CHARGING SLOT PREDICTION AND AUTOMATION SYSTEM FOR ELECTRIC VEHICLE CHARGING STATION

KARTHIK.B
UG Student
Department of Computer Science and Engineering
E.G.S Pillay Engineering College
Nagapattinam, India
karthikbanarjee@gmail.com

SHANMUGASUNDARAM.S
UG Student
Department of Computer Science and Engineering
E.G.S Pillay Engineering College
Nagapattinam, India
shanmugasundaram192@gmail.com

VIJAYASARATHY.R
UG Student
Department of Computer Science and Engineering
E.G.S Pillay Engineering College
Nagapattinam, India
vijaysar900@gmail.com

Mr. A. BASKAR M.E., (Ph.D.)
Assistant Professor
Department of Computer Science and Engineering
E.G.S Pillay Engineering College
Nagapattinam, India
baskarit@gmail.com

Abstract— Electric vehicle charging stations (EVCS) play a vital role in providing charging support to EV users. The rapid adoption of electric vehicles (EVs) stimulates the proliferation of charging stations (CSs), motivating the cooperative management of growing CSs. However, cooperative CS management still remains an open problem, due to the uncertain user behaviors and heterogeneous service capabilities. To capture the CS dynamics caused by uncertain user behaviors, we propose a deep reinforcement learning (DRL)-based cooperative method for multiple CSs, towards maximizing the total profit. Developed the Framework and Architecture of the Next-Generation Communication System based on Web Dashboard based EVCS Slot Prediction and Online EVs Charging Slot Booking at Charging Station. We built the stochastic queuing model for EVs in the charging station. We formulated the objective function of EV's charging at charging points in charging stations to determine the optimal charging time, minimal charging cost, least distance, minimal queuing delay and optimal duration for particular charging slots. The proposed model of the slot prediction and booking system is designed to create a cost effective and efficient system. Our Cloud based Charging Station Management platform is developed to network and manage multiple charging stations. The proposed IoT and server-based real-time forecast charging infrastructure avoids waiting times and its scheduling management efficiently prevents the EV from halting on the road due to battery drain out.

Keywords: **Electric vehicles (EVs), Electric vehicle charging stations (EVCS), Deep reinforcement learning (DRL), Cloud based charging station management platform.**

I.INTRODUCTION

An electric vehicle charging station is equipment that connects an electric vehicle (EV) to a source of electricity to recharge electric cars, neighborhood electric vehicles and plug-in hybrids. Some charging stations have advanced features such as smart metering, cellular capability and network connectivity, while others are more basic. Charging stations are also called electric vehicle supply equipment (EVSE) and are provided in municipal parking locations by electric utility companies or at retail shopping centers by private companies. These stations provide special connectors that conform to the variety of electric charging connector standards.

In many countries people live in densely populated areas, specifically in apartment buildings. This concept is radically different from those parts of the globe where people tend to live in family houses, typically far from big cities. Since many car makers are currently developing electric vehicles (EVs), the replacement of current combustion engines seems to be plausible in the years to come. As a result, the creation of a network of public and private charging points will be required, and the grid will have to absorb the increase in demand. In the case of family houses, only a minor electrical renovation might be required, mainly to adapt the installation to provide the current needed for a quicker charge. Communal garages are a different story as parking places do not usually have a socket already installed and, in addition, it is not clear yet how the energy cost will be charged to the owners. It is also worth mentioning that power requirements for a quick charge are very high, which will require running three-phase wires of a certain section to each available socket.

An electric vehicle, also called an EV, uses one or more electric motors or traction motors for propulsion. An electric vehicle (EV) is one that operates on an electric motor, instead of an internal-combustion engine that generates power by burning a mix of fuel and gases. Though the concept of electric vehicles has been around for a long time, it has drawn a considerable amount of interest in the past decade amid a rising carbon footprint and other environmental impacts of fuel-based vehicles.

