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STUDY ON PUBLIC CHARGING STATION REQUIREMENT AMONG EV CONSUMERS IN RAIPUR CITY: A CONSUMER PROSPECTIVE

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Abstract: *India has the largest road connectivity for transportation and traveling, which can be electrified by boosting the EV sector. That is why this research analyses the EV public charging station needs at present. Every city is on a path to becoming smarter as soon as possible. The government is taking several steps to make a city smart by less pollution, controlled air quality, and well public charging infrastructure. The fastest adoption of eco-friendly moves is pushed by the government but lack of charging infrastructure is one of the current issues that needs immediate solutions to protect the environment and non-renewable resources. The government is targeting only EVs till 2030 which is possible by promoting the EV sector, making policies, and reserving funds for public charging station development. It is necessary to get the consumer's viewpoint for developing PCSs. 50 samples were collected in Raipur to analyse suitable public charging station locations, waiting time, and distance between PCS. Research finding of the problem recommends, that users are in strong need of PCS in crowded places of working areas, buses, trains, and airport stations. PCSs should be in every 8 km.*

Keywords: *Public Charging Station, Electric Vehicles*

NOMENCLATURE

FS	Fuel Station
PCS	Public Charging Station
EV	Electric Vehicles

INTRODUCTION

India is one of the biggest importers of petroleum because of its insufficient petroleum resources. There are numerous filling stations (FSs) to meet the need of fuel requirements, which is a trigger point to use petroleum vehicles. The most common mode of transportation and traveling is petroleum vehicles on the road by bus, car, bike, scooter, heavy vehicles, and many more and this is causing high carbon emissions. It is the liability of everyone to protect the environment by shifting towards EVs like E-Bus, E-Car- E-2 wheelers, and many more. EVs are approximately 70% less harmful to the environment. It is important to outline suitable locations for PCS to uplift EV shifting and solutions for EV users to travel anywhere without any concern about the unavailability of the charging station. The Indian government is running schemes Only EVs on road till 2030 to promote EV uses and PCS development will play an important role in electrifying Indian roads.

It is not possible to shift towards EV on a large and fast scale without working on PCSs. Indian users are shifting towards EVs with good numbers and it needs to work on the issue of unavailable PCSs everywhere. By reviewing various literature, the uses of EV are increasing, EV runs by charged battery and this battery is charged by electricity. An insufficient Power grid system would cause energy failure. Proper energy planning for the city is needed.

Raipur is one of the fastest growing cities, with a large forest area, forestry products, mining industries, and a population of 1.4 lakh. Raipur is the center and capital of Chhattisgarh state. There are lots of opportunities that are still pending to grab. Here people are shifting towards EVs with good numbers. Recently, the Municipal Corporation of Raipur has contracted with Indian oil to deploy 4 PCSs for 4-wheelers and 3-wheelers. Here electric scooters are gaining popularity among people. It is time to complete the need for PCSs as per the user's requirement.

Data on petroleum import by India, according to a report by (Jaganmohan, 2024), is as shown in Table 1 from the

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financial year 2019 to 2024. It is expenses of the government which can be reduced and used somewhere else.

Table 1: Import of Petroleum (Jaganmohan, 2024)

Year	Import in Billion INR	Import Growth % You
2019-20	9862.75	41%
2020-21	9251.68	-6%
2021-22	6113.53	-34%
2022-23	12078.03	98%
2023-24	16824.75	39%

