

Optimal Sizing of Battery Storage Units Integrated Into Fast Charging EV Stations

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Abstract—The paper brings a mixed integer linear programming (MILP) solution for defining optimal size and operational strategy of battery storage systems (BSS) integrated with fast charging electric vehicle stations (FCS). The idea emerged as a solution for issues arising from strategies promoting installations of fast charging electric vehicle stations. Short, high power period peaks of fast charging increase the volatility of voltage in distribution networks and result in line congestions, requiring grid reinforcements by the distribution system operator (DSO). Additionally, transmission system operators (TSO) need to treat these power spikes, characterized by uncertainty of occurrence, by ensuring additional system flexibility. Coupling battery storage systems with FCS so that they serve as a buffer between the power system, reducing the stress of fast charging, and the electric vehicle (EV) users, providing the desired comfort in terms of charging speed, create multiple benefits for system participants. The results of the developed optimization model demonstrate that there is a feasible investment case for the proposed concept even in cases where only energy arbitrage is in place. Uncertainty aspects, such as unknown time of EV arrival or energy required by EVs, are considered for multiple locations where FCS are going to be installed.

Keywords—battery storage; electric vehicles; mixed integer linear programming; uncertainty;

NOMENCLATURE

Indices and Sets:

$t \in T$	Time
$i \in I$	Cars
$s \in S$	SOC scenarios
$v \in V$	Time scenarios

Parameters:

$P_{ch}(t,s,v)$	Charging power of the BSS in minute t of SOC scenario s and time scenario v
$P_{dis}(t,s,v)$	Discharging power of the BSS into car in minute t of SOC scenario s and time scenario v

$SOC(t,s,v)$	State of charge of the BSS in minute t of SOC scenario s and time scenario v
$SOC_{car}(i,t,s,v)$	State of charge of the car i in minute t of SOC scenario s and time scenario v
$CarCapacity(i)$	Car i battery capacity
Bat_cap	Capacity of the BSS
SOC_{min}	Minimum BSS state of charge, dependant on battery technology
$P_{max}(i)$	Maximum charging power of car i
Operational cost	Electricity cost for FCS with BSS
t_0	Beginning of charging process
t_e	End of charging process
$percentage_t_0(i,s,v)$	SOC percentage of car i at the beginning of charging process of SOC scenario s and time scenario v
$percentage_t_e(i,s,v)$	Demanded SOC percentage of car i at the ending of charging process of SOC scenario s and time scenario v

I. INTRODUCTION

Regulatory changes encouraging reduction of fossil fuel consumption and CO₂ emissions, in which personal vehicles have a large percentage, are causing a disruption in traditional way the power system has been planned and operated. The emerging growth of renewable energy source share in the energy mixes around the world is expected to be followed by electrification of transport [1]. While numbers of electric vehicles (EV) on roads today are still low, lessons learned from renewable energy sources (RES) integration suggest that disruptive technologies do not follow trend forecasts and similar patterns can be expected with EV. This goes hand in hand with goals, stated by several countries, of completely banning fossil fuel transportation in the upcoming years [2]. Vehicles powered by an electric motor have proved to be superior to Internal Combustion Engine (ICE) vehicles in both environmental (ICE are responsible for 12% of total CO₂ emission in the European

Union [3]) and driving experience aspect. The main disadvantages of EVs are their energy tanks, batteries, which today are still not comparable to conventional fuel tanks. To initiate the spark of transport electrification, the focus is put on installing publicly available fast charging electric vehicle stations at locations with frequent traffic. While this might encourage wider adoption of EV by final users, charging an EV at super-fast charging stations, with power up to 120 kW, may result in disturbance to the power grid such as power unbalances, voltage drops and frequency fluctuation [4]. The unpredictability of charging timetable, combined with high power demand for fast charging, enhances above mentioned problems. On the other hand, by increasing controllability and predictability of EV arrival and charging, the entire power system benefits from a new source of flexibility [5], [6], [7], [8]. This potentially is significant, as in 2015 there were 28.000 publicly available fast charging outlets [9] with numbers growing exponentially [10]. Due to the expected increase of EV stock [11], fast charging stations network will have to significantly expand. Therefore, it is necessary to find a solution for adequate integration of fast charging stations in the electric power system.

