POLICY ADVICE PAPER
REVIEW OF ELECTRIC VEHICLE CHARGING STATION LOCATION METHODS

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LIST OF ABBREVIATIONS

EU	European Union
EV	Electric vehicle
GHG	Greenhouse gas
GIS	Geographic information systems
ICEV	Internal-combustion-engine vehicle
V2G	Vehicle-to-grid

Executive Summary

This policy advice paper aims to provide guidance for policymakers who are interested in deploying electric vehicle (EV) charging stations in their regions. EVs are considered a greener alternative to traditional internal-combustion-engine vehicles (ICEVs), as they produce zero tailpipe emissions and can help reduce greenhouse gas (GHG) emissions from the transport sector. However, the adoption of EVs is hindered by the lack of adequate and accessible charging infrastructure, which can cause range anxiety and inconvenience for potential EV users. Therefore, planning for optimal charging station siting is an essential task for policymakers who aim to promote EV adoption and achieve their emission reduction targets.

A comprehensive and evidence-based analysis of the EV charging station location problem is provided, drawing on a literature review of academic papers on the topic. By expanding and optimising charging infrastructure, more people will be encouraged to switch to EVs, thus reducing GHG emissions from the transport sector and contributing to the mitigation of climate change. The transition from ICEVs to EVs is a crucial step towards the decarbonisation of transport and the achievement of GHG emission reduction targets.

The policy recommendations outlined in the paper are:

1. **Employ a data-driven approach for planning EV charging station siting.** To be efficiently located, charging stations need to be planned with a data-driven approach. Statistics on electricity demand, vehicle fleet characteristics, and the supply of semi-public and private charging facilities can be used to identify points of charging demand in a study region. Real-world travel data can help understand where EV drivers spend significant time, indicating suitable places for deploying charging stations.

2. **Plan for charging infrastructure deployment over time.** A multi-periodic approach can account for the predicted evolution of the EV market, as well as the changes in mobility patterns, electricity demand, and grid capacity over time. This can help avoid over-investing in infrastructure that may become under-utilised or obsolete, or under-investing in infrastructure that may cause bottlenecks or reliability issues. Genetic algorithms can be employed to model optimal locations in different time horizons, allowing for plans to be adjusted accordingly.

3. **Consider the interaction between transportation and power distribution networks.** To mitigate adverse effects of EV charging on the power grid, not only data on mobility patterns should be considered for choosing ideal charging station locations, but also on the local electricity demand and the hosting capacity of the electricity network. By optimising infrastructure use, potential risks to the stability and dependability of the electricity system can be mitigated.

4. **For most cases, regular charging infrastructure should be preferred over fast charging infrastructure.** In contrast to fast charging equipment, regular charging equipment exerts less pressure on the electricity network, provides greater efficiency,

and slows EV battery degradation. Strategically placing regular charging equipment could enhance charging infrastructure coverage while minimising both the investment costs and the burden on the power grid. Fast charging equipment deployment should be orientated by the need to meet certain performance criteria, such as offering quick partial recharging for taxis and city busses.

1. Introduction

To mitigate climate change, different countries have set greenhouse gas (GHG) emission reduction targets for the course of the next decades. China, the world's biggest source of GHG emissions, has committed to reaching its highest level of CO2 emissions before 2030 and to becoming carbon neutral before 2060 (IEA, 2021), while the United States, the world's largest economy, has a goal of cutting GHG emissions by 50-52% by 2030, compared to 2005 levels, and becoming carbon neutral by 2050 (U.S. Government, 2021). Likewise, the European Union (EU) has set the goal to become climate neutral by 2050, introducing the "Fit for 55" legislative package with the aim of reducing GHG emissions by 55% by 2030, from 1990 levels. The European package, more specifically, encompasses a prohibition on the selling of internal-combustion-engine vehicles (ICEVs) by 2035, as well as a new regulation for the deployment of alternative fuels infrastructure (AFIR) for electric vehicles (EVs) and hydrogen-powered vehicles along European roads (European Commission, 2023).

