a damping resistor is added into the BPF in order to improve the system stability margin. The proposed control strategy cannot only significantly reduce the SHC in the front- end dc–dc converter but also improve the dynamic performance of the front-end dc–dc converter effectively while guaranteeing the stability of the converter.

A. FRONT END DC-DC CONVERTER

A virtual resistor in series with the filter inductor Lf can help reduce the SHC in the front-end dc–dc converter effectively, the magnitude of the uncompensated loop gain in the low-frequency region will be significantly lowered, further adversely affecting the increase of the voltage loop crossover frequency. The highest voltage loop crossover frequency is still quite low, being only about f2nd/16, and it can be expected that the dynamic performance is relatively poor during load transient.

DC voltage is given as input to the circuit. Inverter converts the DC voltage to AC to give AC input to the transformer. At the primary side of the transformer there is circulating current loss (due to switching activity of the MOSFET).AC voltage is again converted into dc by using rectifier circuit. Here voltage stress occurs. By using a BPF harmonics, and stress are reduced.

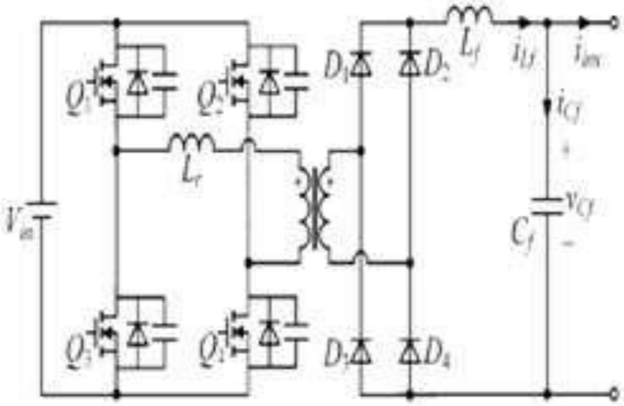


Fig.2 Front End DC-DC Converter

B. ENHANCED FRONT END DC-DC CONVERTER

Adding a virtual resistor in series with the filter inductor Lf can help to reduce the SHC in the front-end DC– DC converter effectively .A new front-end DC-DC converter for fuel cell systems that replaces the former front-end DC-DC converter in such a way that the DC-AC converter of the solar project can be reused and that the effort of designing a new DC-AC converter can be spared.

The assignment was to realise a four way interleaved boost converter for a 2 kW fuel cell system. The power should be equally distributed over all four branches. One should be able to connect the existing DC-AC converter of the EYO-2000 platform to the new DC-DC converter or to the series connection of the new DC-DC converter and the altered isolation stage.

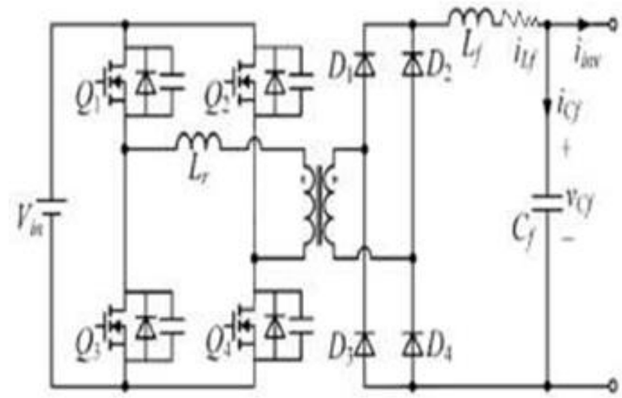


Fig. 3 Resistor Added Front End DC to DC Converter

C. ELECTRIC VEHICLE CHARGING INFRASTRUCTURE

Recent debates show that there also is a need to discuss which types of agents should be authorized to provide EV charging infrastructure, which theoretically could be considered a fully regulated monopoly or a commercial activity. One could imagine three general possible ownership structures, namely

(i)similarly regulated entities,

(ii) commercial actors and private investors (including retailers or ag- gregators),

(iii) Public entities, maybe even offering free access. Today, all forms of ownership can be observed: In Germany, more than 50 charging stations (VKU, 2012). In Florence, Italy, SILFI SPA, the public lighting company, operates more than 100 charging stations. But also private investors are entering the market, often backed-up by pilot- project initiatives and corresponding public funding (Pike Research, 2012).