An interesting solution, analyzed in this paper, is integrating a battery storage system within the fast charging station. The battery storage system would serve as a buffer between the distribution grid (potentially also the transmission grid) and the final user. The charging power could be controllable and therefore much lower than if there was no battery within the FCS, while charging would occur even during periods when vehicles are not connected to the station, ensuring the battery storage system has sufficient energy to fast charge the EV when required. Several papers have proposed solutions for large scale integration of FCS, focusing mostly on planning [12], optimal placement [13] or market participation of aggregated FCS [14]. Some researchers have already considered integrating BSS with FCS, however they either focus on control strategies for such systems [15], or battery technology selection [16]. The only paper that deals with BSS optimal sizing and operational strategy, to the authors knowledge, is [17]. However, the authors of [17] neglect the uncertainty of EV arrival and state-of-charge (SOC) at the FCS as well as impact of injected power which is charged by the Distribution/Transmission System Operator (DSO/TSO).

In the line with the above, the paper brings the following contributions:

- We provide a mixed integer linear programming model for dimensioning the optimal capacity of the battery storage system integrated in the FCS. The model captures operating strategy for the BSS making sure the stress on the distribution grid (and consequently on the rest of the power system) is reduced while maintaining the desirable comfort level for the EV users. The model captures uncertainties related to time of arrival and state-of-charge of EV batteries.
- We assess the profitability of investment in such a charging station (with integrated BSS) for different locations and frequency of traffic and EV charging. It needs to be recognized that the investment is based on

both energy arbitrage and power taken from the network and charged by the system operator.

The paper is organized as follows: Section II describes modelling and optimization of BSS size, Section III shows the results of several scenarios and analyzes the impact of uncertainty parameters while Section IV provides most relevant conclusions.

II. MODEL DESCRIPTION

A. Optimization model

To evaluate the idea of a battery storage system within FCS, an optimization model is defined with technical and economic characteristics of the charging station. The mathematical model captures physical boundaries and possibilities of the charging station as well as that of BSS and arriving EVs.

The objective of the optimization model is to minimize the operational cost of electrical energy for charging EV. This objective is used since a significant cost difference can be achieved by buying electricity during low market prices. Prices used in this model are Day Ahead (DA) prices at EPEX SPOT [18] market. Operational cost is defined as following (1):

$$\text{Operational Cost} = \sum_{t=1}^T Pch(t) * DAprice(t) \quad (1)$$

To get another perspective of the economics, net present value (NPV) is calculated for each simulation (2). Calculating the NPV is an economics method of evaluating the profitability of an investment. NPV is the difference between the present value of cash inflows and the present value of cash outflows over a period of time [19]. To demonstrate the operational perspective, time step T is 1 hour for one full day, while in case of optimal decisions and NPV calculations, minimization of objective function is run over the entire year for 8760 hours.

$$NPV = -Investment + \sum_{i=1}^n \frac{Cashflow_i}{(1+r)^i} \quad (2)$$

Regular fast EV charging stations have direct grid connection, therefore they are billed, by their energy supply company, with a fee for the peak demanded power. In Croatia, for peak power above 20 kW, a monthly fee of 6€/kW for measured peak power has to be paid [20]. Therefore, absence of payment of this fee for integrated BSS and FCS will be included in calculating income as well as the difference between daily electricity cost for FCS with and without battery storage system.

The main outcome is the cost of investment in the battery storage. In this calculation, the battery price of 132 €/kWh is used [21]. Investment is approximated to last 10 years at discount rate of 5%. It should be noted that charging and discharging patterns have impact of the lifetime of BSS, however in this paper this is not considered.

B. FCS location and charging modelling

Several scenarios for modelling operational behavior are implemented by using stochastic programming, which allows modelling of imperfect knowledge of parameters. While in this

paper uncertainties are defined by probability distribution of each scenario, other probability distributions could be applied as well. The proposed concept is demonstrated for three different locations since every location is characterized by different patterns and schedules of car arrivals, based on specifics of the location. For each of the locations, the following parameters are inputs to the algorithm:

- Arrival time
- Departure time
- SOC at the time of arrival
- Requested SOC at end
- Type of car

Three popular locations for an EV charging station are described below. Default schedules for each location, as well as initial and final SOC of arriving cars are presented in Table I, II and III.