Over the past decade, EVs, touted as a greener alternative to traditional ICEVs, have seen increasing vehicle fleet penetration rates. Governmental policies aimed at reducing greenhouse GHG emissions around the globe usually promote fleet electrification as one way of helping achieve their targets, with tax incentives commonly proposed with the goal of accelerating the transition from ICEVs to EVs.

While the transportation sector is one of the largest contributors to GHG emissions, EVs produce zero tailpipe emissions. Xia et al. (2022) conducted a literature review on studies that analysed the lifecycle GHG emissions of EVs in different countries, finding that EVs have lower lifecycle GHG emissions than ICEVs in countries with a low share of coal-fired power in the electricity mix. Thus, encouraging the transition from ICEVs to EVs can contribute to the reduction of GHG emissions within the transport sector in regions where the electricity mix is predominantly composed of low-emission power sources such as hydroelectric, solar, wind, and nuclear.

However, such transition is currently hampered by the suboptimal availability and location of charging stations. Range anxiety, or the fear that the vehicle's range will be insufficient to cover the distance to a desired destination, is a significant barrier for the deployment of EVs, which can be overcome by the increased availability of charging infrastructure (Transportation Research Board and National Research Council, 2015). Research shows that expanding charging infrastructure is more effective than improving EV driving range for tackling the issue of range anxiety (He & Hu, 2023).

It is important to note that by alleviating range anxiety through the expansion of charging infrastructure, the need for larger battery packs in EVs could be reduced. The production of lithium-ion batteries requires the extraction and processing of minerals such as lithium, cobalt, and nickel, which involve significant energy, water, and land use. Charging infrastructure expansion could potentially enable manufacturers to employ smaller batteries in future EV models, resulting in lighter, more affordable, and less resource-intensive vehicles (IEA, 2022). As high purchase prices are another factor that discourages people from buying EVs (Metais et al., 2022), expanding charging infrastructure could help promote EV adoption also in this aspect.

Moreover, besides its emission reduction benefits, the deployment of charging infrastructure can foster economic growth. It has the potential to stimulate job creation in various sectors such as manufacturing, installation, maintenance, and services (Burmahl, 2022).

One of the key challenges for the deployment of charging infrastructure is the identification of suitable sites for charging stations. Several factors need to be considered when selecting sites for charging stations, such as local traffic, population density, vehicle ownership, and travel patterns. Different methods and approaches have been proposed in the literature to address the problem of charging station site selection, using tools such as geographic information systems (GIS), optimisation models, and genetic algorithms. These methods and approaches aim to balance the trade-offs between different objectives and constraints, such as maximising the coverage and utilisation of charging stations while minimising the deployment costs and adverse impacts on the electricity grid.

As local characteristics greatly influence the optimal siting of charging infrastructure in a region, there is no one-size-fits-all solution to this problem (Barris et al., 2023). Therefore, it is essential that policymakers conduct a comprehensive and context-specific analysis of their local environments when deploying charging infrastructure. This policy advice paper delves into scientific literature to analyse the state of the art for EV charging station location planning approaches, with the aim of offering policy recommendations for charging infrastructure siting based on the current best practices.

This policy advice paper is structured as follows: Chapter 2 presents the method and approach adopted for this policy paper. Chapter 3 presents the main findings from a literature review on the EV charging station location problem, covering different requirements, objectives, and approaches used for siting decisions. Case studies are presented, demonstrating how different siting methods can be applied to find ideal charging station locations in real world scenarios. Chapter 4 provides policy recommendations for charging infrastructure siting based on the current best practices, highlighting the need for a data-driven approach that accounts for the diversity and dynamics of local contexts. Chapter 5 concludes the paper, summarising the main findings.

2. Method and Approach

A literature review was conducted on diverse EV charging station siting approaches. Scopus was the primary source for retrieving pertinent papers by using the following search terms:

- electric vehicle*, EV
- charging station*, infrastructure
- siting, location

Search terms in the same row were connected with the Boolean operator “OR” and those in different rows with “AND”. Potentially relevant studies referenced in the found papers were also searched for. This provided a comprehensive body of literature with substantial support for the literature review.

