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Power Interchange Analysis for Reliable Vehicle to Grid Connections

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***Abstract*—Due to the progressively growing energy demand, electric vehicles (EVs) are increasingly replacing unfashionable vehicles equipped with internal combustion engines. The new era of modern grid is aiming to unlock the possibility of resource coordination between EVs and power grid. The goal of including vehicle-to-grid (V2G) technology is to enable shared access to power resources. To define such initiative, this article investigates V2G technology considering the bi-directional power flow between EVs and the main grid. The article addresses a new framework algorithm for energy optimization that enables real-time decision making to facilitate charge/discharge processes in grid connected mode. Accordingly, the energy flow optimization, communications for data exchange and local controller are coupled to support system reliability for both power grid and EV owners at parking lot sites. The local controller is the key component that collects the EV data for decision-making through real-time communications with EV platforms. The main responsibility of this controller is managing the energy flow during the process of real-time charging without impacting the basic functionalities of both grid and EV systems. Finally, a case study of modified Institute of Electrical and Electronics Engineers (IEEE) 13 node test feeder is proposed to validate the impact of energy flow optimization using V2G technology. This visionary concept provides improve the grid scalability and reliability to grid operations through accessing EV power storage as a complementary resource of future energy systems.**

INTRODUCTION

NOWADAYS, power grid utilities are upgrading their communication networks to formulate a new industry era of smart grid distribution that can improve utility provider operations [1]. The integration of vehicles with power grid has triggered a dramatic need for critical infrastructures that employ features beyond current old-style power grids. In addition, the utility revolution energies step-by-step with the rapid growth in demand causing an urgent need to advance communication infrastructure. These challenges need to adopt new technologies to achieve resilient system operations that can support new power grid services. Therefore, industrial market and vehicles manufacturing are competing to develop an automated smart vehicle considering many challenges including connectivity and economic side. For example, the USA government allocated 2.4 billion dollars for investigating the future of V2G technology along with new battery storage products [2]. For smart grid domain, V2G technology also receives high attention for the critical nature of their networking service and precise data abstracted from various sensors [3]. However, the rapid growth of EVs penetration is anticipated to be an additional driver to modernize the current smart power grid models. For example, the ability to access EVs storage for charging/discharging allows the grid system to increase the overall storage capacity with direct access to EVs especially when located at parking sites [4]. Nevertheless, this integration requires additional features for managing power exchanges and defining the necessary communication network entities. From a power management perspective, the V2G technology requires additional load balancing when connected to the electric power system to facilitate bi-directional peak demand reserves. Since individual EV has a limited contribution to support the main power system, V2G technology bridges all connected EVs with the power system through shared information platform that delivers a collective EVs status to the energy management system (EMS) [5]. The industry market is connected through EMS to evaluate the changes in demand/supply and subsequently decides the electricity pricing [6]. Therefore, ancillary services of industry market require more information about connected vehicles to estimate the whole available electrical capacity throughout the grid. From a technical perspective, ancillary services require around 1 MW of electricity to control and perform dispatch at each time interval. Therefore, 100-200 electric vehicles may consume less than 10 kW of available output capacity to provide 1 MW block of electric capacity back to the grid [7].

A cooperative scheme is a key enabler for grid-connected EVs to support the grid load, improve service quality, control grid frequency, and reduce generation cost. However, there are other numerous features in utility power grid where energy storage and V2G can be an active portion to improve grid capacity. For example, the demand response management (DRM) is used to re-balance the power system when the load demand exceeds the peak levels within any time frame. Considering our proposed model, this DRM can help to coordinate and control charge/discharge process in each vehicle connected with power grid [8]. Alternatively, V2G technology can be used as a new style of portable energy storage that can facilitate to meet the power grid operation requirements. Moreover, EV batteries need to support various bidirectional charge/discharge operations and connect to data collection interfaces for on-time status monitoring of resources in the distribution networks [9]. Therefore, any EV battery is recognized as a transportable energy storage that can be used to support demand response services and provide EV owners with payback value [10]. Future energy storage is expected to provide a constant reliable power without any disruption during the peak demand hours or fluctuations in frequency/voltage. From networking perspective, there is a need to develop new components that