Location I: Charging station along the highway

- Open 0-24h
- Minimum charging time due to customers' wish to finish the trip as soon as possible

Location II: Charging station within a shopping center

- Open 07-22h
- Significantly longer charging time, 60-90 minutes, due to customers' shopping time habits

Location III: Charging station at a restaurant's parking lot

- Open 10-24h
- Rush hour for lunch time, 12-15h, and dinner time, 20-24h

TABLE I SCHEDULE OF ARRIVAL AT LOCATION I

Vehicle type	Arrival time	Departure time	Initial SOC	Final SOC
Tesla	02:00	02:45	35%	80%
BMW	04:00	04:30	20%	55%
VW	06:00	06:45	10%	85%
Tesla	07:30	08:15	10%	65%
Nissan	09:00	09:30	30%	70%
Tesla	10:00	10:30	30%	65%
VW	12:30	13:00	40%	85%
BMW	13:00	14:00	5%	95%
Tesla	15:30	16:15	20%	75%
Nissan	16:15	17:00	20%	80%
BMW	18:00	19:00	10%	80%
Nissan	19:00	20:00	25%	90%
VW	20:00	20:30	45%	80%
Tesla	21:30	22:00	20%	60%

VW	22:30	23:30	5%	60%
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TABLE II SCHEDULE OF ARRIVAL AT LOCATION II

Vehicle type	Arrival time	Departure time	Initial SOC	Final SOC
VW	07:00	08:00	15%	90%
Tesla	08:00	08:30	65%	85%
Nissan	09:30	10:30	30%	85%
Nissan	10:30	11:30	50%	90%
Tesla	12:00	13:30	5%	95%
BMW	14:30	15:30	40%	90%
VW	15:30	16:30	40%	80%
Tesla	17:00	18:00	50%	90%
Nissan	18:00	19:30	20%	95%
VW	20:30	21:30	25%	80%
Tesla	21:30	22:00	45%	65%

TABLE III SCHEDULE OF ARRIVAL AT LOCATION III

Vehicle type	Arrival time	Departure time	Initial SOC	Final SOC
BMW	10:00	10:30	25%	60%
Nissan	10:30	11:00	40%	70%
Tesla	12:00	12:45	40%	80%
Nissan	12:45	14:00	25%	90%
Tesla	14:00	15:00	55%	95%
BMW	17:00	18:00	55%	90%
BMW	19:15	20:00	20%	50%
Tesla	20:00	21:00	65%	95%
VW	21:00	22:00	30%	75%
VW	22:00	23:00	45%	95%
Nissan	23:00	24:00	10%	80%

Times of arrival and departure, as well as the initial SOC of the car battery are modelled as uncertain parameters. For example, in case of SOC, the parameters will deviate from the default values for a randomly defined value within limits. For time of arrival and departure these limits are defined as ± 15 minutes while initial SOC can vary up to $\pm 28\%$. There are total of 16 different scenarios and each scenario is equally probable.

Four different car models are used in this model, technical details are listed in Table IV:

TABLE IV CAR SPECIFICATIONS

Model	Battery capacity [kWh]	Maximum charging power [kW]
Tesla model S P85D	85	120
Volkswagen E-Golf	35.8	50
Nissan Leaf	30	50
BMW i3	33	50

For each car there is a different charging curve (3-6) that is approximated using available data [22], [23], [24], [25].

Tesla model S:

$$P_{dis}(t) = -1062 * \frac{SOC_{car}(Tesla,t)}{CarCapacity(Tesla)} + P_{max}(Tesla) \quad (3)$$

Volkswagen E-Golf

$$P_{dis}(t) = -250 * \frac{SOC_{car}(VW,t)}{CarCapacity(VW)} + P_{max}(VW) \quad (4)$$

Nissan Leaf

$$P_{dis}(t) = -420 * \frac{SOC_{car}(Nissan,t)}{CarCapacity(Nissan)} + P_{max}(Nissan) \quad (5)$$