Recognizing that “a question of great importance concerns the degree of regulation needed for an effective and efficiently functioning market for charging infrastructure”, Eurelectric (2010c) describes four possible market models for public charging infrastructure23

1) Integrated infrastructure market model:

The charging infrastructure is fully integrated into the DSO’s assets and the commercial relationship stays between customers and retailers using this infrastructure. The main difference to a conventional electricity contract is that customers are allowed to charge at any location within the charging network managed by the DSO while still receiving one bill from the retailer. Charging infrastructure would be collectively financed with costs being reflected in tariffs for grid usage.

2) Separated infrastructure market model:

EV charging infrastructure is conceived as a new, separate and independent step in the value chain, and therefore a new agent, the “charging infrastructure operator” would be created. This new operator still is a special distributor that is independent of retailing activities, and infrastructure falls under rules concerning unbundling. Retailers have access to all EV charging sockets of all charging infrastructure operators. Charging infrastructure would be financed based on the “user-pays” principle.

3) Independent e-mobility market model:

An “independent e-mobility provider” would install a proprietary network of EV charging sockets and provide electricity bundled with other services (incl. the charging). Charging infrastructure would be financed based on the “user-pays” principle.

4) Spot operator owned charging stations market model:

Charging stations and selling of electricity are conducted by parking spot owner or operator who does not directly on the spot but rather has the right or license to operate it. Multiple market players together with existing players like retailers and DSOs (outside their regulated activity) would compete. Charging infrastructure would be financed based on the “user-pays” principle.

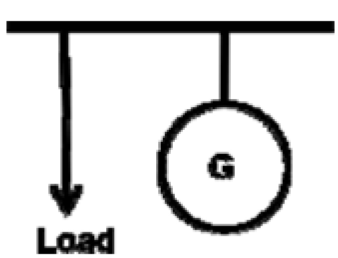


Fig. 4 Modeling of Electric Vehicles

D. MODELING OF ELECTRIC VEHICLES

To carry out the study EVs have been modeled as a combination of load and a generator as shown in Figure. The load in Figure 3 signifies the charging of electric vehicles and is calculated based on the number of electric vehicles charging at any particular hour. The generator part are the vehicles connected to the system, which are capable of providing support to grid. In case of generator, the capacity support that can be provided will depend upon the state of charge of batteries. The reliability of generators in this case has been considered to be 100%. This is a valid assumption as failure of one vehicle will not have any major impact on the capacity of the fleet of vehicles.

E. CHARGING/RECHARGING FREQUENCY AND STRATEGIES

Battery size and capacity are important factors in determining the initial price for a PEV. Reduction in battery weight also increases overall vehicle efficiency. Operating costs and emissions are reduced low-capacity PEVs. When battery size rises from a PEV7 (a hypothetical vehicle with nominal 7-mi electric-only range) to a much more battery-intensive PEV60, there will be about a 10% increase in average energy needs (in terms of Wh/km), and an 8% increase in effective fuel consumption Lower energy can be an advantage for utilities wanting to limit on-peak PEV impact to minimize costs. High power charging was found to increase peak power demand by about 50% (home-work) to 62% (anywhere). Each plug-in hybrid electric vehicle (PHEV) could add 560–910 W at peak times to the system load depending on the size of the charger and the charging scheme. It was reported that in a U.S. simulation study, the availability of charging stations at workplaces increases the daily electric energy use of PHEVs by 24% to 29%. The economic costs, emissions, and distribution system impacts of the V2G concept depend on PEV penetration and charging/ discharging strategies. Large-scale unregulated deployment can have a detrimental and destabilizing effect on the electric grid. The impact of large-scale deployment of PEVs on the California grid is summarized in Fig. As penetration increases, so does the total annual electrical energy demand [see Fig.]. And, PEV peak power demand significantly increases the total peak requirements [see Fig.]. Thus, a high level of PEV penetration could disrupt distribution systems, depending on the charging power and schedule.

1) Uncoordinated Charging/Discharging

Uncoordinated charging indicates that PEV batteries either start charging immediately when plugged in or start after a user-adjustable fixed delay, and continue charging until they are fully charged or disconnected. This charging system is most likely at Level 1. Uncoordinated charging operations tend to increase the load at peak hours and can cause local distribution grid problems such as extra power losses and voltage deviations that affect power quality. They may lead to overloads in distribution transformers and cables, increased power losses, and reduction in grid reliability and cost.