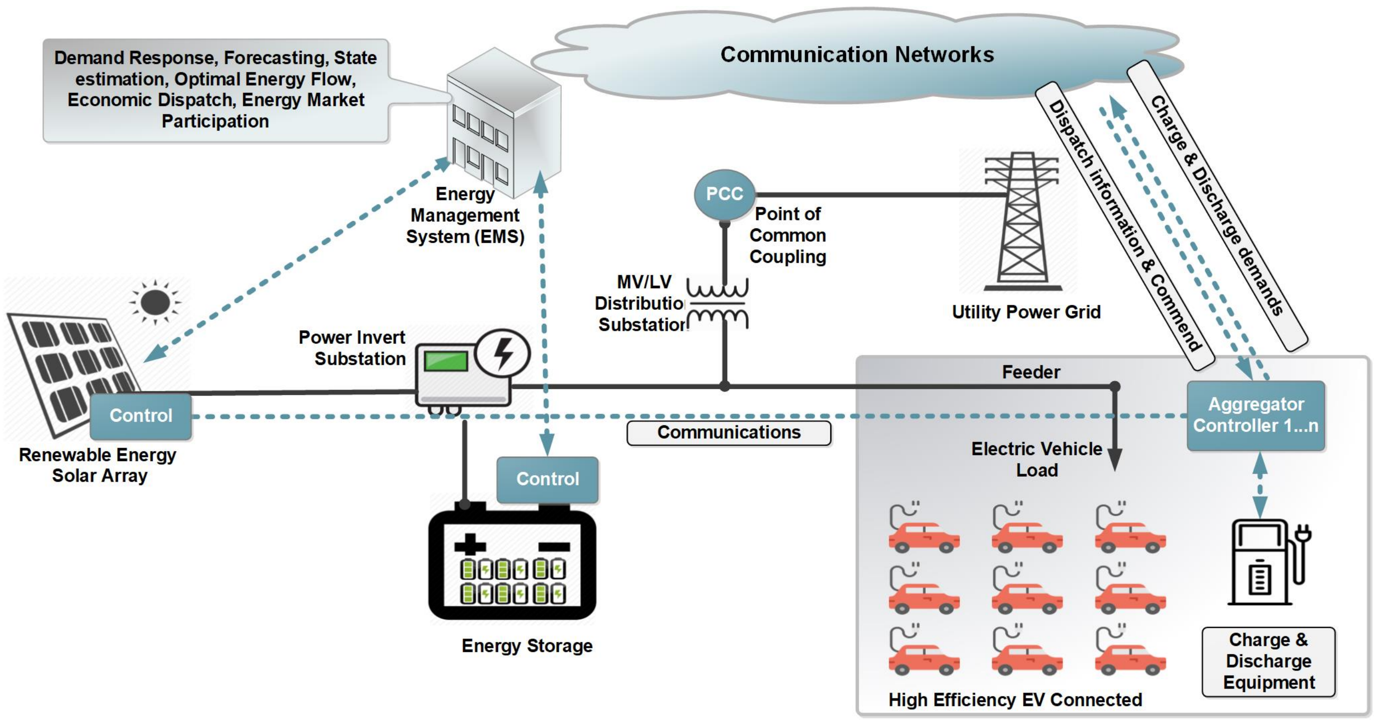

Fig. 1. Vehicle to grid communication system layout.

leverage the integration of V2G with wide power grid and also to monitor the battery storage status of every single EV across the system. These components will build-upon current technologies for autonomous cars to employ software agents, control protocols, data management entities, and decision making controllers. It is also understood that electricity demand and the daily scheduling of energy consumption are still major challenges during peak load demands [11]. To this end, utilities worldwide need to determine the opportunity to employ operational tools that build a healthy intelligent system that is capable of managing all the uncertainties of renewable generation or load demand. To define the main concepts for such transition, this article develop a new optimization framework for energy flow decision making bringing together smart grid and EV technology in a grid connected mode. There are various types of data collected from an EV trip that may influence the critical infrastructure and need to be predicated prior to any trip. Therefore, we mainly focus on the connectivity constraint to mange and control the charging plans.

The main contributions of this article are summarized as follows:

1) Identify a V2G communication scheme that can operates seamlessly in the grid connected mode while recognizing the load requirements through integrated controllers. A scenario for reliable grid operations is considered to support data exchange between EV and smart grid at public parking lots.
2) The article addresses a new framework algorithm for energy flow management that supports local control in cooperation with EVs, and accordingly it can intelligently handles the connected vehicle charging/discharging actions and potential revenues. The control node can process various system messages to facilitate real-time decision making using the energy bidirectional transformation of coordinated vehicle in such V2G system. Therefore, the EV charging station can be connected with EMS using the smart grid network to capture demand response and load status charges.
3) Many of the developed test feeders were deigned to test new algorithms for distribution systems. Similarly, the IEEE 13 Node Test Feeder was created to test the ability of power flow solvers to handle highly unbalanced systems. In this article, the validity of the proposed case study technique is evaluated using modified IEEE 13 node test feeder. The new modified IEEE 13 node supports modeling electric vehicle in parking lots considering a random distribution of 150 EVs, which are implemented using GridLAB-D tool.