BMW i3

$$P_{dis}(t) = -305 * \frac{SOC_{car}(BMW,t)}{CarCapacity(BMW)} + P_{max}(BMW) \quad (6)$$

C. FCS and battery modelling

BSS, within the charging station, is charged from the grid with power up to 19 kW in order to avoid additional costs for power and to reduce previously elaborated negative impacts on the distribution grid (7):

$$0 \text{ kW} \leq P_{ch}(t,s,v) \leq 19 \text{ kW} \quad (7)$$

The charging station is designed for fast charging with maximal output up to 120 kW, meaning the end-user, in this case the EV, can be charged with 120 kW from the BSS of FCS (8):

$$0 \text{ kW} \leq P_{dis}(t,s,v) \leq 120 \text{ kW} \quad (8)$$

The state of charge of the BSS can be from SOCmin to battery capacity (9):

$$SOC_{min} \leq SOC(t,s,v) \leq Bat_cap \quad (9)$$

BSS state of charge is defined as (10):

$$SOC(t,s,v) = SOC(t-1,s,v) + P_{ch}(t,s,v) - P_{dis}(t,s,v) \quad (10)$$

SOC of car i in time t is defined as SOC of the same car i in time $t-1$ plus charging of the car at that moment (11):

$$SOC_{car}(i,t,s,v) = SOC_{car}(i,t-1,s,v) + P_{dis}(t,s,v) \quad (11)$$

At the beginning of charging a vehicle, its SOC is defined as in (12):

$$SOC_{car}(i,t_0,s,v) = percentage_{t_0}(i,s,v) * CarCapacity(i) \quad (12)$$

Every vehicle must be charged to its demanded value (13):

$$SOC_{car}(i,t_e,s,v) = percentage_{t_e}(i,s,v) * CarCapacity(i) \quad (13)$$

Initial conditions at the beginning of the day are given with (14) and (15):

$$SOC(0,s,v) = 0 \quad (14)$$

$$P_{ch}(0,s,v) = 0 \quad (15)$$

III. RESULTS

A. Optimization results

Optimization results for each location are presented in Table V. Presented data shows operational cost of a single FCS with battery system and without battery system, lowest operational cost, battery size, maximum car charging power for given schedules and scenarios and minimum battery capacity, which is the minimum capacity required to meet all charging demands stated in schedules of arrivals in Tables I, II and III, including all possible uncertainty scenarios, with respect to defined constraints in Section II C.

TABLE V SIMULATION RESULTS

	Location I	Location II	Location III
Operational cost [€/year]	4993.20	3080.6	2062.25
Operational cost without BS [€/year]	5504.20	4263.2	3062.35
Battery capacity [kWh]	76.58	133.00	133.00
Maximum charging power [kW]	109.4	114.7	84.7
Minimum battery capacity [kWh]	39.50	48.00	30.50

Figure 1 presents battery charge (power from the distribution grid) and discharge power (power charging the EV), while Figure 2 presents SOC of battery and prices of electricity during a single day for one selected scenario in Location I.