REVIEW OF LITERATURE

- Desai et al. (2023), The topic of research is "The impact of electric vehicle charging infrastructure on the energy demand of cities," where the researcher describes that electric vehicles are growing well and will be very popular soon. This will increase the demand for electric vehicles, which will also increase the need for electric vehicle charging stations. Electric vehicles are powered by rechargeable batteries, and this complete process is only done with electricity. Without proper planning of the power grid system, the demand and supply of electricity will be mismatched, resulting in power grid failure. In this paper, a study was conducted in the city of Surat by getting data from Regional Transport Office (RTO) registrations. Surat is selected for the first phase of charging infrastructure development by the government of India.
- Mastoi et al. (2022), The topic of the research "An in-depth analysis of electric vehicle charging station infrastructure, policy implications, and future trends" is done in the year of 2022. The highlight of the research papers are electric vehicle charging station infrastructure, power grid and technical challenges, government policies, and future trends in EV sector. This research paper provides information about planning and technology development for improving charging station infrastructure. Researcher identified various challenges related to this EV sector and emphasising on optimised EV charging infrastructure in supporting wind and solar energy integration and reducing grid load by using tools like metaheuristic algorithms to reduce power grid load
- Gupta et al. (2021), The past decade saw the electrification of the transportation division as the primary research area. It has been seen in the past few years that Electric Vehicles (EV). The researcher has done the study on the topic "Optimal allocation of electric vehicle charging infrastructure, policies, and future trends" and describes that the transportation sector is a major reason for the rapid depletion of conventional fuel. This led to the need to find new alternatives and electric vehicles. Every sector is increasing, but the power grid load is also affected. This research paper is concerned with the power grid load impacted by the increase in EV charging. However, detailed economic analysis, future financial impact, consumer charging habits, and preferences are missing key points.
- Mishra et al. (2021) shifting from conventional fossil fuel-powered vehicles to zero or ultra-low tailpipe emission vehicles. To support this transformation, a proper charging station (CS: The topic of study is "A Comprehensive Review of Developments in Electric Vehicle Charging Station Infrastructure and the Present Scenario of India," where researchers studied that the transportation sector is rapidly moving from fossil-fuel-powered vehicles to zero- or low-tailpipe vehicles. The focus area of this paper is to outline proper charging stations, information technology, energy distribution, and government policies that should be taken to support this transition. The present scenario of the EV is also addressed. It is a review of problems associated with charging station infrastructure and proper management for that.
- Csiszár et al. (2019), The study's topic is "Urban public charging station locating method for electric vehicles based on land use approach." The researcher explains in this paper that the inaccessibility and poor location of charging stations present obstacles to the widespread use of electric vehicles. To address these issues, the researchers developed a two-level charging station locating method. Weighted multicriteria techniques were implemented to identify an appropriate site and assign a charging station. This method's primary goals include land use, prospective use of electric vehicles, and potential locations for charging stations. The researcher distributed charging demand into two parts: one is inter-city and the other is intra-city, based on two questions: when and where. The research was conducted in Budapest, the capital city of Hungary, and found that public charging station (PCS) placement in the park-and-ride (P+R) areas, near concentrated services, and in a high-density area is better than gas station placement for the urban public.

Most of the research papers related to public charging infrastructure is only based on power grid load. There is no research paper for PCS development based on consumer needs and preferences.

STATEMENT OF THE PROBLEM

The electric vehicle industry is gaining significant attention globally, including in India. Chhattisgarh, with Raipur as its capital, is undergoing development in this sector. For the government to accelerate the transition to electric vehicles, a robust public charging infrastructure is essential. This study aims to examine the impact of Public Charging Station (PCS) infrastructure development in Raipur city, both before and after its implementation, and to assess consumer demand for such facilities. Key questions include: Where should PCSs be located, and how frequently should they be installed along the routes? Addressing these issues is crucial for understanding consumer perspectives on the development of public charging infrastructure.

RESEARCH GAP

The Indian government is strongly encouraging the shift towards electric vehicles while discouraging the use of petroleum-powered vehicles. The primary reason behind this push is to reduce the country's dependency on fuel imports. Numerous studies have been conducted on electric vehicle adoption, consumer perceptions, satisfaction, and attitudes. However, a review of the literature on charging station infrastructure development reveals that most existing research focuses primarily on the impact on the power grid, technical aspects, and installation processes of PCSs.

OBJECTIVES OF STUDY

- To find out the need for PCS among EV users.
- To know the preferred location for PCS development.

SCOPE OF THE STUDY

This study focuses on the development and impact of Public Charging Station (PCS) infrastructure for electric vehicles in Raipur city, Chhattisgarh. It aims to assess consumer opinions regarding the location and spacing of charging stations to support faster adoption of electric vehicles. The research will examine infrastructure requirements before and after PCS implementation, emphasizing the practical needs of EV users. Technical aspects like power grid load are beyond the scope, as the focus is primarily on consumer behaviour and infrastructure planning for public use.

Hypothesis

- H_{01} = There are significant differences in preferring EV before and after PCS availability.
- H_{02} = There is a significant need for PCS among users.

Sub-hypothesis for this:

A significant difference exists between the observed and expected distribution of PCS needs.

RESEARCH METHODOLOGY

Research methodology provides a systematic approach for conducting this study, helping the researcher to collect, analyse, and interpret data related to PCS requirements among EV users in Raipur city.

Research Design

This study follows a descriptive research design using both primary and secondary data sources. The aim is to understand consumer preferences, needs, and expectations for PCS development in Raipur from a practical and real-world perspective.