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The remainder of the article is organized as follows. This article discusses the vehicle to grid connections and highlights the main challenges of smart charging technique. Furthermore, new framework for energy flow optimization with V2G features and potential advantages is presented. The next section points out the case study scenario using modified IEEE 13 node. Then, we describe the vehicles to grid services and applications. Finally, conclusions remarks are provided.

Vehicle to Grid Connections

Electric Vehicles contribute to signaling exchanged on the grid communication network and energy delivered over the power system. As a remarkable number of smart vehicles penetrate the market, smart grid can use them as supplementary power storage that is randomly mobilized between various grid sites. Theoretically, more EVs provide more electrical capacity to the power grid and also maintain the power system during emergency situations (e.g. islanding). Therefore, EVs can play a vital part in the power system not just as a consumer but also as an agile extra or backup energy storage for the grid. The conventional control center of the power grid is facing many challenges including aging distribution energy networks and uncertainty of demand. Therefore, V2G is accepted as one of the major future technologies to revolutionize the grid architecture. In V2G systems, data communication infrastructure is the most critical segment to achieve efficient connectivity between plugged electric vehicles and grid system [12]. The communication network can facilitates transferring the information on EV battery status to the main control center, especially when EV is connected to charging station. Although EV charges at the offered electricity unit price considering the demand status and available energy sources, the grid may offer a lower price back to EV during discharging considering the overall market sale and technology complications. Therefore, the preference is to use EVs power locally within their geographical sites because of low power volumes.

The trade-off pricing policies may require vehicles owners to accept automated access to their EVs batteries to meet the energy grid demand. The EMS will obtain the predicting information and status of charging and discharging on real-time (e.g. battery capacity) from the control entity interface with battery station. Then, the EMS functionality will take a step forward considering each case to decide the amount of power that can an individual EV of set of them provide to the grid. In additional, the electricity price will be decided for all vehicle connected with the grid based on power delivery on real-time. The main components of communication data exchange platform are shown in Fig. 1 and listed as following [13]:

1) *Electric Vehicles*: The EVs are using communication channel to request charging if their state-of-charge (SOC) indicators fall below certain threshold values.
2) *Aggregator Controller*: It is a control entity that can manage multiple grid elements using advanced algorithms and policies. Also, it is responsible for safety and security of charging/discharging procedures. The aggregator controller allocates power resources considering power demand and grid status. The starting time of charging processes for EVs can be managed by the local aggregators.
3) *Charge and Discharge Equipment*: The charge/discharge equipments are integrated with EVs to provide the access tools for V2G and grid-to-vehicle (G2V) systems. Since a single EV has a very limited storage, a large number of EVs is required to facilitate substantial auxiliary services to smart grid systems.

The features of energy storage that EV employs can have a significant impact on power supplied to the main grid and the evolution of innovative energy vehicles. In the meantime, a vehicle connected to the power grid can deliver an excellent peak shaving that also requires longer time intervals for connecting EV battery storage to the grid. Peak shaving function will be one of the features that V2G offers, particularly when efficient battery technology becomes more reliable in future.

Vehicles to Grid Challenges

Forecasting is an important feature for V2G technology to predict the number of vehicles participating in grid connected mode, the total additional energy capacity and the available extra power per time interval. Therefore, the accurate definition of V2G parameters is the basic requirement to realize a fully functional system. The two-way interaction of V2G makes the predication of available capacity more complicated than conventional load forecasting schemes. Therefore, EVs must be dynamically scheduled considering their arrival order within the corresponding area to improve the regional distribution network during peak power times.

From technology to analysis, V2G storage capacity can be obtained using the following two options:

1) *Real-time Monitoring*: The vehicle owner can configure the next week program for V2G participants allowing the system to access the vehicle system and predict the power status. The V2G central system decides the charge and discharge priorities as soon as the vehicle is connected to a charging station. Future charging stations will employ bidirectional chargers that act as the front ports for grid power management. In this case, the V2G can predict the points of potential connectivity to the smart grid, since it has the ability to access the directory on the vehicle and owner preferred locations. This option provides the grid with prior indications about available energy storage using real-time connected vehicle communications that help the controller evaluating the next connectivity point and steer resources accordingly.
2) *Historical Data*: The vehicle power capacity is closely related with the size of participant vehicle, user habits, weather, energy price, season and the economic development. When initializing the V2G service, the system collects all the aforementioned data from participant vehicles and process them to create relevant profiles. These profiles will be continuously updated each time there is as access to the vehicle either through remote communication system or physical connectivity of charging stations. After few iterations, the system start to create its own predictions for each vehicle potential charging/discharging locations. The accuracy of those estimates are still subject to many factors that may reduce the feasibility of identifying the next hub for additional power storage within the smart grid architecture.