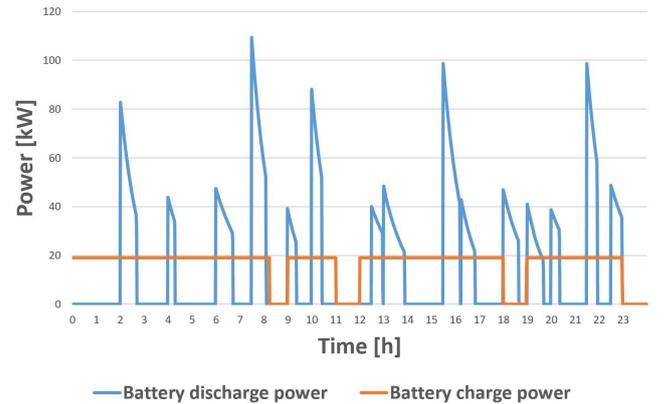


Figure 1 Battery charge and discharge power – Location I

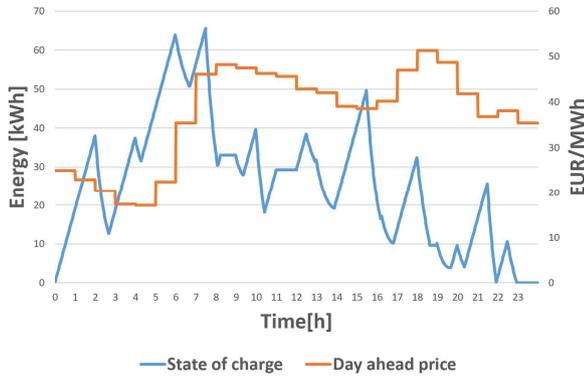


Figure 2 Battery SOC and electricity prices – Location I

As seen in Figures 1 and 2, battery was charged with maximum power during most hours of the day, trying to avoid periods of electricity peak prices. In case when only minimization of operational cost is considered as the objective function, without the investment cost of BSS, battery capacities are notably higher, up to 133 kWh. Batteries of these size cost a lot of money, but are not necessary to fulfill all EV charging demands during the day. To compare profits, simulations with the same objective as stated in (1), but including investment aspects are shown in the next subsection.

B. Optimal battery size considering investments

For each location six simulations are made. The starting size is the minimum capacity, as shown in Table 5 and explained in the previous paragraph, analyzing additional battery sizes in steps of 20 kWh capacity, namely: 55, 75, 95, 115 and 135 kWh. The results of minimum operational cost optimization are shown in Figure 3. Net present values are graphically presented in Figure 4. Higher battery capacity results in lower operational cost, since the potential to buy electricity during non-peak hours is greater with larger battery. On the other hand, batteries with larger capacity result in lower NPV. Highest NPV for all 3 locations is with the minimal battery capacity as shown in Figure 4.

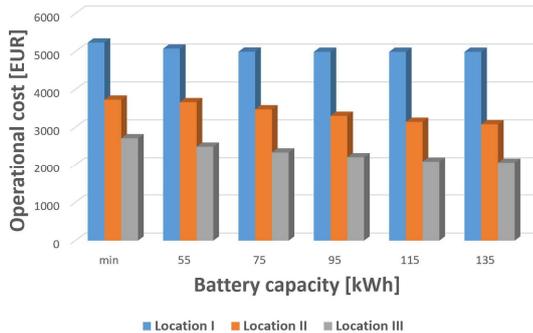


Figure 3 Yearly operational cost

C. Payback period

Another procedure used for economic evaluation is discounted payback period (DPP), giving insight into number of years for the discounted future cash flows to break even with initial investment. It is interesting to notice in Figure 5, where DPP for all observed locations and battery capacities are

presented, that the minimum size battery storage has a short payback period (under one year) for all analyzed scenarios.

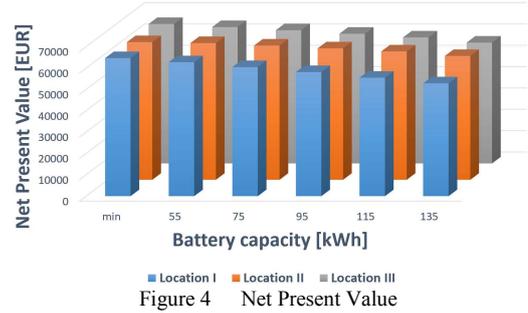


Figure 4 Net Present Value

D. Look into the future

Battery prices are expected to fall to 60€/kWh by 2030, according to [21]. It can also be assumed that EV stock will significantly increase and consequentially the usage of FCS will increase. Additional simulations to estimate fast charging in 2030 are made, with previously mentioned battery prices and 50% increase in number of EV served during a single day. It should be mentioned that an approximation was done here, taking same electricity prices as they are today (same as in previous simulations). Forecasting future market prices is outside of the scope of this paper.

FCS at Location I could not fulfill all the demands. Due to the BSS charging power limit to 19 kW, the FCS can daily deliver maximum 456 kWh of energy (which is equal to the product off BSS charging power limit and 24 hours). An increase of 50% in Location I means that total energy demand is higher than maximum possible.