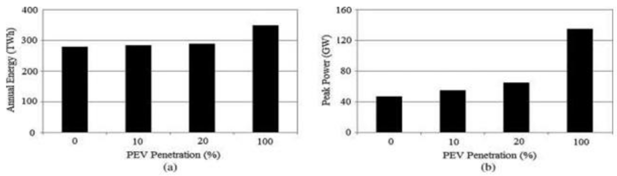


Fig. 5 Impact on California's (a) annual electrical energy demand and (b) peak power demandfor varying levels of PEV penetration from the state's 30 million light duty vehicles

A simulation study on impacts of uncoordinated PEV charging on the daily peak power and base consumption was carried out in the Danish island of Bornholm, based on 2200 vehicles . The aggregated load in the simulated system is shown in Fig. 5, and peaks increase substantially. Some utility companies offer a dual tariff (cheap night rates) to PEV owners as a way to reduce peak load . When the user agrees to an adjustable fixed delay, owners can wait for cheap off-peak prices. Off-peak charging takes place during the night when the electricity demand is low and generation is mostly base load . Van Vliet et al. showed that off-peak charging would result in a 20% higher, more stable base load and no additional peak load based on the Netherlands national grid. Thus, no additional generation capacity would be required . In the U.K. case study , off-peak charging was shown to increase electricity consumption throughout the night with no impact on the daily peak load. In fact, when PEV nightly charging is added, the load factor improves as some portions of the off-peak valley are filled.

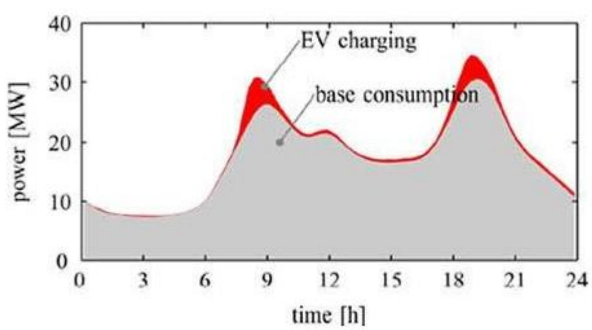


Fig. 6 System base load and total aggregated PEV (2200) charging using uncoordinated direct charging of all the PEVs.

Coordinated Smart Charging/Discharging

Coordinated smart charging and discharging can optimize time and power demand and reduce daily electricity costs, voltage deviations, line currents, and transformer load surges. It can also flatten the voltage profile of a distribution

node . Incremental investments and high energy losses can be avoided, and wasting renewable energy and network congestion prevented. Coordinated charging management concepts can be divided into centralized and decentralized approaches.

The decentralized approaches let the PEV optimize its charging behavior based on a price signal broadcast. The drawback of this approach is that the PEV needs to collect and store the trip history. The centralized approaches focus on a centralized unit that directly controls PEV charging.

F. BENEFITS OF V2G SYSTEMS

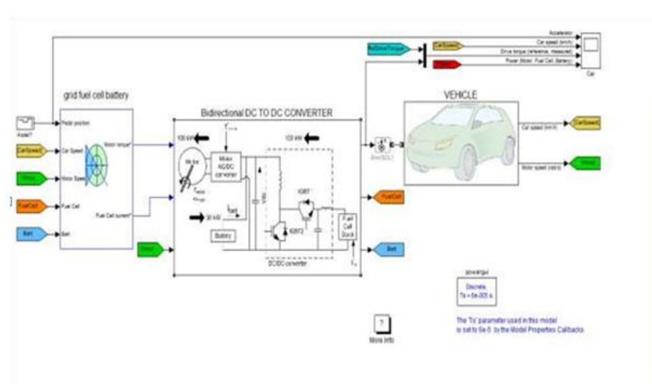
Studies have shown that PEVs could provide ancillary services such as voltage and frequency regulation (primary, secondary, and tertiary control) , spinning reserves, reactive power support, peak shaving, valley filling (charging at night when demand is low), load following, and energy balance . V2G systems can reduce overall costs of service and prices to customers, and selling energy to the grid could improve load factors and reduce emissions They could also replace large-scale energy storage systems.

1) Environmental Advantages on the Grid

A number of existing studies have shown that PEVs have emissions benefits over HEVs and conventional vehicles, even accounting for generation emissions. Studies the Northwest Power and Conservation Council determined that CO2 emissions would fall significantly if PEVs replace conventional ICE vehicles. When the V2G concept is added, PEVs could offer further environmental benefits and directly reduce greenhouse gas (GHG) emissions . On a per vehicle basis, CO2 emissions are projected to drop from about 6.2 tons per year to fewer than 4 tons . GHG emissions linked to driving depend on the electricity generation fuel type. If electricity is produced from polluting sources, the environmental advantages of PEVs are more limited: GHG emissions range between 0 g/km for renewables and 155 g/km for lower coal-based plants . If PEVs charge their batteries from low quality coal-fired sources, their emissions may be 7–21% lower than HEVs . Even when powered entirely by coal-fired electricity, PEVs still produce around 25% fewer GHG emissionsthan ICE vehicles . Estimated reductions for PEVs range from 15% to 65% in another study that examined low-carbon electricity sources.