The geographical scope of the paper is global, drawing on case studies from different countries and regions that illustrate how different methods and approaches can be applied to analyse and plan EV charging infrastructure deployment. The policy paper does not provide a one-size-fits-all solution for charging station siting, as local characteristics greatly influence the optimal siting of charging infrastructure in a region. Rather, the policy paper offers a framework and recommendations for charging infrastructure siting that can be adapted to different contexts and objectives.

3. Findings

Scientific literature presents different methods and techniques for the optimal siting of charging stations. Likewise, different objectives can be elected to orientate charging station siting planning. The main findings from literature, summarised in this Chapter, have been synthesised into a straightforward framework, presented in Figure 1, to assist policymakers in deploying EV charging infrastructure.

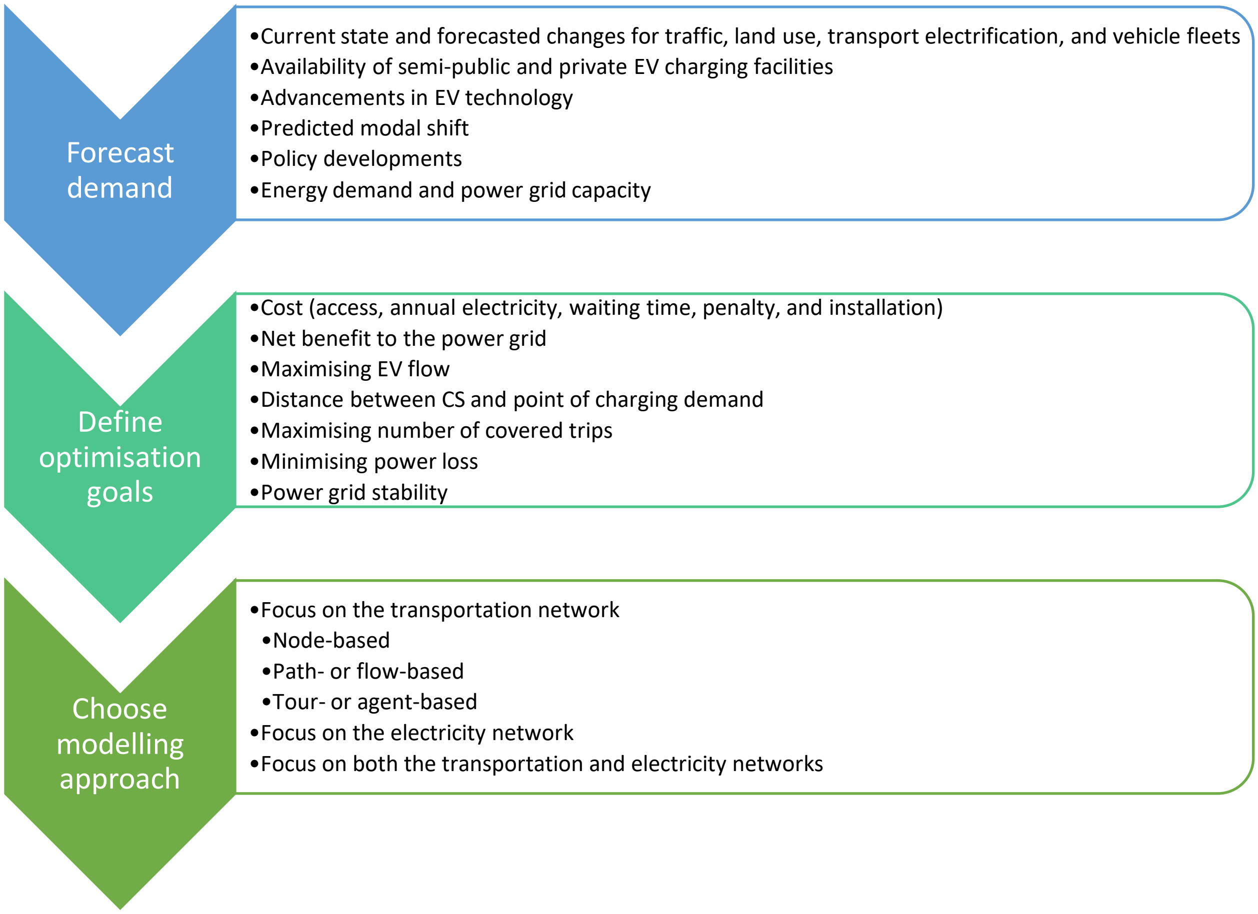

Figure 1. A framework for optimal charging station siting.

