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ANALYSING THE OPTIMISATION TACTICS FOR ELECTRICAL VEHICLE CHARGING POINTS

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ABSTRACT

In spite of the restricted range of electric vehicles (EVs) and the limited availability of charging stations, drivers of EVs who are contemplating long-distance journeys continue to experience range anxiety. As a result, it is essential to ascertain whether or not the chosen route is feasible and to pinpoint the most effective method of charging. A mixed integer linear programming (MILP) method is proposed in this paper for the electric vehicle charging strategy problem (EVCSP). This approach incorporates a piecewise linear approximation technique to handle the issues that are provided by nonlinear charging durations. This approach is an essential component of decision support for electric vehicle drivers. The suggested optimisation model, which is known as CSPM, is responsible for determining where, when, and how much to charge an electric vehicle for a certain route in order to reduce the amount of time and money spent travelling. The resilience and dependability of the CSPM reveals itself via the solution time of large-scale test issues as well as through a case study on Turkey. In addition, the case study is subjected to the application of two kinds of multi-objective optimisation techniques, namely the weighted sum method and the lexicographic approach, and the outcomes are analysed. There is a range of 46.09 percent across all of the charging techniques that were applied, which indicates that the trip cost is more sensitive to the chosen charging approach. On the other hand, journey time is more durable, with a maximum variation of 19.77 percent. The CSPM cut travel time by 60.1% and improved cost efficiency by 105.72%, according to a comparison study with a complete charging approach. This is the result of the CSPM.

KEYWORDS: *Electric Vehicle Charging Probability Model, Traffic Congestion Management, Charging Strategy Development, Electric Vehicle Charging Networks.*

INTRODUCTION

Given the present situation, it is incredible that there is so much enthusiasm in developing and spreading alternative forms of energy throughout the world. The majority of consumers thus support and identify new energy electric vehicles. This is due to the fact that they represent the creation and implementation of alternative energy sources. There has been a rise in the need for charging stations tailored to new energy vehicles to keep up with the proliferation of electric automobiles fuelled by these sources (Zhou et al., 2022). The distribution of charging stations should be optimised as much as possible to meet the charging needs of electric automobiles effectively. This is why this study will address a major scientific issue: where to best install charging stations for electric vehicles. The construction of charging stations for private electric cars, buses, and taxis is only one example of the substantial scholarly interest in this area. This study presents the best model and methodology for electric car charging station distribution after analysing the aspects affecting station placement from several angles, including environmental advantages. Economic cost and user demand are also the subject of a large number of research academics. A lack of structure and preparation is impacting the electric car sector in a big way down the road. The electric car industry is huge and promising in many nations, yet there is very little investment in charging stations. Therefore, finding the right placement of EV charging stations according to market and location-related factors is a major factor in the expansion of the EV market. An expansion of charging infrastructure is necessary to keep up with the rapid uptake of electric vehicles, especially in major markets such as the United States, the European Union, and China. Local and regional governments are the most suited to oversee electric vehicle uptake and charging infrastructure. A big problem is the increasing length of time that electric vehicles remain idling while connected but not charging. The challenge impacts infrastructure size, cost, and availability. ML has the potential to enhance infrastructure management and boost EV adoption by allowing for more accurate idle time estimations and management, which would be beneficial for policymakers, network owners, and EV drivers alike. Electric vehicles are rapidly replacing gas-powered vehicles as the preferred mode of transportation due to their low environmental impact and reduced reliance on fossil fuels (Zhang et al., 2019).

BACKGROUND OF THE STUDY

Reducing peak loads and increasing grid stability while keeping end users' charge costs to a minimum is one of the main motivations for the study. Under varying conditions, simulations were run to prove that the suggested approach effectively reduced peak demand and optimised energy use. Instead of charging lithium-ion batteries to their full capacity, it is advised to charge them to around 80%. The majority of EVs really let the researcher set a "target charge" of their choosing (Zhang et al., 2021). For guidance on finding the perfect charging level, see the owner's manual. Though it's generally safe to charge at home, researchers who plan to use a level-1 charging cable for extended periods of time should consult a licensed electrician to ensure that their electrical system can handle the load. Using a standard electrical outlet to power a plug-in hybrid electric vehicle (PHEV) is illegal. If the battery is at an abnormally high or low charge, its lifespan can be reduced. Many modern electric car chargers are designed to automatically switch off when the battery becomes full. The ideal charging level for a researcher's battery is anywhere between 30 and 80 percent. It is advised that electric cars be charged no more than 80% of their capacity, since charging rates start to drop dramatically beyond that point. In addition, keeping the battery pack below 100 percent is good for the researchers' vehicle's battery pack in the long run (Xiao et al., 2020).

