AIMS Energy, 13(6): 1518–1537.
DOI: 10.3934/energy.2025056
Received: 24 March 2025
Revised: 11 August 2025
Accepted: 16 October 2025
Published: 09 December 2025

https://www.aimspress.com/journal/energy

*Research article*

# Business model & load profile for commercial EV charging stations

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**Abstract:** The rapid growth of electric vehicles (EVs) necessitates a robust charging infrastructure to ensure reliability, grid stability, and user convenience. This study developeda data-driven framework for optimal siting and sizing of electric vehicle charging stations (EVCS) using geographic information systems (GISs) combined with multi-criteria decision-making techniques such as fuzzy analytical hierarchy process (FAHP) and multi-attributive border approximation area comparison (MABAC). Using the GIS-FAHP-MABAC method, we found that Site D emerges as the most suitable (suitability score of 0.86). The methodology integrates spatial, technical, and socio-economic factors to evaluate research sites while considering power system constraints and projected demand growth. Simulation results demonstrated that the proposed approach enhances load distribution, reduces grid stress, and improves accessibility compared to conventional planning methods. The findings provide actionable insights for policymakers and urban planners to accelerate sustainable EV adoption while supporting renewable energy integration and reducing dependence on fossil fuels. This paper examined the many factors that influence the business model and load profile of EV charging stations in Kota City, as well as the proportions of their charging voltage (CV) and charging current (CC) for certain stochastic distributions of the various components. The suggested business model for EV charging stations, which includes all stakeholders, can enable car owners to travel at a lower cost.

**Keywords**: electric vehicles; charging stations; distributed energy resources (DERs); business model; sustainability

**Nomenclature:** EV: electric vehicles; $F_V$: future value; CS: charging station; $r$: interest rate; EVCSs: electricvehicle charging stations; $n$: number of years; MoP: minister of power; $P_L$: peak load; $C_C$: income cost; $T_{ec}$: total energy consumption (kWh); $C_V$: investment cost; $PD_E$: power demand factor; $C_E$: electricity cost; $T$: timeinterval (hours); $G_R$: ground rentalcost; $L_f$: load factor; $C_M$: maintenance cost; $L_a$: average load; $C_D$: charging demand; $E_{Total}$: total energy; $C_p$: charging price; $U_f$: utilization factor; $P_V$: present value; $T_{total}$: total time

## 1. Introduction

The electrification of road transport is accelerating globally, placing urgent demands on planning, siting, and operating resilient electric vehicle charging station (EVCS) networks. Public charging infrastructure has expanded rapidly since 2022—with over a million public chargers added in 2024 alone—creating both opportunity and new operational stresses for distribution systems. Recent empirical datasets and city-scale harmonized transaction records now allow planners to move from coarse, top-down estimates to fine-grained, data-driven siting and sizing decisions for electric vehicle supply equipment (EVSE) and associated solar photovoltaic (PV) system + battery energy storage (BES) integration.

Site selection of EVCSs has seen a methodological shift toward geographic information systems (GISs) combined with fuzzy multi-criteria decision making (MCDM). The latest work explicitly applying a GIS-FAHP-MABAC pipeline demonstrates how spatial constraints, weighted criteria, and robust MCDM ranking can identify ranked alternatives for network expansion with high geographic specificity [1]. At the same time, review studies reveal advances in smart charging, V2G, PV-coupled charging, and the use of large transaction datasets to model temporal demand patterns—yet these studies also highlight recurring gaps: (i) limited integration of high-resolution spatial MCDM with empirical charging transaction data; (ii) few standardized approaches to jointly size PV + BES based on site-specific load forecasts; and (iii) insufficient articulation of equity and reliability trade-offs in site-allocation models.

Governments can provide fair access to the infrastructure needed for growing mobility and population density. In order to reduce pollution and raise the city's air quality index, Kota, which had 1,558,470 residents and 63,740 automobiles in 2024, is quickly transitioning to electric vehicles. So, in this paper, the main focus is on the load profile and business model for commercial EV charging stations in Kota City [2,3].