Charging infrastructure deployment is preceded by forecasting charging demand. The main factors to influence demand forecast are (Barris et al., 2023):

- Transportation data, including the amount of long-distance traffic, the number of daily commuters going to a specific area, and the current state and expected changes for traffic densities and traffic flows.
- Current and projected state of vehicle fleet electrification in the region.
- Predicted modal shifts.
- Changes in urban planning, for example, how land use is expected to evolve in certain areas of the region under analysis.
- Supply of semi-public and private charging facilities.
- Improvements in EV technology such as range, efficiency, and recharging speed.
- Transport policies such as prohibitions on the sales of ICEVs and the establishment of zero emission zones.
- Local demand for electricity, as well as power grid capacity.

Barris et al. (2023) emphasize that different regions have different needs, and there is no single solution that works for everyone. The best solutions for locating EV charging stations depend on the travel patterns of each region (how people get around, where they start and end their trips, how long they travel), how they use and drive EVs (e.g., typical driving distances), housing types, electricity availability, land features, and temperature changes. These factors influence how well EVs function and how much energy and charging they require.

Following demand forecasting, it is important to define optimisation goals associated with the deployment of charging infrastructure. They will later be translated into objective functions for charging station location modelling. Objective functions are mathematical expressions that describe the targets or criteria that a policymaker wants to achieve or optimise. In the context of charging station siting, an objective function could be to minimise the total cost of installing and operating the charging stations, or to maximise the net benefit of providing electricity to the grid from the EVs. Objective functions can be single or multiple, depending on how many optimisation goals or criteria are involved. Some of the objective functions that could be elected are (Deb et al., 2018):

- Costs, whether related to access (incurred by users for travelling from a point of charging demand to a charging station), the electricity required for operation, waiting time (incurred due to the lack of free charging spots), penalty (paid by operators for violating safe operational limits of an electricity network), and installation.
- Net benefit, when planning V2G (vehicle-to-grid) -enabled charging stations to enable EVs to supply additional electricity to the grid is an intended goal.
- EV flow, when an elected target is to place charging stations in a way that serves the greatest number of users possible.
- Distance between a point of charging demand and a charging station.
- Number of covered trips, when an objective is to minimise the time spent for EV charging for commercial fleets such as taxis, for example.
- Power loss, when planning with the goal to reduce the adverse effects that charging stations pose on the power grid.
- Power supply moment balance index, when planning with the goal of improving this index by reducing not only power loss, but also electricity supply fluctuation, and enhancing the stability of the electricity network.

Metais et al. (2022) conducted a literature review and found further natures of issues that need to be taken into account when planning EV charging infrastructure:

- Technical: there are different tiers of charging equipment, with different charging power and, consequently, charging speed.
- Charging infrastructure and EV adoption: the longer time required to recharge an EV, compared to the time required to refuel an ICEV, sets different design and management requirements for charging stations. Furthermore, while recharging times and range constraints pose a challenge to EV acceptance, deployment of charging infrastructure increases the demand for EVs.

- Economic: the investment costs of charging stations increase as the charging equipment power increases. Therefore, specific needs need to be considered for the deployment of fast charging stations, as they can lead to higher service prices and not necessarily improve the level of service.
- Electricity network: existing electricity infrastructure faces more pressure from more powerful charging equipment, incurring further costs related to strengthening the power grid. However, the authors suggest methods in which EVs could help to stabilise the power grid: by using smart grid management techniques, EV batteries could be used to store excess energy produced from renewable sources, or to provide energy to the power grid through V2G-enabled charging stations.