India is one of the top ten automotive markets in the world today and having highly increasing middle-class population with buying potential and the steady economic growth. But petrol price has increased more than 50% in 13 different steps in last two years. Here comes the potential need for alternative technologies in automobiles such as electric vehicles (EV) in India. Although the initial investment is around 1.5 times than conventional IC engine, but time has come when cost of environment is now more of concern than the cost of vehicle. National governments are focusing on R&D and consumer incentives, whereas city governments are supporting infrastructure deployment locally through public-private partnerships and other programs. The Global EV Outlook (GEO) finds that global EV sale has increased more than double between 2011 and 2012, exceeding the 100,000 sales milestones. Together EVI countries have deployed about 47,000 slow and 1,900 fast non-residential charging points till 2012, and their governments have spent approximately USD 800 million on infrastructure deployment since 2008.In the last decade two fundamental issues emerged in terms of energy throughout the world. The first one is running out of limited petroleum in the near future and the other one is carbon emission result in global warming. Many countries currently rely heavily on coal, oil, and natural gas for its energy. Fossil fuels are non-renewable, that is, they draw on finite resources that will eventually dwindle, becoming too expensive or too environmentally damaging to retrieve. In contrast, the many types of renewable energy resources-such as wind, and solar energy-are constantly replenished and will never run out. Renewable energy is mostly called “clean energy” or “green power” because it doesn’t pollute the air or the water and does not result carbon emission.

II.RELATED WORK

In this study, we design a novel cloud-based charging management system for electric vehicles (EVs). To the best of our knowledge, only a few works consider automation of electric vehicle charging station using cloud-based system. In a similar study using a cloud-based charging management system using two levels of cloud computing, i.e., local and remote cloud, these two levels are employed to meet the different latency requirements of the heterogeneous EVs, this system follows first come first serve priority for charging the EVs [1]. A proposed study focuses on a genetic algorithm-based scheduling method of charging electric vehicles. It manages to determine a sub-optimal charging timetable which satisfies the given electric load curve under the structural constraints of their system. The charging facility consists of several charging bays which offer multiple connectors to vehicles, but of which only one can be actively charging at a time. An ideal load curve is defined as a step function in order to make use of the late-night off-peak electricity prices. Problem is split into two: (i) connecting problem (selecting a charger to which the EV should connect) and (ii) scheduling problem (determine the starting time of charging). The genetic algorithm is applied to the latter, with the goal off fitting the total charging load curve to the ideal load curve. Individual evaluation is based on the sum of the squares of difference between the ideal load value and the total charging load value at each sampling time. They simulate several battery charge state settings on 20 EVs and 10 chargers with 2 connectors. The results show that controlled charging manages to level off the electric load as well as to reduce the capacity and cost of charging equipment, as opposed to the uncontrolled one [2].

A study on intelligent binary particle swarm optimization (BPSO) based approach to schedule the usage of available energy storage capacity from EVs. Next to the vehicles being able to take power from the grid and charge the batteries, they introduce an idea of also providing power to the grid when parked, so called vehicle-to-grid (V2G) concept. A scalable parking lot model, with the objective of maximizing profit for the operator, is developed. BPSO is applied to schedule whether each vehicle should buy, sell, or hold at every time step it is parked. This general setting renders the charging periods as preemptive (i.e., charging periods are not necessarily contiguous). Each vehicle’s SoC is expected to be at 60%, which is to be satisfied even in the case of early departure. A day is split into 1-hour intervals (to match the hourly prices), and an infinitely large connection to the grid is assigned to each parking lot, meaning they do not consider available power as a resource. Two case studies have been conducted. The first one takes the price curve and determines the best (maximum) selling and best (minimum) buying price — this way only one transaction occurs for each vehicle. This results in lower profit potential but the schedule is easy to determine. The second case study considers multiple transactions throughout the parking duration. This allows for higher profits but greatly increases the scheduling difficulty. However, the problem is separable, since there are no common constraints and the solution can be found for each vehicle individually, which greatly reduces its dimensionality. The results show that multiple transactions result not only in significantly higher profits, but also reduce the net power out to the grid [3].

A study researches several kinds of alternative vehicles: hybrid electric vehicles (HEV), fuel-cell electric vehicle (FCEV) and plug-in hybrid electric vehicle (PHEV), but focus on the last one, stating that PHEVs might take up to 5% of total electrical consumption in Belgium and up to 30% of the market share by 2030. The model, in which the PHEVs charge at home, defines four essential charging periods for a residential radial network. Daily (winter and summer) load profiles are selected from available historical data, and given on a 15-minute time base. First, they describe uncoordinated charging, where the vehicles are charged (at constant power of 4 kW) immediately when plugged in or after a fixed start delay, which leads to grid problems. Next proposed is coordinated charging which computes the optimal PHEV charge profile (at variable charge rate) by minimizing the power losses. EV owners are now only allowed to define a point in time when the battery must be fully charged. The starting time of charging is determined by the sequential quadratic optimization program. This approach manages to decrease the power losses for all charging periods and seasons. They also make use of stochastic programming to forecast the daily load profile, which introduces an efficiency loss (as the charge profiles are no longer optimal for the specific daily load profile, i.e., the stochastic optimum differs from the deterministic one) [4].