Smart Charging Coordination

The interaction between the EV and charging station is well-defined by international electro technical commission IEC 61851 standard. This standard defines the requirements for conductive connection of EV to the grid. Originally, IEC 61851 standard was established to facilitate the interoperability among various field vendor devices at the substation

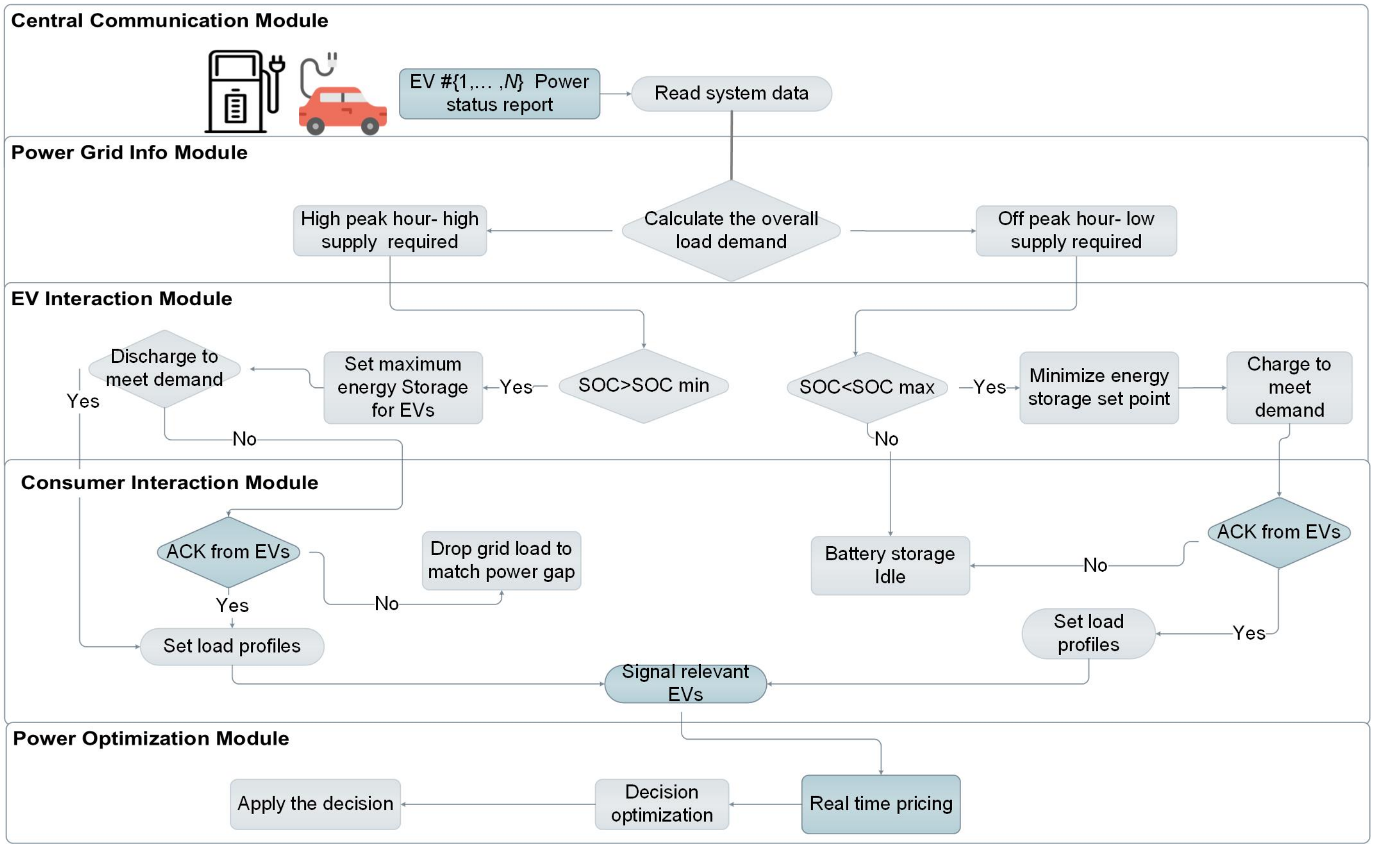

Fig. 2. A framework algorithm for real-time decision making.

level. Later, IEC 61850 advanced standard has been extended to support V2G networks by intellectualizing the EVs as distributed energy storage. The charging status, limitation, and publishing of regulation demands influence the choice between the appropriate EV charging mode, as defined in IEC 61851 [14]. Currently, charging stations are supporting alternative current (AC) with weak communication features. For instance, increasing the number of electric vehicles and charging stations is anticipated to increase the interruptions of communications. Therefore, V2G features such as data scheduling become very important to achieve a reliable power grid. On the other hand, power line communication (PLC) is the most widely used communication technology by utilities to facilitate data exchange.