By considering these issues, charging infrastructure deployment can achieve a more efficient and effective allocation of resources, while still meeting the needs and expectations of EV drivers and potential adopters. This can also facilitate the integration of EVs into the electricity network, supporting the decarbonisation of transport while avoiding unnecessary costs.

Regarding the technical and economic issues related to different tiers of charging equipment, Barris et al. (2023) set out a few principles that should orientate charging infrastructure planning:

- Low-power, slow charging should be prioritised instead of high-power, fast charging. The former poses less stress on the electricity network, provides greater charging efficiency, and extends the lifetime of EV batteries.
- Full battery charging should be performed when the EV is parked at a destination (when charging can take longer), instead of during a trip (when high-power, fast charging is preferred), encouraging the deployment of lower-power, less expensive chargers in both commercial and residential districts, and private chargers at residences. This way, charging infrastructure coverage is enhanced while posing less stress on the electricity network.
- Because of its higher costs and stress posed on the electricity network, fast charging infrastructure deployment should be justified by specific necessities. Opportunity charging during long journeys, and partial recharging of commercial fleets and public transport EVs whose range is shorter than the required for daily operation are a few examples for which high-power charging stations would be preferrable. According to the authors, these stations should ideally be sited at the main roads' intersections in the outskirts of a city, and at quick stop destinations.

Following demand forecasting and the definition of objective functions, the next step is to choose a modelling approach that best suits the problem and the data availability. According to literature, there are three main categories of modelling approaches for locating charging stations, depending on the level of detail and complexity involved:

- Focus on transportation network: with the objectives of satisfying demand for EV charging, making the charging process more efficient, and improving the travel patterns for EV drivers (Unterluggauer et al., 2022), the optimal location of charging stations focused on the transportation network can be based on nodes, paths/flows, or tours/agents:

a. Node-based: facilities need to be allocated at the nodes to meet the demand estimated at each of them. Compared to other methods, the main advantage of the node-based approach is that it only requires easily accessible data on population density (Metais et al., 2022). However, as it can only portray a static estimation of the demand for EV charging, this method might not realistically portray user behaviour (Unterluggauer et al., 2022).
b. Path- or flow-based: aims to maximise the vehicle flows along trips, by allocating one or more charging station along them (Deb et al., 2018). It expects EV charging will happen during trips, which might be only suitable for fast charging infrastructure. Thus, the flow-based location approach could be more applicable to charging station planning on motorways (Unterluggauer et al., 2022).
c. Tour- or agent-based: finds optimal charging station locations based on a realistic representation of round trips and random trips. However, a significant amount of detailed data on individual trips and driving behaviour of EV users, with a large enough sample size, is required for this method (Deb et al., 2018; Metais et al., 2022). In this approach, EV charging demand is modelled by considering heterogeneous agents, with different demand preferences and socio-economic statuses (Unterluggauer et al., 2022). Agent-based models, therefore, locate charging station sites according to users' behaviours (Pagany, Ramirez Camargo, et al., 2019).

- Focus on electricity network: locating charging stations optimally with a focus on the power distribution network mainly seeks to lower the negative impacts of EV charging on the power grid, so as to avoid risks to the power system's safety and dependability. Some of the main goals to be met while choosing optimal charging station sites along the distribution network are to ensure electric tension stability and to avoid power losses (Deb et al., 2018). Other factors include the costs of connecting the charging infrastructure to the grid, the costs of strengthening the grid, the costs of operating the grid, the availability of electricity supply, and the effect of EV charging on the electricity distribution network (Unterluggauer et al., 2022).
- Focus on both transportation and power distribution networks: optimal charging station siting should consider the interaction of transportation and power distribution networks. Research works with this approach are still rare (Deb et al., 2018; Unterluggauer et al., 2022).

As demonstrated in this chapter, identifying optimal locations for charging infrastructure is not a trivial task, as it depends on the availability of data regarding numerous factors such as travel behaviour, land use, socio-economic characteristics, budget constraints, and existing electricity network capacity. Chapter 3.1 presents case studies which demonstrate some of the existing methods and tools that have been developed to address this challenge.