In a study they compare two different approaches to optimize EV battery charging behavior with the goal of minimizing charging costs, achieving satisfactory state-of charge (SoC) levels and optimal power balancing. The first one is based on a linear approximation, whereas the second one uses a quadratic approximation. The battery's non-linear and state-dependent model is used to evaluate the obtained solutions. They do mention the V2G concept, but do not apply it in their setting. The driving pattern prediction (vehicle arrivals, departures and energy requirements) is assumed to be available. The difference between the two methods turns to be minor and they conclude that a linear approximation is sufficient, as the resulting violations of the battery boundaries are less than 2% (however, in a perfect, deterministic setting). They continue their work by proposing a method of planning the individual charging schedules of a large EV fleet while respecting the constrained low-voltage distribution grid. It has been tested in a simulation environment in which the movement and charging of individual EVs are simulated simultaneously. Here, the planning period is represented by 96 slots of 15 minutes and the charging spots are rated at 16 kW. A centralized fleet operator is assumed, which handles data storage, trip forecasting (here assumed perfect), optimization, customer relationship and billing information, and communication. Three different charging schemes are compared: (i) Eager charging (connect and charge), (ii) Price-based charging (unconstrained grid, minimizing only the total cost of electricity used for the fleet) and (iii) Grid aware price-based charging (respecting the grid capacity as well). For (iii) they clearly separate the grid congestion evaluation and charging schedules optimization phase, using the concepts of load flow network, maximum flow problem solving and linear programming, while iteratively updating the grid constraints. Results show that both for eager and pure price-based charging, the grid is significantly overloaded. Including the grid constraints reduces the overload (however, with still present peaks), but slightly increases the total cost [5].

Electric power management at parking garages, as new potential high concentrated electric consumption nodes. By exploring the benefits of implementing a consumption management control (CMC) in a 50 plug-in vehicles case study, they analyze power capacity requirements and costs, savings on energy consumption and penalties for non-supplied energy. The vehicles are modeled as EV and PHEV entities with specific attributes, such as maximum battery charge (23 kWh and 7.2 kWh), charging rate (3.8 kW and 2.2 kW), arrival time, stay duration, and initial and final SOC. At the parking garage, power capacity is considered an actual parking resource, next to the several parking zones managing different charging status of the vehicles: waiting, charging and resting (FIFO queues). Vehicle arrivals are modeled as a Poisson process with a different arrival rate for each hour of the day. The CMC attempts to avoid excesses over the total power capacity and to minimize the total energy cost, based on three charging time frames: two valleys (0:00 – 3:00; 3:00 – 6:00) and off-valley (6:00 – 0:00). Simulations show that implementing the CMC: (i) delays a significant percentage of the supply energy to a period of lower energy prices, (ii) avoids overcoming the power capacity, (iii) reduces the contracted power capacity, and (iv) reduces the non-supplied energy levels. Total cost savings are rated at 34% to 50% when CMC is employed. Next, they state that the optimal installed power capacity for their 50 vehicles case study, given different PHEV-EV scenarios, is 40-50 kW per garage (from purely economic perspective). A" rule of thumb" is also established, saying that 1 kW per plug-in vehicle is a reasonable rate to set an installed power capacity [6].

III.EXISTING METHODOLOGIES

First Come First Serve (FCFS) priority for charging, in "Recharging Phase", each CS (Charging Station) performs scheduling for EVs already parking herein based on the FCFS order, or even with smart method by knowing the anticipated EVs arrival information (as included in EVs reservation information).

Admission Control Algorithm, the admission control mechanism can be viewed as a virtual scheduling procedure. Whenever a new task I arrives, it will be put into an active scheduling task set I together with the existing admitted tasks. Then, all the tasks in I will be scheduled by the corresponding scheduling algorithm.

Electric Vehicles Recharge Scheduling with Time Windows (EVRSTW), it is closely related to the resource allocation and resource constrained scheduling problems. EVRSTW, in its special case, belongs to the class of NP complete problems, meaning that exact methods are usually unable to cope with large problem instances in reasonable time, and display unpredictable runtimes. In order to build a real-world dynamic system based on user requests and almost immediate system responses, we need to find methods which can operate within a short, bounded execution time.