Data Collection Methods

- *Primary Data:* Primary data were collected using a structured questionnaire, distributed both online and in person. Respondents were selected randomly from charging stations, parks, and EV service centres in Raipur. A total of 50 EV users participated in the survey.
- *Secondary Data:* Secondary data were obtained from various reliable sources, including:
  - Government reports and press releases (e.g., PIB, 2022 & 2024)
  - Industry websites (e.g., Ather Grid)
  - Official project documents (e.g., Raipur Smart City proposal)
  - Relevant literature and previous research papers on EV and charging infrastructure.

Sampling Method and Size

A random sampling technique was used to select respondents. The sample size was 50, which included electric two-wheeler and four-wheeler users from different parts of Raipur city.

Data Analysis Techniques

- The collected data were analysed using percentage-based analysis and ranking methods.

- Chi-square tests were applied to test the stated hypotheses and understand statistical significance.
- Tables and charts were used to interpret consumer responses, preferences for PCS locations, acceptable waiting times, and desired distances between charging stations.

Tools and Techniques

- Microsoft Excel was used for organising and computing basic statistics like mean, standard deviation, and frequency distribution.
- Hypothesis testing was done using chi-square analysis to measure the relationship between variables such as PCS availability and EV preference.

Reliability and Validity of Data

Reliability of Data

To ensure the consistency and reliability of responses, a pilot survey was conducted with a small group of EV users before final data collection. Feedback from the pilot was used to refine and clarify the questionnaire.

- The internal consistency of the data was tested using Cronbach's Alpha, which is a common method for measuring reliability in surveys with scaled responses (e.g., 1 to 5 rating).
- In this study, the Cronbach's Alpha score was 0.78, indicating a good level of reliability (a score above 0.7 is generally acceptable in social science research).

This shows that the survey instrument provided consistent results among different respondents.

Validity of Data

To ensure the validity (accuracy and relevance) of the data collected:

- Content Validity was ensured by preparing the questionnaire based on literature review, previous research, and expert inputs from the EV sector and urban planning.
- The questions were designed to match the study objectives—mainly to assess consumer opinions about PCS requirements, preferred locations, and waiting times.
- The study also used construct validity by comparing responses with secondary data (e.g., government policies and reports) to confirm that the survey reflects the real-world situation of PCS development in Raipur.

DATA ANALYSIS AND INTERPRETATION

Secondary Data Analysis: Official News Websites, Articles, and Government Reports as below:

- (PIB, 2024) In the press report of PIB, the Ministry of Heavy Industries is working on the promotion of EVs in India, and the Ministry of Power is taking multiple steps for the deployment of FPCs. The government has issued multiple guidelines for charging infrastructure for EVs. EVs can be charged at offices or residences by using electricity, making electricity available in less timeline of PCS, deciding the cost of charging, and so on. 12146 PCS are operational across the country, where the State of Maharashtra has a top position for PCS deployment as 3079 PCSs and Chhattisgarh have only 149 PCSs.
- (Ather Grid, 2024) Another two-wheeler electric scooter is the fastest and largest EV fast PCS provider in India, 2500+ fast PCS deployed till March 2024, and 1000+ locations are identified for fast PCS. In Raipur city, there are more than 10+ fast PCSs in working condition. This location includes the main market, hospital area, temple area, Naya Raipur, Café, service centre, and outer area.
- (PIB, 2022) In the press report of PIB released on 22 March 2022, "According to MOP, there will be set up at least one PCS in every 3 KM by 3 KM grid in the city, there shall be at least one PCS in every 25 KM on both side of the highway and also one PCS for heavy-duty vehicles on both side in every 100 KM in highway".
- (Raipur Smart City, 2020) It is a request proposal and project for "Selection of Agency for Installation, Operation and Maintenance of Electric Vehicle Charging Station at various identified locations in Raipur, on Annual License fee basis" According to this project 25 locations are proposed to install fast and slow PCS, installation cost of PCS is also included in this project. Those places are shown in Table 2.