The EV receives the control signaling along with energy when it is connected to electric vehicle supply equipment (EVSE) widely known as “Charging Station”. The available current of the charging station will be based on the average voltage measured by estimating the variable duty cycle and high voltage. Later, Pulse width modulation (PWM) is used to convert the high charging voltage into variable voltage, variable frequency to operate the vehicle motor. The smart vehicle should not exceed the maximum amount of charge to avoid any damages to its battery and electronic circuits. The EV has the ability to charge up to maximum voltage level where the controller signals the vehicles charging statues back to the charging station. The smart charger station will periodically for checking the status of connected vehicle to make a proper decision based on incoming signals from vehicle controller. Also, the charging station will terminates the connectivity during the discharging operations if the energy levels of vehicle batter become low or the power grid condition is not stable. This means that EVSE have the ability to change the scheduling mode during the charging/discharging operations if the vehicle or grid operation system condition changed. Specifically, the charging station can also reverse power directions between vehicle and smart grid taking into account the status changes of the power system. However, the changes in charging rate will happen gradually to prevent any technical implications while the power grid returns to normal status. If the power grid situation continue in hazards, the charging station can react immediately to terminate the charging completely.

Peak Power Shifting

The supplementary energy storage accessed through V2G technology is used by smart grid to meet sudden power demand and increase the system reliability. On average, vehicles can stay idle for almost 3 to 5 hours a day at the parking lots. During this time, an EV battery can operate as a distributed energy storage for the power system. This battery storage can deliver the stored energy back to the power grid without impacting the functionality or usability of the vehicle. The response time of the EV charge/discharge procedure can be completed in milliseconds since there are no mechanical equipment involved in those operations. Using EV as an additional energy storage shifts the load paradigm in local domains from day time to where EVs are most likely located at parking lots to night time where the demand for power grow as most EVs are connected to charge from homes. Therefore, there is a need to expand the proposed model in this article to include home discharging scenarios. However, any solutions to include home discharging models should consider the capacity of grid networking to residential sites and employing energy management controllers locally within neighborhoods and microgrids.

Energy Flow Framework Optimization

Smart grids need to adopt flexible EVs charging scenarios to tackle the fluctuations of load demand peak hours during the day. Motivated by V2G challenge, this article proposes a new operational algorithm that enables efficient charging/discharging operations for an EV battery when connected to the smart grid, as shown in Fig. 2. The uncertainties associated with EV SOC status and departure time are taken into consideration in the proposed aggregator controller to manage the random energy available to the grid. However, the proposed technique considers similar pricing priority for all EVs, namely real-time charging technique. Prices are calculated using different factors reflecting on power grid, vehicle, battery, aggregator controller, and charger. To increase the revenue obtained from a smart charging of end-user demand response, a framework for energy flow is developed in which the aggregator controller can manage the decision-making using real-time interactions with EV owners. This method is based on technique evaluations in which EV charging can help real-time proficient energy delivery and phase-unbalance mitigation for a three phase low voltage (LV) system.

The optimal battery capacity for grid connected modes is studied using two scenarios. First, the battery is set to work in discharging mode. Then, the electricity imported from the grid is measured as grid more than zero, and the electricity export to the grid is considered as grid less than zero. Second, battery charging process is measured as battery direct current (DC) more than 0 and battery discharging is measured as battery DC less than 0. The dispatch scheduling mechanism will push the battery storage to supply the required loads during the peak hours when the cost of electricity is high. In particular, The battery charging process will due during the night by purchase low electricity prices from the main grid during off peak hours. New operational algorithms for real-time decision making are introduced to handle the charging of connected vehicle and the management of their battery storage as a supplementary component for grid support. To locate participant vehicle at public parking lots, a framework has been proposed in which the local control aggregator can derive the required information and pass relevant decisions via real-time communication connections with associated EV. The real-time communications provide the vehicle with suitable method for contributing to energy flow control according to the enforced pricing policy. This algorithm framework provides great revenue to EV owners by maintaining reasonable pricing for power exchange transactions. In this case, the EV owners will get dedications for sharing their available resources considering the amount of electricity released back to the grid. To harmonize such scheme in real-life, the connected EVs should be controlled by local aggregator for efficient regulation provision and to stabilize the SOC for each connected EV. Therefore, revenue can be generated once the EV connects to the main grid and operates in power storage mode. In the energy optimization context, the optimal controller can handle the energy flow leading to maximizing the revenue for individual vehicle connected by of local aggregator to the main power grid.

