CHARGING STATION SCHEDULING OF EVS USING WEIGHTED VORONOI DIAGRAM

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Abstract

The major goal of this study is to develop a revenue optimization model for scheduling EV charging stations by considering and accounting for the various aspects of charging station construction. Using the charging and travel habits of EVs, an estimate of the power consumption is made to establish the charging station's capacity needs in the designated area. Based on the number of EVs on the road, a weighted Voronoi diagram is modified to optimise the distribution of service areas and load rates. One concept of charging station scheduling for electric automobiles uses particle swarm optimization and the weighted Voronoi diagram to maximise efficiency in station location and service coverage. The study's findings provide substantial support to the validity of the model and the viability of the proposed procedure.

Keywords:electric vehicles; charging station Scheduling; charging power demand analysis;weighted Voronoi diagram

1. Introduction

Commercialization of the EV somewhat successful **[1]** because to the EV's efficiency. In order to promote widespread adoption of EVs, requisite foundational infrastructure, particularly charging infrastructure, must be finalised. Increasing the availability of charging stations for EVs is crucial to the growth of the EV sector. Smart power grid and urban infrastructure network success relies heavily on well-thought-out design for charging stations.

Building charging stations for electric vehicles is a challenging task since it is a multi-objective issue. Substations for municipal power grids structures have profited from the solutions developed for such massive nonlinear optimization problems. Yet, while designing charging stations for electric vehicles, it is important to think about traffic patterns, the number of cars that will use them, and how they will be utilised. Planning charging stations requires consideration of not just the restrictions and economics of the power grid. Educators have provided different viewpoints on the topic of where to place EV charging stations. Chargers take up more or less space depending on factors like the number of outlets and whether or not they have an outside access point **[2, 3].** Using an analysis of EV charging needs, **[4]** lays out the aspects that should be taken into account and suggests some fundamental ideas for creating a backinglocation. The ideal capacity of the economic ideal was determined by modelling load distribution of the number of electric cars owned by residents, and AHP was used to provide relative relevance ratings to each candidate for the charging stations. As the area of services and other factors have not been adequately established, the traffic factor of electric car charging stations has not been significantly changed by these techniques.

This study evaluates critical elements in EV charging station design and construction, and then develops a revenue optimization model for the rollout of EV charging infrastructure. By changing the coefficient of a weighted Voronoi diagram, the distribution of service regions and load rates may be made more equitable in relation to the total number of EVs.

2. Electric vehicle charging station Scheduling

2.1Charging power demand analysis

It is dependent on a number of factors, including the user's attributes, the charging price, the proximity of charging stations, and the like, as to how far and how long an electric car may be driven daily. It was assumed that the average battery capacity of a domestic passenger vehicle was somewhere between 20 and 30 kWh. The expected 24-hour charging power requirement for a single EV may be estimated with the use of Monte Carlo simulation **[5].** Power consumption throughout the course of a day for a single electric car is depicted as an average in Figure 1. The aggregate power requirements of a fleet of electric cars may be calculated using the central limit theorem.

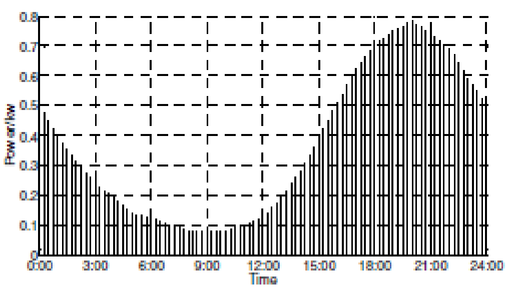
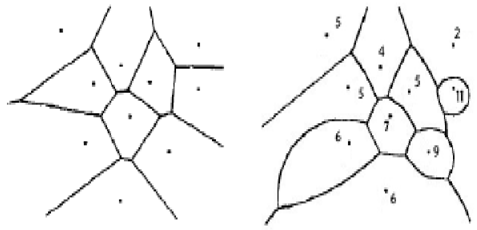


Figure. 1 The daily average power consumption of a single electric car

2.2. Using a weighted Voronoi diagram, analyse the coverage areas for various services.

In computational geometry, the Voronoi diagram—also called a "near polygon"—plays a crucial role. It has found widespread application in geo-location and power grids **[6].**



Weighted Voronoi diagram

Using a weighted Voronoi diagram to account for variables like effective service radius and average load rate at the charging station. These are the detailed instructions:

1. Establish the starting weights by using the formula$\omega_{0i} = \sqrt{\frac{W_{0i}}{S_i}}$. The location of the charging station serves as the origin of a Voronoi diagram to determine where the load is distributed.