3.1. Case studies

The following four case studies, retrieved from scientific literature, approach the issue of EV charging station location planning by examining real-world scenarios in different regions and countries around the globe. The studies present diverse strategies on how to optimally locate EV charging stations, depending on data availability for demand estimation, the selected objective functions, and the chosen modelling approach – the main factors outlined in the framework presented in Chapter 3.

Fast charging infrastructure planning considering transportation and electricity networks

Kong et al. (2019) proposed a simulation framework to find optimal sites for EV fast charging stations, taking into account, among other factors, how they affect the stability of the power grid: one of the main requirements set in the study is that the voltage deviation never exceeds 7% when a charging station is fully used during peak times.

The simulation framework has a modular structure and could potentially be transferred to other cities or regions. In the top layer of the framework, a construction cost model is set up to show the total costs associated to the deployment of charging stations, including land, charging infrastructure, and auxiliary infrastructure costs. In the bottom layer of the framework, an operational cost model was developed to simulate the operation of charging stations and its effects on users, vehicles, traffic flow, and the electricity network.

A simulation was carried on a case study area in Beijing, China, where EV fleet penetration is expected to grow. The authors adopted a flow-based approach: dynamic vehicle flow with more than 11,500 EVs with random starting points, destinations, and state of charge, was included in the simulation. Factors such as charging power and price are considered. In an effort to reflect the real-time conditions of the transport and electricity systems, charging demand is based on dynamic real-time data, rather than statistical data: the dynamic traffic flow and the interaction between an EV's current location, its destination, and the potential charging station locations are considered.

Results indicated that the proposed approach could improve the economic appeal for operators, ensure user satisfaction, maintain traffic flow, and preserve the safety of the electricity network. The most suitable locations for charging stations were defined based on the lowest operating cost. The method also allowed to match the sizes of charging stations to the amount of EVs served, achieving a rational allocation of charging resources.

Identifying locations with the highest EV charging demand in southeast Germany

Pagany, Marquardt, et al. (2019) developed the Electric Charging Demand Location (ECDL) model, which can be applied to estimate the demand for EV charging at points of interest (POIs) – here defined as living, working, shopping, and recreation destinations – and identify the ideal position for a charging station by considering an acceptable walking distance between POIs and the charging station. The ECDL model summarises the EV charging demand at individual POIs in an area and finds the ideal charging station location by minimising the walking distances between the charging station and related POIs. The ECDL model can both allow for allocating enough charging stations to meet the total EV charging demand in an area, and for efficiently concentrating the charging stations, optimising building and operation costs.

The main goal of the ECDL model is to strategically position charging stations within the daily activity zones of EV users, allowing them to conveniently recharge the vehicle while visiting a POI. Therefore, the model considers, as its key factors, the spatial distribution of POIs, the EV drivers' length of stay at POIs, the distances between POIs, the walking distance between a parking spot and a POI, and the walking distance between a charging station and a POI. According to the authors, as the ECDL model considers neighbourhood interactions, it can be an efficient model for siting charging stations in a whole region, preventing the oversupply of charging stations in a same area.

The main sources used for the ECDL model are: 1) a survey measuring how much time people spend, on average, on different daily activities, 2) regional information about age groups and number of vehicles owned, and 3) the georeferenced location of POIs that people often visit. GIS is used to identify possible sites for charging stations in public and semi-public areas at a detailed level. The demand for EV charging at a site is estimated based on the duration and frequency of vehicle users' visits to nearby POIs. By identifying the areas with the highest charging demand and the shortest walking distances to the POIs, the model iteratively selects the best locations for charging stations.

The model was applied to a case study area of 7,200 km^2 and a population of around 800,000 inhabitants in south-eastern Germany. The area encompasses the administrative districts of Cham, Deggendorf, Freyung-Grafenau, Passau, Regen, and Straubing-Bogen, and was assumed to have a 50% EV fleet penetration at the time of the study. The model allowed to calculate the electricity demand for each type of POI and group of users, and to display the location of charging stations in a map.