PURPOSE OF THE RESEARCH

The reduction of peak loads, the improvement of grid stability, and the reduction of the amount of money that end consumers are paid for their purchases are two of the most significant goals that the project aims to accomplish. The efficiency of the suggested strategy in reducing peak demand and achieving the most efficient use of energy was shown via simulations that were carried out under a range of scenarios by demonstrating that the method was successful. Both plug-in hybrid PEVs and conventional EVs are able to receive electricity via electric vehicle charging stations, which are also referred to as EVSEs. It is possible to get improved fuel efficiency, reduced fuel costs, and a decrease in the quantity of pollutants created with any form of electric vehicle. This is a possibility. Electricity is a wonderful source of power for transportation because it helps to establish a more robust system, and it is helpful to both the environment and public health. Electricity is also useful to the environment. Additionally, it has the effect of making roads safer. It is the responsibility of charging systems to maintain the charge of the battery and to give the vehicle used by the researchers with the electrical energy that it requires in order to operate while it is in motion.

LITERATURE REVIEW

Researchers primarily focus on three areas when examining electric car charging station locations: the variables impacting the position of the station, the algorithm connected with the location model, and the creation of a model for optimum site. The greatest options, given the increasing environmental concerns and energy limitations, seem to be renewable energy and electric vehicles (Aljaidi et al., 2020). This tendency is likely to continue. Most people keep their passenger cars parked for more than 90% of the time, which is a lot more time than the batteries require to recharge. Hence, EVs can both power the vehicle's electronics and act as a portable batteries. The majority of the cells in electric car batteries are lithium-ion cells. It is difficult to make lighter electric vehicles using traditional materials, despite the fact that doing so would increase their range and decrease their carbon impact. The widespread use of electric cars has prompted city planners in large cities to consider how best to install charging stations around the city. When compared to gas-powered automobiles, electric vehicles have a larger charging distance and a higher charging demand. Compared to gas-powered vehicles, electric cars with four wheels have fewer moving parts. Construction made easier. The cost of maintaining such a vehicle is, hence, minimal. In addition to lowering pollution levels, electric cars improve air quality. In addition, these vehicles produce less noise pollution. In a collision, the impact potential of an electric car is lower. This is due to the automobiles' lightweight design, since their frames do not hold a great deal of mass. Much study has focused on the effects of charging electric vehicles on the power system. Concerns concerning power network instability due to EV charging have, however, received surprisingly little attention (Wang et al., 2023).

RESEARCH QUESTION

- What is the effect of customer segmentation on electric vehicle charging stations?

RESEARCH METHODOLOGY

RESEARCH DESIGN:

Quantitative data analysis were conducted using SPSS version 25. The researchers used the odds ratio and the 95% confidence interval to evaluate the strength and direction of the statistical association. The researchers established a statistically significant threshold at $p < 0.05$. An analytical description revealed essential attributes of the data. Data collected via surveys, polls, and questionnaires, together with data processed using computing tools for statistical assessment, are often evaluated using quantitative methods.

SAMPLING:

Research participants filled out questionnaires to provide information for the research. Using the Rao-soft programme, researchers determined that there were 657people in the research population, so researchers sent out 896 questionnaires. The researchers got 823 back, and they excluded 45 due to incompleteness, so the researchers ended up with a sample size of 778.

DATA AND MEASUREMENT:

The study mostly used data acquired from a questionnaire survey. The participant's essential demographic information was requested first. Participants were then given a 5-point Likert scale to evaluate the online and offline channels. The researchers rigorously analysed several resources, especially internet databases, for this secondary data gathering.