2) Ancillary Services

Ancillary services are necessary in the power system for maintaining grid reliability, balancing supply and demand, and supporting the transmission of power from seller to purchaser. A bidirectional V2G concept can provide higher quality ancillary services than are currently available:



- quick frequency and voltage regulation

- load leveling and peak power management
- effective spinning reserves.

Aggregators are expected to collect PEVs into a group to create a larger, more desirable load for the utility.

3) Renewable Energy Supporting and Balancing

PEVs can be combined with renewable energy to buffer and store energy generated by intermittent wind and solar plants. For example, peak solar radiation occurs a few hours before peak energy draw in many markets If the energy injected to the grid from renewable resources is too high, centralized power plants must decrease their production to restore balance or the distributed generator units must be curtailed. Vehicles can help match consumption and generation by discharging and charging so the utility does not need to decrease the power output. PEVs also can store excess renewable energy. This stored energy can be used for driving needs or to provide power to the grid at a later time . V2G thus increases the flexibility for the grid to better utilize intermittent renewable sources.

III. SIMULATION RESULTS

1) FRONT END DC TO DC CONVERTER USING BAND PASS FILTER

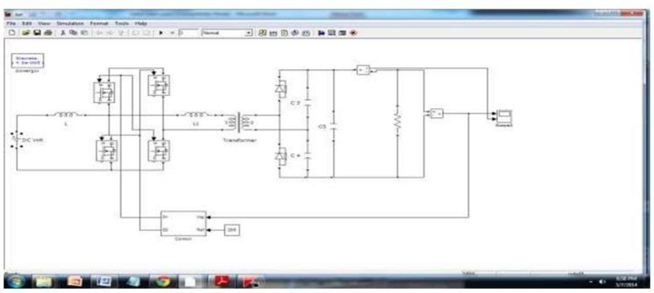
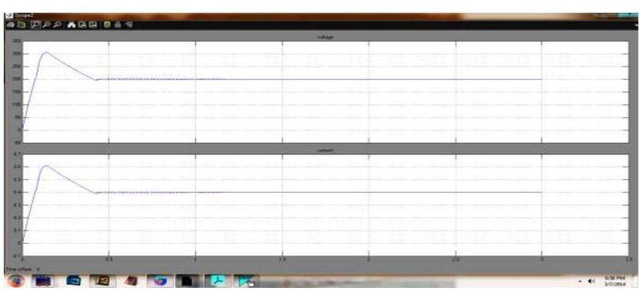


Fig. 7 Circuit Diagram for Front End DC to DC converter using Band pass filter

2) FRONT END DC TO DC CONVERTER USING BAND PASS FILTER

Fig.Simulation for Front End DC to DC converter using Band pass filter



3) SIMULATION RESULT FOR VEHICLE TO GRID

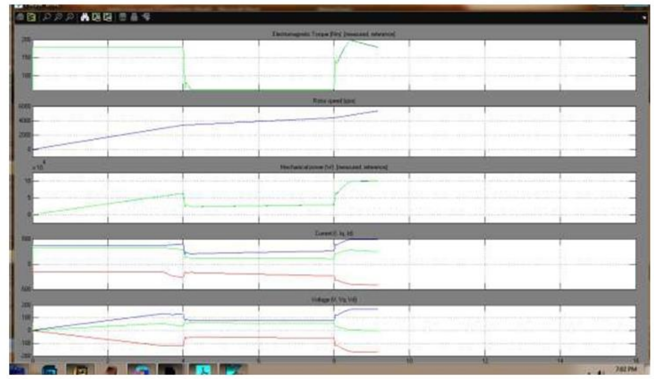


Fig 8 Simulation Result for Vehicle

IV. CONCLUSION AND FUTURE SCOPE

Thus, proposed a SHC is generated in the front-end dc–dc converter due to the instantaneous output power of the inverter pulsating at twice the output voltage frequency, which will lead to increased current stress in power switches and additional losses in both power switches and magnetic components. In order to increase the voltage loop crossover frequency, a control strategy with a BPF incorporated into the inductor current feedback path was proposed in this paper and a damping resistor was added into the BPF to improve the system stability margin. Finally, voltage stress, circulating current loss and second harmonic current are reduced by the use of band pass filter and also provide superior dynamic performance for Electric Vehicles.

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