Table 2: Raipur Smart City Project Memorandum

Category A		**Category B**	
Slow PCS			
Sr. No.		**Sr. No.**	
1	Amanaka Bus Stand	1	DKS Super Speciality Hospital
2	Pandri Bus Stand	2	Mekahara Hospital

Sr. No.		Sr. No.	
3	Balbir Singh Juneja Indoor Stadium		
4	Telibandha Talab		
5	Greenfield Oxycodone		
6	Katora Talab Garden		
7	Vivekananda Sarovar		
8	Anupam Garden		
9	Gandhi Maidan		
10	Jawahar Bazaar		
11	Dhamastal		
12	Bhainsthan		
Fast PCS			
1	ISBT	1	Raipur Municipal Corporation
2	Muli-Level Car Parking	2	Sapre Ground
3	Subash Stadium	3	NIT Raipur
4	Nehru Garden	4	Govt. Nagarjuna Science College
		5	Pt. Ravishankar Shukla University
		6	AIIMS Hospital
		7	Collectorate garden

Primary Data Analysis: 50 electric vehicle users are taken for data analysis and observation as below:

Every traveling kilometre by electric vehicle users by their EV in only around Raipur City is as mention in Table 3.

Table 3: Everyday Ride in Kilometre

Row Labels	
16 to 30 KM	12
31 to 45 KM	13
Above 46 KM	14
Less than 15 KM	11
Grand Total	50

The mean is 20 and the Standard deviation is 7.52, indicating moderate variability.

- Choices among EV users to travel intercity by road:
  - One is Situation A as the current situation of Chhattisgarh state PCS is not available everywhere and respondents can choose 1 or more than 1 options.
  - Other is situation B it is a hypothetical situation if PCS is available everywhere as FS. Respondents have only 1 option to choose.

We can see in Table 4 that PCS development has a positive impact on EV users to choose EVs for one another city ride. 84% of people would like to travel from their EV, which is 4.5 times Situation A. Hence, the alternate hypothesis is accepted.

Table 4: After and Before PCS Availability

	Prefer Car	Prefer Bike	Prefer Bus	Prefer EV (Bike, Car, Bus)	Total
Before PCS availability	31	20	24	9	84
After PCS availability	11	8	7	41	67
Total	42	28	31	50	151

Hypothesis Testing for Hypothesis 1

H_{01} = There are significant differences in preferring EV before and after PCS availability.

The chi-square test of independence was used to test hypothesis 01.

Where,

The chi-square value is 37.32

LOS is 0.05

Df is 3

p-value is $1.66*10^{-8}$

p-value >LOS very small hence null hypothesis is rejected and hypothesis 01, which means there are significant differences in preferring EV before and after PNCS availability.

- On a scale of 5 to 1, where 5 denotes very high need 1 denotes no need at all, and 4.48 mean score of 50 respondents denotes the highest need and importunate of PCS. Alternate hypothesis 1 is accepted (Table 5).

Table 5: PCS Needs

PCS Needs In-Rank	Count
5 Highest needs	27
4	16
3	4
2	1
1 Lowest need	2
	50
	Chi-square value is 50.6 df is 4 p-value is less than 0.001

The p-value is less than 0.05, hence rejecting null hypothesis 2 and accepting the alternate hypothesis.

H_{02} = There is a significant need for PCS among users.

Sub-hypothesis for this:

A significant difference exists between the observed and expected distribution of PCS needs.

Table 6 shows EV users' points of view on the deployment of PCS in kilometers for Highways.

Table 6: Distance Between PCS

Option	Count	Weightage	Rank
8km	20	40%	1
28km	18	36%	2
13km	17	34%	3
18km	13	26%	4
3km	12	24%	5
23km	8	16%	6
Above 28km	2	4%	7

- Consumer preferences for installation of PCS in the city as shown in Table 7. Consumers were free to take one or more options as per their needs. Data is arranged in sequence to get ranking. It will be very helpful to install PCS step by step. Alternate hypothesis 2 is accepted.

Table 7: Suitable Places for PCS

Options	Count	Weightage	Rank
Bus, Train, Airport Parking Area	41	82%	1
Office, University, College Area	37	74%	2
Main Market Area	33	66%	3
Shopping malls	32	64%	4
Hotels, Dhaba, Restaurants	27	54%	5
Hospital	24	48%	6

- Table 8 shows respondents' choice of waiting time in PCS. 72% of users can wait up to 30 minutes the average waiting time of 50 users will be 20 minutes and the standard deviation is 21.679.

Table 8: Waiting Time in Queue

Row Labels	
0 minutes	4
Maximum 30 minutes	36
Maximum 60 minutes	8
Maximum 90 minutes	2
Grand Total	50

- Significance of the Study

My Way

The PCS is not enough when we compare with fuel station. There is strong potential in near future because both electric vehicles number and PCS development number has proportionate relationship. Indian government is very supportive and liberal for this electric vehicles and charging station infrastructure development.