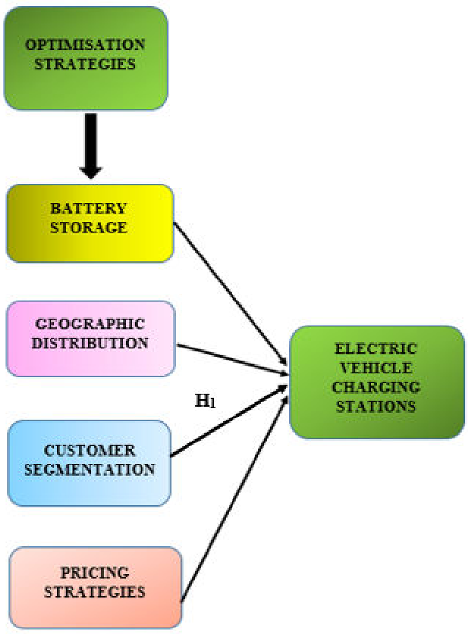
STATISTICAL SOFTWARE

The statistical analysis was conducted using SPSS 25 and MS-Excel.

STATISTICAL TOOLS

To grasp the fundamental character of the data, descriptive analysis was used. The researcher is required to analyse the data using ANOVA.

CONCEPTUAL FRAMEWORK



RESULTS

- **FACTOR ANALYSIS**

One typical use of Factor Analysis (FA) is to verify the existence of latent components in observable data. When there are not easily observable visual or diagnostic markers, it is common practice to utilise regression coefficients to produce ratings. In FA, models are essential for success. Finding mistakes, intrusions, and obvious connections are the aims of modelling. One way to assess datasets produced by multiple regression studies is with the use of the Kaiser-Meyer-Olkin (KMO) Test. They] verify that the model and sample variables are representative. According to the numbers, there is data duplication. When the proportions are less, the data is easier to understand. For KMO, the output is a number between zero and one. If the KMO value is between 0.8 and 1, then the sample size should be enough. These are the permissible boundaries, according to Kaiser: The following are the acceptance criteria set by Kaiser:

A pitiful 0.050 to 0.059, below average 0.60 to 0.69

Middle grades often fall within the range of 0.70-0.79.

With a quality point score ranging from 0.80 to 0.89.

They marvel at the range of 0.90 to 1.00.

Table1: KMO and Bartlett's Test

Testing for KMO and Bartlett's

Sampling Adequacy Measured by Kaiser-Meyer-Olkin .957

The results of Bartlett's test of sphericity are as follows: approx. chi-square

df=190

sig.=.000

This establishes the validity of assertions made only for the purpose of sampling. To ensure the relevance of the correlation matrices, researchers used Bartlett's Test of Sphericity. Kaiser-Meyer-Olkin states that a result of 0.957 indicates that the sample is adequate. The p-value is 0.00, as per Bartlett's sphericity test. A favourable result from Bartlett's sphericity test indicates that the correlation matrix is not an identity matrix.

Table: KMO and Bartlett's

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.957
Bartlett's Test of Sphericity	**Approx. Chi-Square**	3252.968
	df	190
	Sig.	.000

Bartlett's Test of Sphericity further substantiated the overall significance of the correlation matrices. The Kaiser-Meyer-Olkin metric of sample adequacy is 0.957. The researchers calculated a p-value of 0.00 using Bartlett's sphericity test. The correlation matrix was rendered invalid by a significant outcome from Bartlett's sphericity test.