IV.PROPOSED FRAMEWORK

Stochastic Queuing Models, Stochastic Queuing Simulation (SQS) is a methodology for characterizing and simulating large-scale workloads (e.g.to evaluate new server configurations, scheduling policies, etc.). While pieces of these methods may be well known to queuing theorists or statisticians, they have not been presented in a cohesive manner, or widely adopted by the systems community. A queuing model is composed of a collection of "slots" which process charge. We model each charging station as a single queuing system; this queuing system may have multiple "slots" which correspond to individual CS in a multicore CS. car arrive into the system according to an inter arrival time distribution and their size (measured in time) is distributed according to a service time distribution. A queuing discipline must be chosen to determine how queued jobs are scheduled and processed.

Forecasting in Open Car Parks with Charging Point, web and mobile application the innovative advantages over other charging stations are the web and mobile application. When a user registers, all the functions of the system can be managed through the application. With the application, charging of EV becomes reliable, and the trip less stressful, as the application allows the user:

- Find the nearest charging station
- Reserve charging time
- Navigation to the location
- Easy charging activation
- Charging limit setup (amount of energy, amount, time)
- Flexible payment system (payment cards, PayPal system…)
- Live monitoring of charging during other activities (meeting, shopping, viewing the show...)

V.ARCHITECHTURE DESIGN

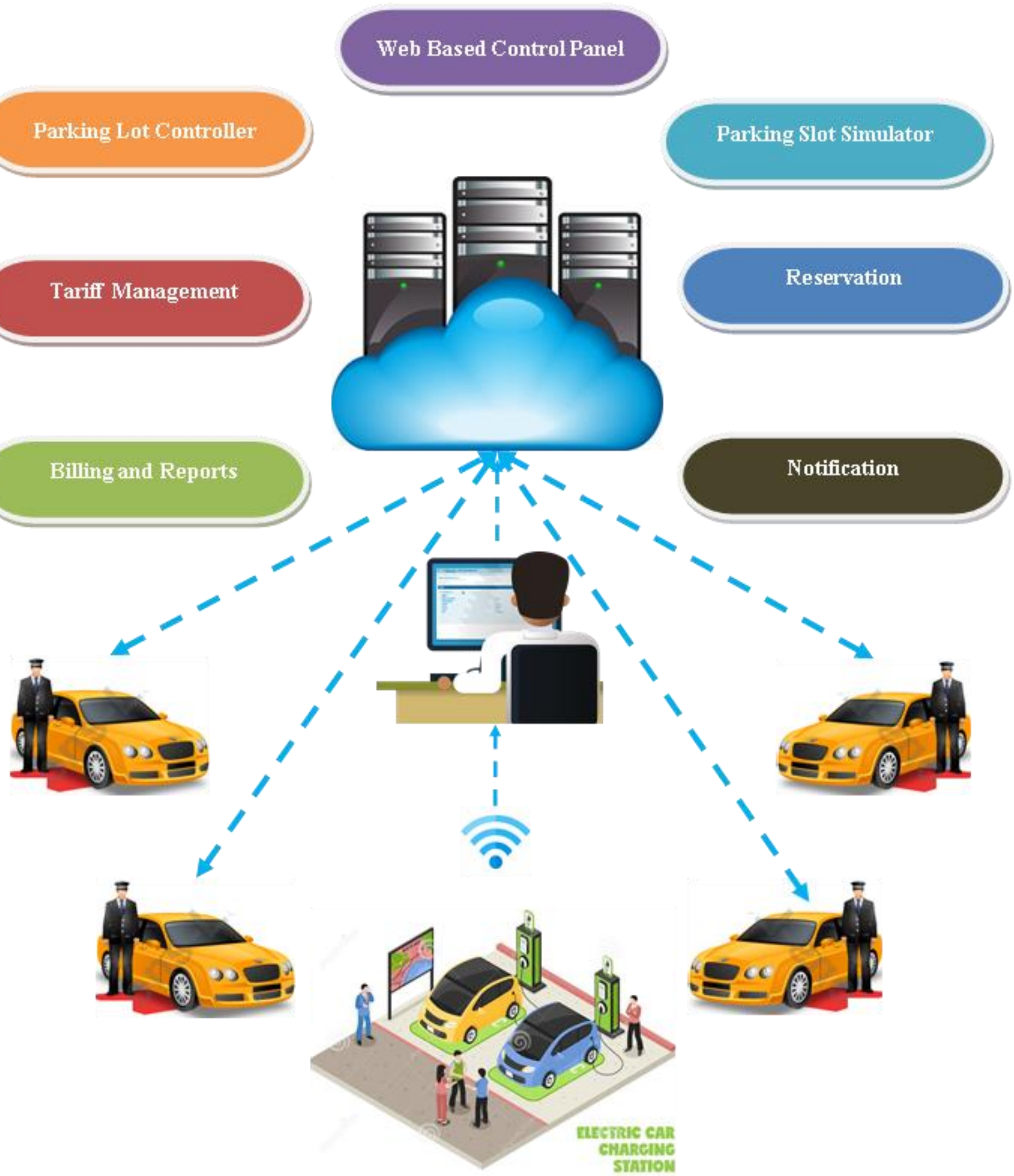

Fig.1. System Architecture

VI.SYSTEM IMPLEMENTATION

Charging Slot Scheduling

Optimal charging scheduling of Electric Vehicles at a charging station with multiple charging points. In their setting, the charging station is equipped with renewable energy (RE) generation devices and can also buy energy from power grid into its storage battery. An interesting point is noted, stating that local renewable energy sources are the ones that should be used at least partially, to achieve real environmental advantages of Electric Vehicles, compared to conventional vehicles. The goal is to minimize the mean waiting time under the long-term cost constraint. Queue mapping is proposed, converting the Electric Vehicle queue to the charge demand queue, along with the proof of equivalence between the average length minimization of the two queues. They derive two necessary conditions of the two-dimensional optimal policy of the formulated and finally investigate two specific stationary policies — radical and conservative.

The already existing system follows first come first serve (FCFS) priority for charging slot allocations. Our proposed system uses deep reinforcement learning for finding the nearest Electric Vehicle (EV) charging station and navigate to the location accurately. Stochastic Queuing simulation (SQS) is used for scheduling the charging slots.

Modules Description

Admin

The admin can login in this page. It checks whether the username and password are correct, if correct allows the administrator to update or view the details else displays the error message.

User Register & Login