Transportation electrification is accelerating globally, spurring urgent demand for strategic deployment of electric vehicle charging stations (EVCSs). High-resolution charging transaction datasets now enable granular, data-driven forecasting of charging behaviour [4,5]. Simultaneously, GIS-integrated multi-criteria decision-making (MCDM) methods—such as GIS-FAHP-MABAC—have gained prominence for spatially informed siting strategies [1]. Yet, significant gaps endure: Existing models often rely on proxy demand indicators and neglect load-profile-informed PV and battery energy storage (PV + BES) sizing, while insufficiently addressing equity and reliability in rollout strategies. This work bridges these gaps by: (1) integrating session-level empirical load profiles into GIS-MCDM weightings; (2) coupling site selection outcomes with PV + BES techno-economic optimization; and (3) embedding equity and reliability considerations into reproducible deployment frameworks.

It is important to invest in EV and EVSE deployments as EVs have zero direct exhaust emissions, which improves local and urban air quality. Additionally, fewer conventional fuel cars are on the road, which lowers local pollutant emissions [6]. We should be moving away from imported fuel oils as the rate of oil is increasing in the international market rapidly after the various disasters and wars, so it is an important step to maximize reliance on home electricity for transportation to boost energy security and decrease fossil fuel imports, and to decrease foreign exchange costs.

This article covers EV production, sales, upkeep, and other services. The deployment of EVSE presents the potential for recharging and similar services in the private sector. Over the past few years, there has been a progressive increase in the importance that practitioners and academics have given to business models. Operational business models for EVSE have expanded beyond simple charge-for-energy to include subscription models, managed charging services, and grid services (frequency regulation via V2G). Evolving standards (OCPP, ISO 15118/Plug & Charge) and market design changes are enabling these services while also introducing cybersecurity and interoperability concerns that must be addressed in deployment strategies [2,7]. In order to handle higher charging demands, grid operators must enhance grid capacity and charge point operators (CPOs) must buy energy from the electrical market. Usually, load profiles for families are summarized using past energy consumption information for various dwelling types, seasons, days, etc. [3]. These profiles are known as standard load profiles. Traditionally, these characteristics are taken into account while designing the grid and buying energy [8]. They are also used to calculate the transformer and transmission capacity for a specific number of EV customers. There are no such profiles for PCSs, though, and only sporadic small-scale results or models that concentrate on either simultaneity factors or EV recharging have been published to forecast the load profiles brought about by EVs [9]. This paper is unique due to the scale of the analyzed data and can thereby provide a new level of detail.

This paper proposes the case study of Kota City located in the state of Rajasthan, India. Electric car charging stations can be built and installed in compliance with regional standards. It would be profitable to monitor and repair EV charging stations. The prospect of starting and maintaining a full charging station management system increases with the number of charging stations.

In the filling-station model, this is not utilized. It is possible for an EV that is parked to be a linked vehicle, a battery pack that is connected to the power grid and offers possibilities for dynamic energy management, interactive intelligence, and charge alignment. You may choose how and when to supply energy with a linked automobile [10]. A “charge-only” system provides temporal flexibility and coordination, which is intriguing since bidirectional energy flow does not change the fundamental problems [11]. Coordination between parked cars and service aggregators suggests business ideas. For instance, a downtown parking garage with several charging stations may provide the grid with additional services like frequency control. Businesses from diverse industries are joining at different stages of the value chain [12]. One of the most important requirements for expanding the market for EVs is the availability of charging stations in public areas. To create an enabling EVSE ecosystem and accelerate the introduction of EVs, this paper looks at several topics of the infrastructure of electrical vehicle supply charging stations, such as standards, load profiles, and the business model.