- **INDEPENDENT VARIABLE**
- **OPTIMISATION STRATEGIES:**

Among the many methods that are used in performance optimisation are load balancing, code optimisation, and system tuning, to name just a few. Another method is load balancing, which is an additional strategy (Teng et al., 2020). To improve the computational efficiency of a system in order to reduce the number of resources that are utilised and to minimise the length of time that latencies are experienced is the major goal of this technology. There is a series of systematic activities that are conducted in order to define optimum solutions towards one or multiple parameters while sticking to specific limits in order to either maximise or decrease the goals of particular solutions. The phrase "optimisation strategies" refers to this series of actions. An approach that is used to produce therapies that are effective, affordable, and can be deployed in a wide variety of situations is called the Multiphase Optimisation Strategy, which is also often referred to as MOST. When it comes to the majority of situations, the fundamental goal of MOST is to enhance the efficacy of therapies in terms of improving health or characteristics. One kind of equilibrium that is considered to be specific in the context of optimisation is one in which there is a target that has to be achieved. The term "goal equilibrium" is one form of expression that may be used to refer to this. In the case of utility maximisation, for example, it is essential to ascertain the quantity of things that need to be consumed, taking into account the constraints of a budget, in order to attain the maximum possible degree of satisfaction for the client (Liu et al., 2021).

- **FACTOR**
- **CUSTOMER SEGMENTATION:**

Marketers use customer segmentation to break their target audience into smaller groups based on common characteristics such as age, gender, interests, and buying habits. Segmentation is a method for dividing markets into smaller groups defined by commonalities. Because it shows audience values, good segmentation is a boon to marketing initiatives (Zhou et al., 2022). Segmentation is the process by which a researcher classifies their marketing objectives according to organisations and customers. The answer is customer segmentation, which comprises dividing the people who buy the researcher's product into specific categories. Researchers may better address the expectations of each group while avoiding typical errors by segmenting their clientele based on similar features (such as demographics or product usage habits). Customer segmentation is a marketing tool that helps break down target audiences into smaller groups based on shared characteristics including demographics, purchasing patterns, and other personal facts. Researchers can better meet the unique needs of their customers when they take the time to get to know them on a personal level. Researchers use segmentation to divide their customer base into smaller groups with common interests, requirements, and habits. The results of a customer segmentation study may be used to tailor marketing efforts, including ads, sales presentations, and product descriptions, to specific subsets of the target population. Meeting the specific demands of the study's customers while simultaneously enhancing their empathy, retention, and loyalty, this apparently (Chen, 2021).

- **DEPENDENT VARIABLE**
- **ELECTRIC VEHICLE CHARGING STATIONS:**

Simply said, "EV charging" is the act of supplying electricity to an electric vehicle in order to enable it to run. When connected to a Level 2 charger, which provides electricity to recharge electric car batteries, the vehicles may potentially reach a range of around 250 miles in about six to eight hours. The process of charging an electric car's battery is quite similar to that of charging any other device or appliance that requires an electrical outlet. To do this, it takes electricity from a 240-volt source and transfers it to the car. It might reduce emissions and energy costs while also providing automotive owners with convenient charging options. When it comes to developing more sustainable modes of transportation, electric car charging stations play a major role. Putting power back into an electric vehicle's battery is what's referred to as "charging" the car's battery. A charging station or charger is used to do this with an electric car. An EVSE, or electric vehicle charging station, is a place where electric vehicles may be refuelled. Level 1 chargers, level 2 chargers, and quick chargers powered by diesel are only a few of the options for charging electric cars (Ahmad, 2022).

- **RELATIONSHIP BETWEEN CUSTOMER SEGMENTATION AND ELECTRIC VEHICLE CHARGING STATIONS**

When it comes to designing, building, and optimising EV charging stations, customer segmentation is very essential. To ensure that charging infrastructure is accessible, efficient, and adapted to individual demands, it is crucial to understand the varying requirements, preferences, and behaviours of different consumer groups (Zhang et al., 2021). This will help to control the rising adoption of electric cars. Consumers may be "segmented" into subsets according to their geography, wealth, driving patterns, preferred billing methods, and even their degree of care for the environment. Operators of electric vehicle charging stations may improve the client experience and make the most of their stations by doing this. People who possess electric vehicles but don't have access to home charging capabilities—often because they live in apartments or don't have enough parking—may make up one kind of client. Customers in this demographic may give preference to charging stations situated in highly visible and accessible locations, such as commercial districts, retail malls, or along main thoroughfares. On the other hand, consumers residing in suburban or rural areas may have home charging capabilities, but when travelling long distances, they could go for public stations. They would like charging stations that are at rest stops or along roads so that their cross-country excursions go smoothly. By gaining a comprehensive knowledge of these diverse demands, suppliers of charging stations may strategically install their infrastructure to fulfil demand. Customers might be further segmented according on their income (Xiao et al., 2020).