Users have to register their details and attain ID to login to the system. After login users can view the available charging station and book for Electric Vehicle (EV) charging.

Parking lot control

The parking lot control center (PLCC) plays a major role in collecting all available offer/demand information among parked electric vehicles.

Parking Slot

This module creates and configures parking lots, sometimes referred to as parking orbits, Real-time monitoring of parking space availability by facility, level, and single space. Monitors the occupancy of parking lots and parking garages.

Electric vehicle charging point

Add and manage charging stations and locations. Set access rules and visibility (private/public), monitor usage and consumption.

Charging Station Payment

Accept payments from customers, generate receipts and reports. PayPal, credit & debit card and voucher payments are supported out-of-the-box with further payment options to be added upon request.

Charging history

View usage statistics and generate and export usage reports. Monitor network activity in real time and export historical data.

Notification Service

This module provides all the notification related services to the platform, routing the system-generated notifications to users that had subscribed to that notification (i.e., vehicle charged, abnormal charge pattern, etc.).

Parking Incentives

Free parking for Electric Vehicles citywide, downtown, or in select sectors of the city. Free parking while charging, Parking for Electric Vehicles allowed in otherwise restricted areas, Parking spaces reserved for Electric Vehicles only Reduced parking fees for Electric Vehicles in public lots.

VII. CONCLUSION

We have implemented a complete system to supervise the charging of Electric Vehicles in car parks, using small and cheap is connected to the Internet wirelessly. The proposed system allows a user to access the information associated with the charging process (cost, effective elapsed time, estimated time to full charge, etc.), and a supervisor to manage different aspects of the process such as billing of consumed energy, charging priorities, etc.

The use of a Wi-Fi connection dramatically reduces the wiring and the complexity of the installation, and simplifies the interaction with the users of the system. The main idea behind this is the fact that every single parking space will need to be adapted to serve as a charging point, and given the shared ownership nature of these garages, we need a way to measure and manage the power consumed by the vehicle recharge.

VII.FUTURE SCOPE

The methods used in this study are reproducible for other cities, and the results will be useful for planning EV charging infrastructure development The data collection method is time- and cost-effective because Charge Point charging stations collect data about every charging event, and this data is quick, easy, and free to obtain. Additionally, the results from this case study can be used as a reference for possible expectations of Electric Vehicle (EV) charging station usage on other college campuses. This will be especially useful for colleges that do not have charging stations but want to introduce Electric Vehicle charging infrastructure to their campus.