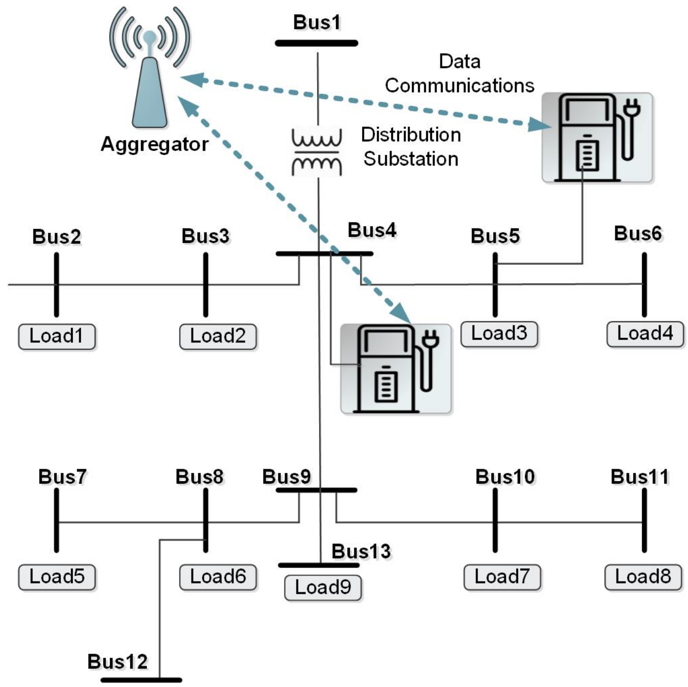

Fig. 3. Single line diagram of modified IEEE 13 node with parking lots

Case Study

A simplified model for a typical distribution system with different parking lots has been used in this study. The voltage on the output of the secondary transformer is set to 1.06 p.u. In the network, each load bus is connected with a set of EVs and transformers are connected to each phase of each node. The minimum allowed voltage at each load bus is assumed to be 4 kV. One aggregator controller is paired with one EV in a cooperative mode to support efficient data exchanges of various actions of load collect/delivery from power system. Moreover, energy demand fluctuates subject to many factors such as weather, thermostat settings, and other objectives behavior. Each EV in the parking lot can deliver measurement data messages to the aggregator controller including initial and final records of SOC, and the anticipated departure time for each EV.

The main system model consists of feeder, step down transformer, and 150 randomly distributed vehicles. The main system model for distributed EVs is designed based on

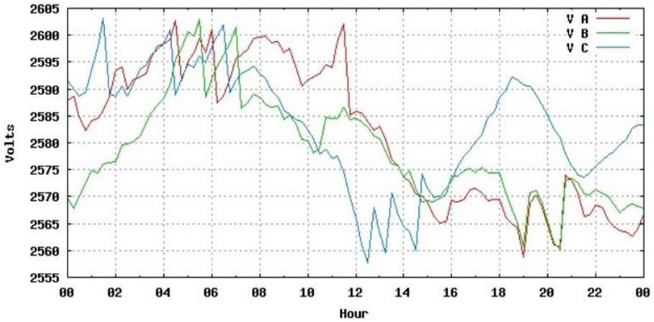

Fig. 4. Average Transformer-Level Power Output

modified IEEE 13 node and implemented using GridLAB-D project tool. Currently, GridLAB-D project is considered as an optimal environment for simulating multi-features of power grid system [15]. GridLAB-D is an open source simulator tool that allows to evaluate power systems. This simulation tool was developed by Pacific Northwest national laboratory (PNNL) that has been funded by the United States Department of Energy (DOE). A single line diagram is designed based on modified IEEE 13 node for IEEE power and energy society test feeder, as shown in Fig. 3. The primary distribution voltage is 33 KV for the feeder in the power system and the value of secondary voltage is considered at 120V of distribution feeder, the substation transformer power rate is 5 MVA and the step-down transformer connected to one of the IEEE 13 nodes. The smart power grid is simulated for parking lots with 150 EVs that were randomly distributed on grid. The EVs are distributed among the nodes of the IEEE 13 node feeder in order of 9 to 11 EVs connected to each step-down transformer. Sample of output voltages at Bus-4 is shown in Fig. 4. In our configurations, the operation of each technology combination was simulated in a sequential hourly dispatch model. The technical specifications of the technology constrained the operations of the modeled storage device, accounting for charging and discharging capacity (in kW), energy storage capacity (kWh), round-trip efficiency, and minimum depth of discharge, among other factors. Within those constraints, each energy storage device was dispatched based on expected load demand to maximize.