Since the above discussion, the researcher formulated the following hypothesis, which was analyse the relationship between Customer Segmentation and Electric Vehicle Charging Stations.

"H_{01}: There is no significant relationship between Customer Segmentation and Electric Vehicle Charging Stations."
"H_1: There is a significant relationship between Customer Segmentation and Electric Vehicle Charging Stations."

Table 2: H_1 ANOVA Test

ANOVA					
Sum					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	39588.620	319	5435.418	1016.916	.000
Within Groups	492.770	458	5.345		
Total	40081.390	777			

In this study, the result is significant. The value of F is 1016.916, which reaches significance with a *p*-value of .000 (which is less than the .05 alpha level). This means the ***"H_1: There is a significant relationship between Geographic Distribution and Electric Vehicle Charging Stations"*** is accepted and the null hypothesis is rejected.

DISCUSSION

Further development of the existing network of charging stations remains a stumbling block to the widespread use of electric vehicles. In preparation for the expected fast adoption of electric cars by increasingly diverse demographics, there is a growing desire for companies to enhance their employee parking lots with more charging stations for these vehicles. The number of workplace chargers will increase fivefold by 2030, according to a new analysis by Charge UK, to handle the expected rates of electric car adoption. The expansion of charging stations and the associated technical and financial challenges have mostly fallen under the purview of local and regional network operators. Businesses have been unable to conduct anticipated impact assessments of the higher demands caused by EV charging mostly due to a lack of expertise in internal energy management. Additionally, the researchers discovered that there is a dearth of literature on the best practices for firms to follow when developing strategies to increase their EV workplace charging infrastructure. To address this gap, the research looks at the mobility industry's attempts to transition to a low-carbon energy system through the eyes of company owners and managers. The researchers show that very large-scale, uncontrolled deployments of EV workplace charging infrastructure may lead to significant inefficiencies, including increased carbon emissions, much higher peaks, and inflated charging fees. Conversely, state-of-the-art control mechanisms and effective SC strategies have the potential to economise, benefit the environment, and save a lot of money. The models continually beat UCC in all the major metrics during a temporal sensitivity analysis, demonstrating their resilience to time-variant variables. However, the researchers show that a CCM or CEM model design that just takes one goal into account may jeopardise the relative performance of other metrics, such maximum peak, when the EV adoption rate exceeds a certain threshold. This highlights how diverse goal functions and their associated outcome assessments will always involve trade-offs. These results are the result of researchers using real-world data to repeatedly test models in different scenarios.

CONCLUSION

In conclusion, the widespread availability of convenient electric vehicle charging stations is critical to the success of the electric vehicle industry. Finding a happy medium between the benefits and drawbacks is crucial for the effective adoption and promotion of sustainable transportation. This improvement has the potential to make better use of the charging infrastructure, which in turn might lessen charging congestion. Renewable energy sources' availability and variability are both included into the model. Stabilising the power grid is aided by increasing the efficiency of these sources. A motor vehicle that is powered fully or mostly by batteries that are powered by electricity is called an "electric vehicle" (EV). Electric vehicles (EVs) include a wide range of transportation options, from automobiles that run on electricity to ships that function underwater, aeroplanes, and even spaceships. Many people charge their electric cars overnight by plugging them in while they sleep. Set the researchers charger to switch off at least an hour or two before the researcher plan to leave the researchers house in the morning if it has a timer. Greenhouse gas emissions from fossil fuel-powered vehicles are much higher than those from electric vehicles, which produce no such emissions at all. Buying an electric car may save annual fuel expenditures by up to Rs. 1,50,000 and greenhouse gas emissions by up to one tonne. Autos that run on electricity are called electric cars, or EVs for short. Electric charge is a property of matter that is carried by some elementary particles and defines how those particles react to an electric or magnetic field. Electric charge, which may be positive or negative, originates from certain units in nature.

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