To mitigate some of the effects that they will have on electric grids, PV and battery energy storage (BES) will need to be included in the EVCS. Forecasting an accurate combined daily EV load profile is therefore crucial for determining the optimal quality of services (QoS), minimizing the impact on the grid during operation, and determining the ideal sizes of PV and BES at the design stage. Using deterministic or stochastic programming, the daily EV demand profile for a single charger or several chargers for uncontrolled or regulated charging for various penetrations in homes, businesses, and industries may be anticipated [13].

Additionally, this study employs the GIS-FAHP-MABAC technique to select sites for the installation of electric vehicle charging stations (EVCSs). High-demand locations close to transportation corridors were physically identified using geographic information system (GIS) data and variables including traffic density, proximity to substations, and land use, which were given priority weights using the fuzzy analytic hierarchy process (FAHP). Then, prospective sites were ranked according to their overall appropriateness ratings using the MABAC (multi-attributive border approximation are a comparison) approach. The growth of EV charging infrastructure is guaranteed to be more location-aware and optimal thanks to this unified decision-making framework. Other methods for predicting the EV load profiles include cost-benefit analysis expressed in terms of losses or monetary values. Load expectation loss (LOLE), energy expectation loss (LOEE), load frequency loss (LOLF), and load duration loss (LOLD) are a few examples of the losses.


**Figure 1.** Overview of Kota City.

The Figure 1 is the overview of area’s present in the Kota city. The Kota City is a smart city which is located in Rajasthan state in India and is well known as a popular study center of India. The population of Kota City in 2024 was 1,558,470, a 3% increase from 2023, which is now the third most populous city in Rajasthan [9]. The total number of vehicles in Kota City in 2024 was 677,237 out of which there are currently 6371 electric vehicles, while in 2022 there were 2913 electric vehicles. This will increase rapidly after allocating a cost-friendly charging in frastructure in various areas of Kota City [14,15]. Kota City is located at 25°11'N and 75°51'E. It covers an area of around 570.36 $km^2$ (220.22 sq mi) and rises up to a height of 271 m (889 ft) above sea level.

**Table 1.** The analysis of different areas of Kota City on various parameters.

| S.NO | Location | Population | Area ($km^2$) | Density |
|---|---|---|---|---|
| 1 | RANBARI | 26,778 | 3.73 | 7173 |
| 2 | NAYAPURA | 30,675 | 4.36 | 7031 |
| 3 | CHAWANI | 12,995 | 1.78 | 7303 |
| 4 | DADABARI | 47,543 | 4.77 | 7361 |
| 5 | GHUMANPURA | 31,638 | 5.91 | 5774 |
| 6 | STUDENT AREA | 59,073 | 7.01 | 5608 |
| 7 | I.L COLONY | 9841 | 1.31 | 7522 |
| 8 | TALWANDI | 24,687 | 3.15 | 8208 |
| 9 | VIGYAN NAGAR | 175,571 | 30.6 | 5737 |
| 10 | MHAVEER NAGAR | 34,596 | 11.28 | 8239 |
| 11 | RAILWAY STATION AREA | 55,487 | 12.56 | 4419 |
| 12 | R.K PURAM | 34,036 | 2.23 | 5324 |
| 13 | SHRINATH PURAM | 16,618 | 3.03 | 5491 |
| 14 | KUNADI | 48,874 | 9.9 | 1204 |
| 15 | BORKHERA | 35,022 | 7.29 | 4419 |

As we can see from Table 1, the spread of population and densities of different areas located in Kota City and the surrounding area are shown in $km^2$. By this, we can predict the rush and demand of charging in the future. The higher the population of the area, the more demand for charging EVs will exist and more profitable businesses will be developed in that area [16]. So, we will only consider areas that are high in density and area, so that we can get more revenue for the EVCSs.