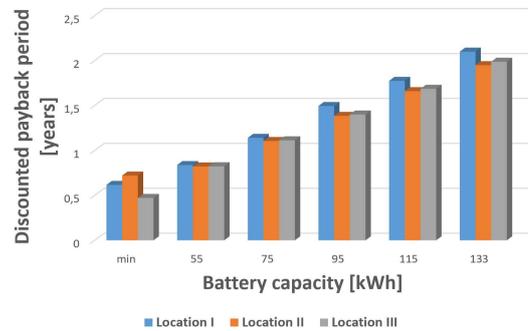


Figure 5 Discounted payback period

TABLE VI SIMULATION RESULTS FOR 2030

	Location I	Location II	Location III
Operational cost [€/year]	/	4901.95	3106.15
Operational cost without BS [€/year]	/	6007.90	4103.70
Battery capacity [kWh]	/	133.00	133.00
Minimum battery capacity [kWh]	/	87.40	50.50
Net present value [EUR]	/	67276	66430

FCS at locations II and III successfully delivered all requested energy. Operational cost, optimal battery capacity, minimum battery capacity and NPV for 2030 with predicted battery price of 60€/kWh are presented in Table VI. Again, the minimum size battery unit complying with all constraints is the optimal solutions considering both minimization of operational costs and investments. However, more frequent arrival schedule resulted in larger battery capacity. On the other hand, due to lower battery investment costs, NPVs have increased.

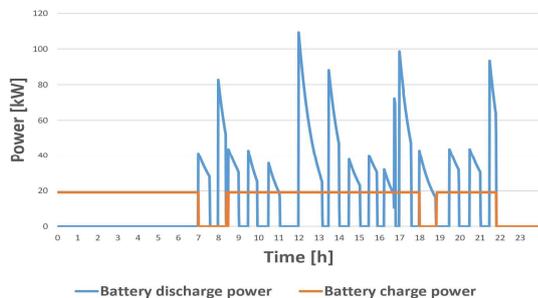


Figure 6 Battery charge and discharge power – Location II 2030

Figure 6 shows charging and discharging power for one scenario in Location II. It is shown that the BSS was charging from the distribution grid during more than 80% of the available time, so there is very little space for further increase of number of EVs charging in single day. It should be noted that the such frequent arrival schedules should also be an indicator for new FCS installations if the comport of EV owners is to remain the same.

IV. CONCLUSION

The proposed concept of integrating a battery storage system into EV fast charging station offers an additional level of controllability and flexibility to otherwise another source of uncertainty in future power systems. Despite the positive impact on the power grid as well as the electric power system, the question is if such an investment is feasible from the economic aspect. The analyses performed in this paper clearly show a positive NPV and DPP already for the smallest battery storage system that complies with technical constraints and does not compromise final EV user comfort. The operational strategy shows that installing BSS units results in steady and constant loading towards the upstream power system, however further quantifications have not been performed.

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REFERENCES

[1] "Electrification of the Transport System Studies and reports." [Online]. Available: https://www.ieee.org/about/ieee_europe/electrification_of_transportation_15_november_2017.pdf
 [2] A. Petroff, "These countries want to ban gas and diesel cars," *CNNMoney*,