EV Charging Controller Analysis

Battery storage operation status is subject to frequent responses of power system. The data rate output from battery storage represents the amount of load exchanged that also reflects the total energy output. Therefore, the EV battery storage should be maintained withing SOC threshold range between 30% to 80%. The EV battery should be disconnected from discharging mode when SOC is below 30% to prevent EV from failing to operate. On another hand, the maximum charging capacity defines the upper limit of the battery storage which is measured at SOC of 90%. The EV indicators started to alarm when the SOC became lower than 10% of the batteries charging capacity. Typically, the storage will start discharging only to support the load demand in the main power system and the storage can be charged later using any source for energy. This assumes that battery storage can improve the power grid reliability and subsequently increases the permissible penetration of PV in LV distribution networks. In addition, charging an EV in such grid connected modes should automatically adjusts the lower limits for battery SOC to preserve additional energy that exceeds regular independent EV modes, as shown in Fig. 5.

To demonstrate the effect of coordinated EV charging in a distributed grid, we developed a fair sharing algorithm to mitigate the peak load of an EV that operates in grid connected mode. We simulate the EVs model using different penetration rates (0%, 10%, 20%, 30%, 40%, and 50%). Then, 150 EVs were randomly distributed in the parking lots for each penetration rate. The analysis results for various EV penetration rates are given in Table I. According to data analysis, the 50% and 60% penetration rates are fully loaded by EV that charging their batteries with a maximum time duration of about 4 hours. The data aggregation time to achieve fully loaded EV charger requires more than 190 hours for 50% penetration. The long time for fully loaded EV charger can help to reduce the transformer life-time. The EV charging effect can be mitigated by efficiently coordinating the EV charging times and locations. By increasing the penetration rate, the number of overloaded parking lots transformers increases exponentially during evening when all the EVs arrive.

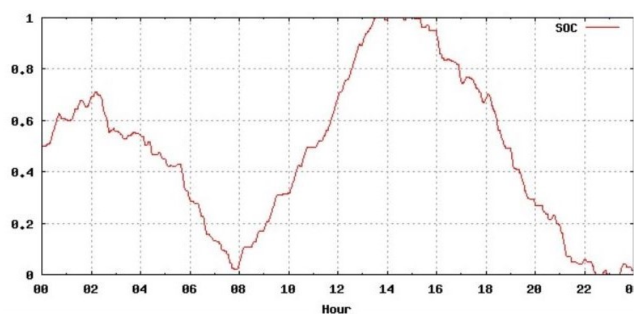

Fig. 5. Battery state of charge

VEHICLES TO GRID SERVICES AND APPLICATIONS

To highlight V2G values, the primary steps to deliver integrated vehicle-to-grid services are already ongoing. However, there is a need to understand the existing opportunities towards matching the EV aggregations objectives with the power grid reliability. The following key services are the main users of V2G technology:

1) *Ancillary Services*: In particular, the ancillary services can be delivered by considering V2G network architectures. In the power grid paradigm, the aggregator will collect the ancillary services provided by each EVs, throughout the grid operator system and produce a signal control for charging and discharging instructions. Since EVs are expected to be located in parking lots during day time, vehicles become the enablers for ancillary services (e.g., Peak shaving, reserve power supply, regulation and renewable energy integration) using V2G network. As

TABLE I
DATA OF FULLY LOADED STATUS FOR DIFFERENT EV PENETRATION

EV Penetration	Fully Loaded Transformers	Maximum Duration (min)	Fully Loaded Aggregator time (min)
0%	0%	0	0
10%	4%	133	477
20%	11%	181	1122
30%	25%	234	4744
40%	50%	290	9022
50%	60%	321	12896

such, these ancillary services need further study to help overcoming some challenges for V2G such as economy cost by reducing the energy pricing for the wholesale markets.

2) *Customer services*: An EV connected to the main grid will open the door to the customer to make profits from their vehicles by selling back the energy to the utility power grid. In addition, V2G can maintain a high quality of power services by getting steady voltage supply that can meet the consumer driving needs. Nevertheless, dynamic pricing schemes should be adopted to allow fair sharing of capital and operational costs between vehicle owners and utility providers.
3) *Maintain Grid Stability*: Automotive industry and utility grids are both emerging technologies that can provide new opportunities when addressing the power demand to manage the stability of the electricity of the main power grid. Therefore, local controllers that manage charging/discharging procedures need further technical definition considering deployment locations and schemes for operation.

The V2G technologies presents a great solution to some local power utility bottlenecks at the distribution level, which can help to modernize grid edge networks.