REFERENCES

[1] Cuiyu Kong, Bhaskar P. Rimal, Martin Reisslein, Martin Maier, Islam Safak Bayram and Michel Devetsikiotis, “Cloud-Based Charging Management of Heterogeneous Electric Vehicles in a Network of Charging Stations: Price Incentive vs. Capacity Expansion,” in IEEE Transactions on Services Computing, vol. 15, no.3, 01 May-June 2022.

[2] Y. Sugii, K. Tsujino and T. Nagano, "A genetic-algorithm based scheduling method of charging electric vehicles," IEEE SMC'99 Conference Proceedings. 1999 IEEE International Conference on Systems, Man, and Cybernetics (Cat. No.99CH37028), Tokyo, Japan, 1999, pp. 435-440 vol.4, doi: 10.1109/ICSMC.1999.812443.

[3] C. Hutson, G. K. Venayagamoorthy and K. A. Corzine, "Intelligent Scheduling of Hybrid and Electric Vehicle Storage Capacity in a Parking Lot for Profit Maximization in Grid Power Transactions," 2008 IEEE Energy 2030 Conference, Atlanta, GA, USA, 2008, pp. 1-8, doi: 10.1109/ENERGY.2008.4781051.

[4] K. Clement, E. Haesen and J. Driesen, "Coordinated charging of multiple plug-in hybrid electric vehicles in residential distribution grids," 2009 IEEE/PES Power Systems Conference and Exposition, Seattle, WA, USA, 2009, pp. 1-7, doi: 10.1109/PSCE.2009.4839973.

[5] O. Sundström and C. Binding, "Planning electric-drive vehicle charging under constrained grid conditions," 2010 International Conference on Power System Technology, Zhejiang, China, 2010, pp. 1-6, doi: 10.1109/POWERCON.2010.5666620.

[6] P. Sánchez-Martín and G. Sánchez, "Optimal electric vehicles consumption management at parking garages," 2011 IEEE Trondheim Powertech, Trondheim, Norway, 2011, pp. 1-7, doi: 10.1109/PTC.2011.6019396.

[7] I. S. Bayram and A. Tajer, “Plug-in Electric Vehicle Grid Integration. Artech House, Norwood, MA, 2017.

[8] Y. He, B. Venkatesh, and L. Guan, “Optimal scheduling for charging and discharging of electric vehicles,” IEEE Trans. Smart Grid, vol. 3, no. 3, pp. 1095–1105, 2012.

[9] H. Hu, Y. Wen, L. Yin, L. Qiu, and D. Niyato, “Coordinating workload scheduling of geo-distributed data centers and electricity generation of smart grid,” IEEE Transactions on Services Computing, in print, 2020.

[10] R. Kaewpuang, S. Chaisiri, D. Niyato, B. Lee, and P. Wang, “Cooperative virtual machine management in smart grid environment,” IEEE Transactions on Services Computing, vol. 7, no. 4, pp. 545–560, Oct 2014.

[11] M. S. Kuran, A. C. Viana, L. Iannone, D. Kofman, G. Mermoud, and J. P. Vasseur, “A smart parking lot management system for scheduling the recharging of electric vehicles,” IEEE Trans. Smart Grid, vol. 6, no. 6, pp. 2942–2953, 2015.

[12] P. Rezaei, J. Frolik, and P. D. Hines, “Packetized plug-in electric vehicle charge management,” IEEE Trans. Smart Grid, vol. 5, no. 2, pp. 642– 650, 2014.

[13] E. Yao, V. W. Wong, and R. Schober, “Robust frequency regulation capacity scheduling algorithm for electric vehicles,” IEEE Trans. Smart Grid, vol. 8, no. 2, pp. 984–997, 2017.

[14] W. Tang and Y. J. Zhang, “Online electric vehicle charging control with multistage stochastic programming,” in Proc., IEEE CISS, 2014, pp. 1–6.

[15] B. Sun, Z. Huang, X. Tan, and D. H. K. Tsang, “Optimal scheduling for electric vehicle charging with discrete charging levels in distribution grid,” IEEE Transactions on Smart Grid, vol. 9, no. 2, pp. 624–634, 2018.

[16] R. Mehta, D. Srinivasan, A. M. Khambadkone, J. Yang, and A. Trivedi, “Smart charging strategies for optimal integration of plug-in electric vehicles within existing distribution system infrastructure,” IEEE Transactions on Smart Grid, vol. 9, no. 1, pp. 299–312, 2018.