## 2. Type of equipment and power flow in EVCSs

There are several viable EVSE business concepts. Various EVSE business models could be suitable for various situations. Although not all EVSE strategic concepts are successful, so other EVSE business model can be required. There are many factors affecting the business model of charging stations; one of the important factors is the type of charging equipment used to charge [17]. In Table 2, we analyzed the various types of chargers, as the main component that affects the cost of a charging station is the charger or sockets used. There are mainly two types of chargers available in the market: AC chargers and DC chargers [18]. The AC chargers consist of Type-1, Type-2, and Type-3 chargers, and the DC chargers consist of a CHAdeMO charger, GB/T, and SAE combined charging system (CCS). The other components used in EVCSs depend on the capacity of the charger and the size of the charging station [16,18]. The Figure 2 shows the power flow of EVCSs. The generated power from power plants comes to the grid then through Utility distribution network it goes to meter where the unit of consumption is measured, then through Electric panel and control panel where the energy and converted and stabilized it goes to EV chargers through which EV gets charge.

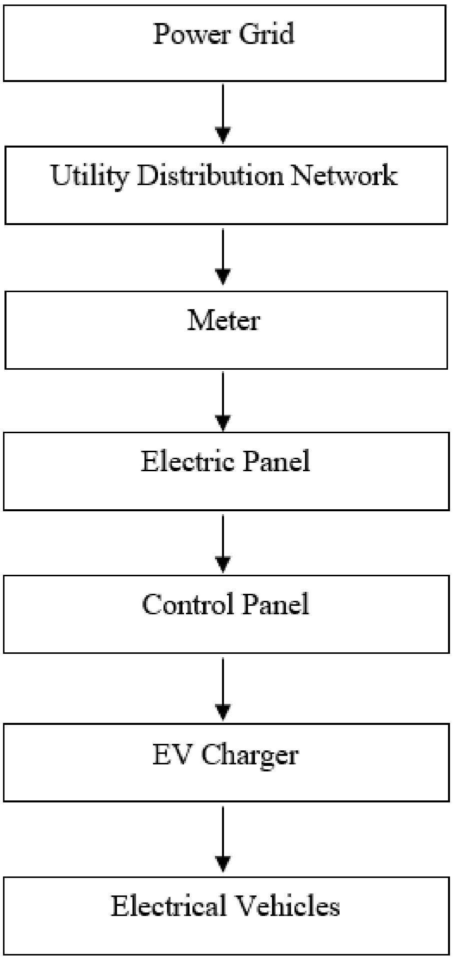


**Figure 2.** Power flow in EVCSs.

**Table 2.** Statical analysis of various types of power supply and charging times of EVs.

| | Power supply | Power | Voltage | Charging time per 100 km |
|---|---|---|---|---|
| High power charging | Direct current | 120 kW | 300–500 V DC | 10 minutes |
| | | 50 kW | 400–500 V DC | 20–30 minutes |
| | Three-phase | 43 kW | 400 V AC | 20–30 minutes |
| Normal power charging | Three-phase | 22 kW | 400 V AC | 1–2 hours |
| | | 11 kW | 400 V AC | 2–3 hours |
| | Single-phase | 7.4 kW | 230 V AC | 3–4 hours |
| | | 3.3 kW | 230 V AC | 6–8 hours |

*2.1. Who can own EVCSs?*

Following extensive stakeholder engagements, the Minister of Power (MoP) issued a statement in April 2018 that made it clear that the purchase of power by EVSE from DISCOMs and the sale of that electricity to EVs were not regarded as the selling or trading of electricity [4,19]. For potential EVSE business owners, this has provided much-needed respite. Anyone now has the option to start a company by applying for new EVSE connections.

*2.2. Land for EVSE*

In order to support the growth of electric cars, at least 10% of parking spots may be set aside for EVSE without leasing rent for the time being. As the EVSE itself takes up minimal room and may even be placed on a wall, data from references such as the Ministry of New and Renewable Energy (MNRE) (2023) and Rajasthan EV tariff guidelines are taken in consideration. However, parking space is needed for the EVs that will be linked to the EVSE for a number of minutes or hours. In cities, the cost of the same type of land might be high. The EVSE company will not be feasible even if local governments or property owners (such as malls/marts, health centers, buildings, offices, institutes, railway stations, bus stations, and transportation hubs) charge a nominal rent for the samearea [20,21]. The Kota Municipal Transport Report 2023 [23] provided the demographic information, and the Rajasthan State EV Policy Dashboard [22] and NITI Aayog 2023 [21] forecasts provided the EV adoption figures.