CONCLUSION

The growing energy demand for the main power grids requires to identify additional resources that can be accessed during overloading and emergencies. In this article, we presented a framework to facilitate a real-time decision making considering charge/discharge processes to meet the load demand. We presented a solution using V2G technology to provide great revenue to EV owners by maintaining reasonable pricing for power exchanges and steering of power resources at high peak times. We mainly focused on the connectivity constraint to mange and control the charging plans to support energy flow optimization that incorporates local aggregator into grid power resources. This article highlighted EV batteries as a supplementary energy storage that can discharge energy back into grid during peak loads. This new framework for energy flow conversion is employing V2G technology together with battery charge/discharge in grid connected mode. These solutions define new research paradigm for expanding grid resources to include EV batteries and stretch the grid developments to consider V2G technologies.

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REFERENCES

[1] S. Al-Rubaye, E. Kadhum, Q. Ni, and A. Anpalagan, "Industrial Internet of Things Driven by SDN Platform for Smart Grid Resiliency," *IEEE Internet of Things Journal*, vol. PP, no. 99, pp. 1–1, 2017.
[2] A. S. A. Awad, M. F. Shaaban, T. H. M. EL-Fouly, E. F. El-Saadany, and M. M. A. Salama, "Optimal resource allocation and charging prices for benefit maximization in smart pev-parking lots," *IEEE Transactions on Sustainable Energy*, vol. 8, no. 3, pp. 906–915, July 2017.
[3] G. Li, J. Wu, J. Li, T. Ye, and R. Morello, "Battery Status Sensing Software-Defined Multicast for V2G Rgulation in Smart Grid," *IEEE Sensors Journal*, vol. 17, no. 23, pp. 7838–7848, Dec 2017.
[4] R. Zhang, X. Cheng, and L. Yang, "Energy Management Framework for Electric Vehicles in the Smart Grid: A Three-Party Game," *IEEE Communications Magazine*, vol. 54, no. 12, pp. 93–101, December 2016.
[5] P. Palensky, E. Widl, M. Stifter, and A. Elsheikh, "Modeling Intelligent Energy Systems: Co-simulation Platform for Validating Flexible-Demand EV Charging Management," *IEEE Transactions on Smart Grid*, vol. 4, no. 4, pp. 1939–1947, Dec 2013.
[6] L. C. Casals and B. A. Garca, "Communications Concerns for Reused Electric Vehicle Vatteries in Smart Grids," *IEEE Communications Magazine*, vol. 54, no. 9, pp. 120–125, September 2016.

[7] R. A. Raustad, “The Role of V2G in the Smart Grid of the Future,” *The Electrochemical Society Interface*, pp. 1–8, Spring 2015.

[8] R. Yu, W. Zhong, S. Xie, C. Yuen, S. Gjessing, and Y. Zhang, “Balancing Power Demand Through EV Mobility in Vehicle-to-Grid Mobile Energy Networks,” *IEEE Transactions on Industrial Informatics*, vol. 12, no. 1, pp. 79–90, Feb 2016.

[9] W. Tang, S. Bi, and Y. J. Zhang, “Online Charging Scheduling Algorithms of Electric Vehicles in Smart Grid: An Overview,” *IEEE Communications Magazine*, vol. 54, no. 12, pp. 76–83, December 2016.

[10] T. N. Le, S. Al-Rubaye, H. Liang, and B. J. Choi, “Dynamic Charging and Discharging for Electric Vehicles in Microgrids,” in *2015 IEEE International Conference on Communication Workshop (ICCW)*, June 2015, pp. 2018–2022.

[11] S. Al-Rubaye and B. J. Choi, “Energy Load Management for Residential Consumers in Smart Grid Networks,” in *2016 IEEE International Conference on Consumer Electronics (ICCE)*, Jan 2016, pp. 579–582.

[12] D. T. Hoang, P. Wang, D. Niyato, and E. Hossain, “Charging and Discharging of Plug-in Electric Vehicles PEVs in Vehicle-to-gridV2G Systems: A Cyber Insurance-Based Model,” *IEEE Access*, vol. 5, pp. 732–754, 2017.

[13] K. Wang, L. Gu, X. He, S. Guo, Y. Sun, A. Vinel, and J. Shen, “Distributed Energy Management for Vehicle-to-Grid Networks,” *IEEE Network*, vol. 31, no. 2, pp. 22–28, March 2017.

[14] T. S. Ustun, C. R. Ozansoy, and A. Zayegh, “Implementing Vehicle-to-Grid V2G Technology with IEC 61850-7-420,” *IEEE Transactions on Smart Grid*, vol. 4, no. 2, pp. 1180–1187, June 2013.

[15] J. A. Martinez, F. de Leon, A. Mehrizi-Sani, M. H. Nehrir, C. Wang, and V. Dinavahi, “Tools for Analysis and Design of Distributed Resources ,Part II: Tools for Planning, Analysis and Design of Distribution Networks with Distributed Resources,” *IEEE Transactions on Power Delivery*, vol. 26, no. 3, pp. 1653–1662, July 2011.