2. Create a weighted Voronoi diagram using the given weights, then use it to locate charging stations and estimate their power needs.

3. Using the formula $\eta_i = W_i/S_i$determine the charging rate of each static ioniser.
4. Consider whether the load rate is adequate. If you haven't already, proceed to Step 2 until you do.

3. Method and Scheduling

A400km^2 planning area was used as an example in this article. During the planned year, it is expected that there will be a total of 400k cars on the road, with 5% of those expected to be EVs. Then, according to the second section, the highest anticipated daily charging power consumption is 17.1MW. Forecasting charging power consumption necessitated subdividing the planned area into 784 smaller areas. In the planning year, 239MW will be the total load (without charging stations) in the planned region. Within the planned area, there are 12 major highways and 5110kV substations. Both Table 1 and Table 2 display the relevant restrictions.

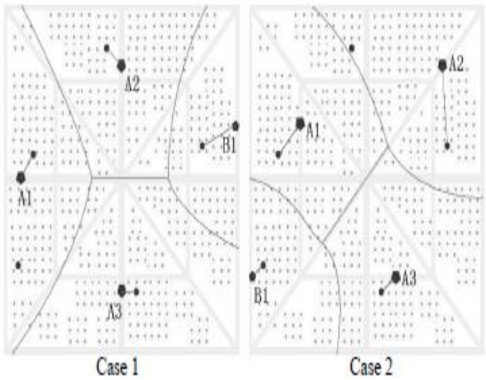
Table 1 charging station/cost

type	Rated Capacity /MW	Initial Investment / million rupees	Land acquisition costs/million rupees	Annual operating costs / million rupees
A	5.0	3.50	3.00	0.30
B	3.0	2.00	1.70	0.20
C	1.5	1.20	1.00	0.15

Table 2 Associated constraint assortment

Constraint	symbols	Value	Constraint	symbols	Value
Battery average capacity	Q	30.0kw · h	Line construction costs	ω_1	0.4 million rupees /km
Power consumption per km	q	0.15kw · h/km	Road construction costs	ξ_k	1.0million rupees/km
Charging price	λ_c	0.6 rupee/kw.h	discount rate	r_0	0.1
Power purchase price	λ_s	0.35rupee /kw · h	depreciable life	n_{yw}	15 years
Power factor of charging station	Cos θ	0.92	Effective operation day	T	350 days

Several iterations of the Scheduling issue have been calculated using the techniques outlined in this article, and the two Scheduling solutions shown below are the most promising.



Two scheduling scheme and services area division

Table 3 Several Scheduling schemes generate income and have varying load rates.

Case 1			Case 2		
Yearly incomes million rupees	Id number	Load rate	Yearly incomes / million rupees	Id number	Load rate
9.1811	A1	0.8796	9.1647	A1	1.0027
	A2	0.9382		A2	0.8855
	A3	1.0204		A3	0.9852
	B1	0.8716		B1	0.9011

Results

With incomes of 9.1811 million rupees in Case 1 and 9.1647 million rupees in Case 2, the disparity between the two is less than 20,000 rupees. In case 1, the maximum load rate was 102.04%, with a minimum load rate of 87.16%. In Case 2, the range of load percentages ranged from 88.55 to 100.27 percent. According to the numbers, the load on two instances has been quite stable at around 80%-120%. Case 2 had a better load rate than Case 1, despite Case 1's larger profits.

Charging station layout in multi-bit aircraft addressing with uneven loads is a highly nonlinear problem. Given the presence of several outliers, determining the optimal mathematical value in such a situation is extremely difficult. Given the closeness of the objective function values in the two cases, it is unnecessary to seek the theoretically perfect value with respect to practical application projects. Knowledgeable planners make the final call on the model's particular implementation plan, which takes into account both quantitative and qualitative factors.

Conclusion

Profit maximisation may be achieved by careful planning of charging station locations and times, which is affected by a number of variables. It depends on a number of things, including the density of EV ownership, the design of the power system, and the accessibility of other forms of transportation. We were able to ascertain the capacity requirements of charging stations in the scheduled region by analysing the power use of EVs while charging and when in use on the road. Based on the number of EVs on the road, a weighted Voronoi diagram is modified to optimise the distribution of service areas and load rates. With, the global search capabilities of particle swarm optimization and the local optimization capabilities of a weighted Voronoi diagram, we can find the optimal locations for charging stations while also minimising the service area required to keep them all operational. The test results demonstrate the model's dependability and the efficacy of the method..

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