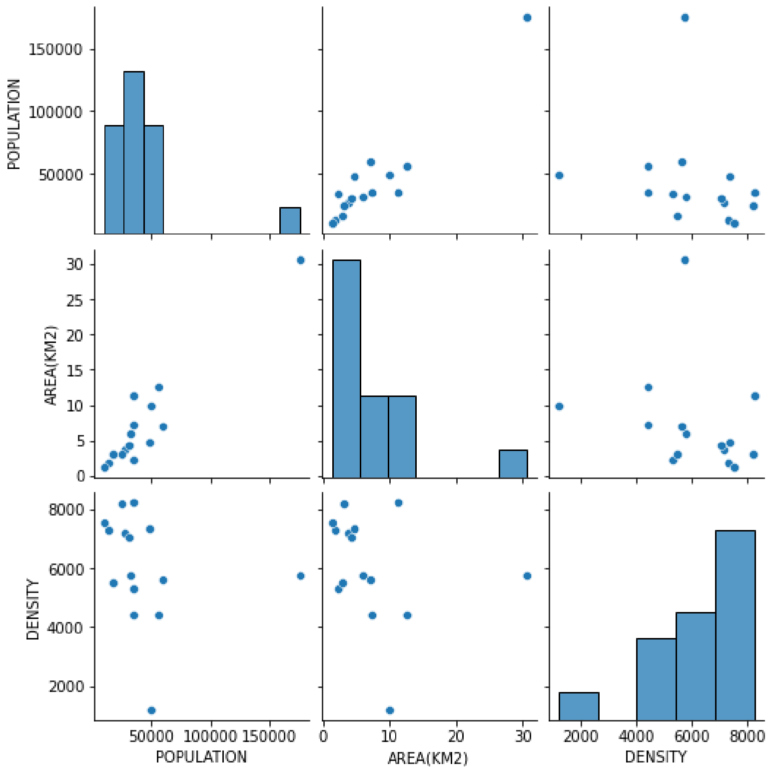


**Figure 3.** Plot pair of various factors for different locations in Kota City.

In Figure 3, we see the graphs showing relations between various parameters of every location in Kota City such as area, density, and population. This helps us to predict the demand for charging stations in Kota City. This tells us that the need for EVCSs is a must in the upcoming year and the business model will be successful in different areas of the city [24].

## 3. Results and discussions

### *3.1. Load profile analysis*

The pattern of electricity demand over time as cars charge is known as the charging station's load profile [23]. It offers information on peak loads, energy consumption, and times of high or low demand, all of which are essential for improving in frastructure development and energy management [24,25]. The charging session frequency is one of the most important elements of a charging station load profile. Energy consumption (kWh), the number of cars charged over time, the time of day (such as nighttime or rush hours), weekday versus weekend usage, the length of the charging sessions, the amount of time cars stay connected (which affects the availability of stations), times when automobiles are linked but not charging, and demand fluctuations might be attributed to pricing incentives, vehicle types, or user behavior [4,5].

In this paper, for analyzing the load profile, we have identified various types of vehicles present in Kota City and their cap a city. Table 3 shows the total number of various kinds of electric vehicles present in Kota City in 2024 in terms of class as well as in terms of fuel [13]. The E-Rickshaw travels a short distance and has frequent stops, so it consumes 8 kWh average daily energy and comes with 3 kW slow chargers and 7 kW medium speed chargers. There are 3652 two-wheelers, which are light usage vehicles that coma with 3 kW slow chargers. Whereas four-wheelers come with medium to fast charging capacity from 7 kW to 50 kW charging speed. The strong hybrid EVs (SHEVs) are vehicles that are capable of running on an electric motor alone for a certain period of time or range. There are 64 SHEV vehicles present in Kota City. These types of vehicles mostly have large batteries that can be recharged by the engine and regenerative braking. So, their period of charging battery is longer as compared to other types of EVs, as they do not require regular based charging (Bi et al., 2025). On the other hand, the electric (BOV) and Pure EV both purely rely on battery power and electric motors, so they need more frequent and regular charges. There was a total of 4936 electric (BOV) and 1331 Pure EVs present in Kota City in 2024.