2017. [Online]. Available: <http://money.cnn.com/2017/09/11/autos/countries-banning-diesel-gas-cars/index.html>
 [3] PBL Netherlands Environmental Assessment Agency and Joint Research Centre, "Trends in Global CO2 Emissions 2016 Report," pp. 6–86, 2016. [Online]. Available: http://edgar.jrc.ec.europa.eu/news_docs/jrc-2016-trends-in-global-co2-emissions-2016-report-103425.pdf
 [4] I. Pavić, T. Capuder, I. Kuzle, "A Comprehensive Approach for Maximizing Flexibility Benefits of Electric Vehicles," *IEEE Systems Journal*, August 2017 pp. 1–12, 2017.
 [5] T. Capuder, I. Kuzle, and I. Pavić, "Value of flexible electric vehicles in providing spinning reserve services," *Applied Energy*, vol. 157, pp. 60–74, 2015.
 [6] T. Capuder, I. Kuzle, and I. Pavić, "Low carbon technologies as providers of operational flexibility in future power systems," *Applied Energy*, vol. 168, pp. 724–738, 2016.
 [7] Y. Xiang, J. Liu, R. Li, F. Li, C. Gu, and S. Tang, "Economic planning of electric vehicle charging stations considering traffic constraints and load profile templates," *Applied Energy*, vol. 178, pp. 647–659, 2016.
 [8] F. Teng, Y. Mu, H. Jia, J. Wu, and P. Zeng, "Challenges of Primary Frequency Control and Benefits of Primary Frequency Response Support from Electric Vehicles," *Energy Procedia*, vol. 88, pp. 985–990, 2016.
 [9] International Energy Agency, "Global EV Outlook 2016 Electric Vehicles Initiative," *Iea*, p. 51, 2016. [Online]. Available: https://www.iea.org/publications/freepublications/publication/Global_EV_Outlook_2016.pdf
 [10] Chargemap, "Recharge stations statistics." [Online]. Available: <https://chargemap.com/about/stats>
 [11] I. E. A. International and E. Agency, "Global EV Outlook 2017 Two million and counting," 2017. [Online]. Available: <https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf>
 [12] H. Zhang, S. J. Moura, Z. Hu, "A Second Order Cone Programming Model for Planning PEV Fast-Charging Stations," *IEEE Transactions on Power Systems*, vol. 8950, pp. 1–14, 2017.
 [13] Y. Xiong, J. Gan, B. An, C. Miao, and A. L. C. Bazzan, "Optimal Electric Vehicle Fast Charging Station Placement Based on Game Theoretical Framework," *IEEE Transactions on Intelligent Transportation Systems*, pp. 1–12, 2017.
 [14] M. R. Sarker, Y. Dvorkin, M. A. Ortega-Vazquez, "Optimal Participation of an Electric Vehicle Aggregator in Day-Ahead Energy and Reserve Markets," *Power and Energy Society General Meeting (PESGM)*, 2016, Boston, USA, vol. 31, no. 5, pp. 3506–3515, 2016.
 [15] B. Sun, T. Dragičević, F. D. Frejedo, J. C. Vasquez, J. M. Guerrero, "A Control Algorithm for Electric Vehicle Fast Charging Stations Equipped with Flywheel Energy Storage Systems," *IEEE Transactions on Power Electronics*, vol. 31, no. 9, pp. 6674–6685, 2016.
 [16] J. Deng, J. Shi, Y. Liu, and Y. Tang, "Application of a hybrid energy storage system in the fast charging station of electric vehicles," *IET Generation, Transmission & Distribution*, vol. 10, pp. 1092–1097, 2016.
 [17] S. Negarestani, M. Fotuhi-Firuzabad, M. Rastegar, A. Rajabi-ghahnavieh, "Optimal Sizing of Storage System in a Fast Charging Station for Plug-in Hybrid Electric Vehicles," *IEEE Transactions on Transportation Electrification*, vol. 2, no. 4, pp. 443–453, 2016.
 [18] EPEX, "Day-Ahead auction," *EPEXSPOT*, 2018. [Online]. Available: <https://www.epexspot.com/en/market-data>
 [19] Investopedia, "Net Present Value," *Net Present Value*. [Online]. Available: <https://www.investopedia.com/terms/n/npv.asp>
 [20] HEP, "Tarifne stavke(cijene)." [Online]. Available: <http://www.hep.hr/ods/korisnici/poduzetnistvo/tarifne-stavke-cijene-161/161>.
 [21] C. Curry, "Lithium-ion Battery Costs and Market," 2017. [Online]. Available: <https://data.bloomberglp.com/bnef/sites/14/2017/07/BNEF-Lithium-ion-battery-costs-and-market.pdf>
 [22] "Tesla Supercharger Charging Rate." [Online]. Available: <https://insideevs.com/tesla-ups-supercharger-charging-rate-refreshed-model-s-90d-p90d-video/>.
 [23] T. Saxton, "DC fast charging billing models and encouraging efficient usage." [Online]. Available: <https://chargedevs.com/features/dc-fast-charging-billing-models-and-encouraging-efficient-usage/>.
 [24] "E-Golf DC fast charging." [Online]. Available: <http://www.mywegolf.com/forum/viewtopic.php?f=12&t=444>.
 [25] "DC fast charging." [Online]. Available: http://electrifyatlanta.com/wp/?page_id=357.