The authors argued that the ECDL model can also be adjusted to different planning objectives, such as the concentrating charging stations in the highest electricity demand areas or setting a percentage of electricity demand coverage to be met. The ECDL model is flexible and has a transferability potential. Although the analysis conducted by the authors for the case study area in Germany relied on assumed values such as EV market penetration, they could be replaced by more precise values obtained from specific regional data, resulting in studies more tailored to meet the needs of a particular region.

Flow-based approach to locate fast charging stations in New Zealand

Rabl et al. (2024) presented a model for the strategic planning of fast charging infrastructure for EVs, with the objective of reducing infrastructure investments. The model considers traffic flows and location-specific investment costs. The authors applied the model to the northern island of New Zealand as case study, with the objective of finding the best location and size strategy for fast charging infrastructure deployment over time in that region.

The authors stressed the importance of a multi-periodic approach, as it allows the model to accommodate the growing EV fleet and the increasing demand for charging over the course of the years. A sensitivity analysis was included for some variables, providing insights into how changes in these variables can impact the results.

When adopting a flow-based approach, modelling locations and sizes of charging stations requires data on traffic flows from every origin to every destination in the transport network. As such data can be difficult and expensive to obtain, traffic flows were calculated using a gravity model which considered the number of households, the average household size, and the median income of both origin and destination regions, as well as the distance between the two. Highway traffic count data in New Zealand was also employed, ensuring that the estimated traffic flows were compatible with the measured traffic volumes.

Results indicated that fast charging stations should be placed along busy routes in areas with high population density in order to be profitable. The selected locations have below-average installation costs and high EV traffic coverage. The model offers a cost-efficient fast charging infrastructure planning tool that could be transferred to other countries.

Genetic algorithms for finding suitable EV charging station locations in Valencia, Spain

Jordán et al. (2022) proposed a charging station siting approach using genetic algorithms and agent-based simulation. A genetic algorithm, according to the authors, is a "type of evolutionary algorithm that is based on the creation of multiple consecutive generations where the information of the best past solutions is recombined in order to improve the population of solutions in each generation". The genetic algorithm proposed in this study relies on the openly available data of a given city to determine optimal sites for charging stations, aiming for both service quality and installation costs, and accounting for factors like population density, traffic, and social network activity. The algorithm also allows for long-term planning, considering the successive deployment of charging stations over the years according to the plans of a city.

The authors also developed a simulation framework that enables the comparison of the suggested solutions with other approaches. The simulation measured the impact of the charging station locations on the waiting time, congestion, and idle rate of the stations.

The city of Valencia in Spain was selected for the case study. Three experiments were conducted, with varying numbers of charging points: 50, 100, and 200. The genetic algorithm was used to incrementally place these points, simulating an installation over several years. Key parameters for the genetic algorithm included the initial population, number of generations, crossover and mutation probabilities, and the quantity of POIs (which were reduced through clustering to ensure a minimum distance of 300 metres between potential charging stations). The costs involved in establishing each charging station (with a minimum of one charging pole), their additional charging poles, as well as their distance from the power grid, were also factored in.

Their genetic algorithm charging station siting approach was compared to four other charging station distribution approaches: uniform, radial, random, and probabilistic. In each of these four distribution approaches, the area is divided into different polygons in which charging stations are placed. While the uniform, radial, and random distributions only use geometry to split the study area, the probabilistic distribution divides the area in uniform cells, assigning to each of them a probability of being selected for charging station deployment, based on real world information such as traffic, land use, and social network activity data.

Results showed that, compared to other methods, the genetic algorithm's distribution of charging stations reduced to 0% the proportion of idle stations. Moreover, mean waiting time for vehicles at charging stations was significantly reduced when compared to other methods, especially in scenarios using real-world traffic data. This suggests that the genetic algorithm can effectively adapt to actual urban mobility patterns.

While the study demonstrated the effectiveness of using a genetic algorithm for EV charging station siting in urban settings, contrarily to the ECDL model developed by Pagany, Marquardt, et al. (2019), this study’s approach did not address charging station siting in interurban contexts; therefore, the authors stressed that the genetic algorithms should be updated to allow for charging station siting planning in larger areas including more than one city.