Anyone who wants to charge electric vehicles in a public area, must be in a queue. If PCS is not facilized with good planning results will be frustrating. According to (Jayanthi Madhukar, 2016) Her book A Nation of Queue Jumpers describes that Indian people have a very bad reputation for queue jumping. The population of Raipur city is estimated at 1,433,000. The summary of the finding can help policymakers, urban planner to create future ready and consumer friendly charging stations. It will give better understanding of consumer point of view about public charging station.

For the deployment of PCSs, Financial planning is needed for multiple installations. This study will also help consumers to shift towards electric vehicles and reduce range anxiety, support eco-friendly transportation.

FINDINGS

The findings of the research are as follows:

- 22% of respondents were female and 78% of respondents were male. During the data collection, it was observed that in the available charging stations, there were no females and there were very few females in the service centre.
- Everyday average driving by EV is 20 km/day in the city only. But most people ride more than 46 km/day.
- After establishing a good number of PCSs, people will choose EVs as their primary vehicles instead of petroleum vehicles.
- PCS need is 4.48 on a 5-point scale, which denotes a very high need for PCSs among customers.
- Consumers of EVs prefer to deploy PCSs mostly every 8 km, 13 km, and 28 km on the highway
- Consumers gave weight to deploying PCSs to public transport areas and office areas in the city.

IMPLICATION

Implications of the Study

This study offers several important implications for policymakers, urban planners, electric vehicle (EV) manufacturers, and infrastructure developers:

- *Consumer-Centric Charging Infrastructure Planning:* The research highlights the critical need to design public charging stations (PCSs) based on actual consumer behaviour and preferences rather than purely technical or grid-centric considerations. Understanding user demand for location, waiting time, and charging frequency allows for a more effective and user-friendly PCS network.
- *Strategic Location Selection:* Insights from this study indicate that PCSs should be prioritised near public transport hubs, shopping centres, educational institutions, and commercial areas to maximise accessibility and convenience. Planning PCSs every 8 to 13 km, aligned with consumer preferences, can reduce range anxiety and encourage wider EV adoption.
- *Enhanced User Experience and Satisfaction:* By acknowledging the acceptable waiting time (up to 30 minutes for 72% of users), stakeholders can optimise charging station management, including the integration of mobile applications to reduce waiting time and provide real-time availability updates.
- *Support for Policy and Investment Decisions:* The findings can inform government policies and private investment strategies by emphasising the importance of interoperable charging points and efficient utilisation of existing parking spaces. This can contribute to the efficient scaling of charging infrastructure in urban areas such as Raipur and similar tier-2 cities.
- *Contribution to Sustainable Urban Mobility:* Effective deployment of PCS as guided by this study supports the larger goals of reducing carbon emissions, promoting clean energy, and enhancing sustainable transportation ecosystems aligned with national initiatives such as FAME II and EV30@30.
- *Basis for Further Research:* The consumer-focused approach provides a foundational model that can be adapted and expanded in future studies to include diverse regions, vehicle types, and evolving technology trends.

SUGGESTIONS

- Electric two-wheelers should be considered for PCS development because most Indian Vehicle owners prefer two-wheelers to cover maximum distance because of affordable ownership of two-wheelers.
- To deal with queues in PCSs, an application can help by providing busy or available for charging; estimated waiting time.
- Numerous parking places all over Raipur must be used for PCS. Naya Raipur should also be considered.
- Most of the EV have different charging ports, it will be very good if it is available for everyone.
- Chhattisgarh has more than 3,500 kilometres of national highways. PCS connectivity is needed to fulfill the target of only EVs till 2030. More than 350 PCS points are needed on this national highway and the cost for this is a minimum of 50 crore.
- From a business point of view a PCS is profitable having potential for another business café, hotel, and Dhaba.
- While reviewing other research papers Energy demand and supply should be taken care of to support the increasing demand for EVs and PCS.

CONCLUSION

The growth of electric vehicles in India depends heavily on the availability and accessibility of public charging stations (PCSs). This study highlights the urgent need for well-planned PCS infrastructure in Raipur city, based on consumer preferences and usage patterns. The findings show that users strongly demand PCSs every 8 to 13 kilometers, especially near transport hubs, offices, markets, and public places. Most users are willing to wait up to 30 minutes, and their willingness to adopt EVs increases significantly with better charging availability. The study confirms that PCS development not only supports EV adoption but also contributes to reducing pollution and fuel dependency. Therefore, integrating consumer insights into infrastructure planning is essential for building a sustainable and EV-friendly urban environment.

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