4. Policy Recommendations

One of the main barriers to EV adoption is the scarcity of adequate and accessible charging infrastructure, which causes range anxiety and inconvenience for potential EV users. Therefore, it is important that public charging stations are deployed in strategic locations that can meet the needs of users and encourage more people to switch to EVs.

This chapter offers policy recommendations based on the literature findings presented in Chapter 3. They are guidelines that can orientate the selection of charging station sites in a cost-effective way, with the goals of encouraging the transition from ICEVs to EVs and accelerating the decarbonisation of transport.

1. **Employ a data-driven approach for planning EV charging station siting.** To be efficiently located, charging stations need to be planned with a data-driven approach. Statistics on electricity demand, vehicle fleet characteristics, and the supply of semi-public and private charging facilities can be used to identify points of charging demand in a study region. Real-world travel data can help understand where EV drivers spend significant time, indicating suitable places for deploying charging stations.

2. **Plan for charging infrastructure deployment over time.** A multi-periodic approach can account for the predicted evolution of the EV market, as well as the changes in mobility patterns, electricity demand, and grid capacity over time. This can help avoid over-investing in infrastructure that may become under-utilised or obsolete, or under-investing in infrastructure that may cause bottlenecks or reliability issues. Genetic algorithms can be employed to model optimal locations in different time horizons, allowing for plans to be adjusted accordingly.

3. **Consider the interaction between transportation and power distribution networks.** To mitigate adverse effects of EV charging on the power grid, not only data on mobility patterns should be considered for choosing ideal charging station locations, but also on the local electricity demand and the hosting capacity of the electricity network. By optimising infrastructure use, potential risks to the stability and dependability of the electricity system can be mitigated.

4. **For most cases, regular charging infrastructure should be preferred over fast charging infrastructure.** In contrast to fast charging equipment, regular charging equipment exerts less pressure on the electricity network, provides greater efficiency, and slows EV battery degradation. Strategically placing regular charging equipment could enhance charging infrastructure coverage while minimising both the investment costs and the burden on the power grid. Fast charging equipment deployment should be orientated by the need to meet certain performance criteria, such as offering quick partial recharging for taxis and city busses.

5. Conclusion

The transition from ICEVs to EVs is a crucial step towards the decarbonisation of transport and the mitigation of climate change. However, this transition depends largely on the availability and accessibility of charging infrastructure, which can address the range anxiety of potential EV users and enhance the convenience and competitiveness of EVs. Therefore, planning for optimal charging station siting is an essential task for policymakers who aim to promote EV adoption and achieve their emission reduction targets.

This policy advice paper has reviewed the state of the art for EV charging station siting methods, based on the scientific literature and case studies from different regions. The paper has proposed a framework for charging infrastructure siting that considers factors related to demand forecasting, objective functions, and modelling approaches. The paper has also provided policy recommendations for charging infrastructure siting that seek to balance these factors and optimise the outcomes for EV users, utilities, and society.

The main recommendations to policymakers outlined in the paper are:

1. Employ a data-driven approach for estimating the charging demand and identifying the most suitable places for charging stations.
2. Plan for charging infrastructure deployment over time by adopting a multi-periodic approach, as to avoid over-investing in infrastructure that may become under-utilised, or under-investing in infrastructure that may become over-utilised.
3. Consider the interaction between transportation and power distribution networks, to minimise the adverse effects of EV charging on the power grid.
4. Regular charging infrastructure should be preferred over fast charging infrastructure, as it poses less stress on the electricity network, provides greater efficiency, and slows battery degradation.

Charging infrastructure is a key enabler for the transition from ICEVs to EVs. Its planning, however, poses significant challenges and trade-offs to policymakers. By adopting a data-driven approach that encompasses the diversity and dynamics of local contexts, policymakers can more efficiently allocate resources to improve the availability of charging stations, facilitate the adoption of greener modes of transportation, and contribute to reaching GHG emission reduction goals.

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