**Table 3.** The analysis of various types of EVs present in Kota City.

| Vehicle Class-Wise Fuel Data of KOTA RTO—RJ20, Rajasthan (2024) | | | | | |
|---|---|---|---|---|---|
| S. No | Vehicle class | Fuel | | | Total |
| | | Electric (BOV) | Pure EV | Strong hybrid EV | |
| 1 | E-RICKSHAW (P) | 1942 | 174 | 0 | 2116 |
| 2 | E-RICKSHAW WITH CART (G) | 311 | 1 | 0 | 312 |
| 3 | GOODS CARRIER | 4 | 0 | 0 | 4 |
| 4 | M-CYCLE/SCOOTER | 2509 | 1143 | 0 | 3652 |
| 5 | MOTOR CAB | 2 | 0 | 0 | 2 |
| 6 | MOTOR CAR | 136 | 13 | 64 | 213 |
| 7 | THREE-WHEELER (GOODS) | 32 | 0 | 0 | 32 |

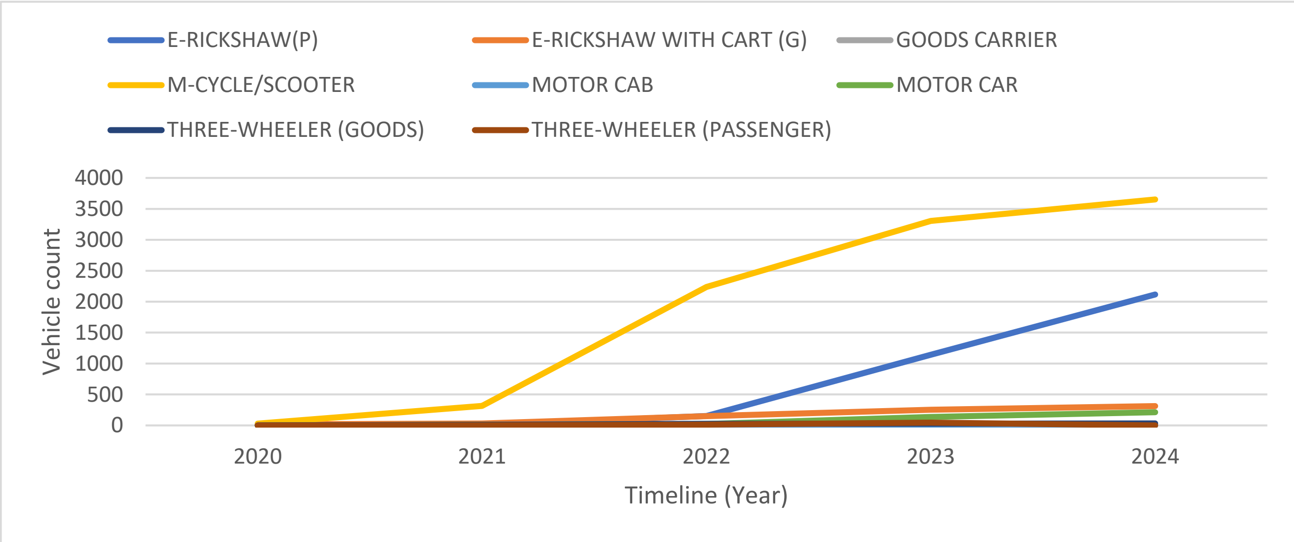


**Figure 4.** Yearly share of various types of EVs in Kota City.

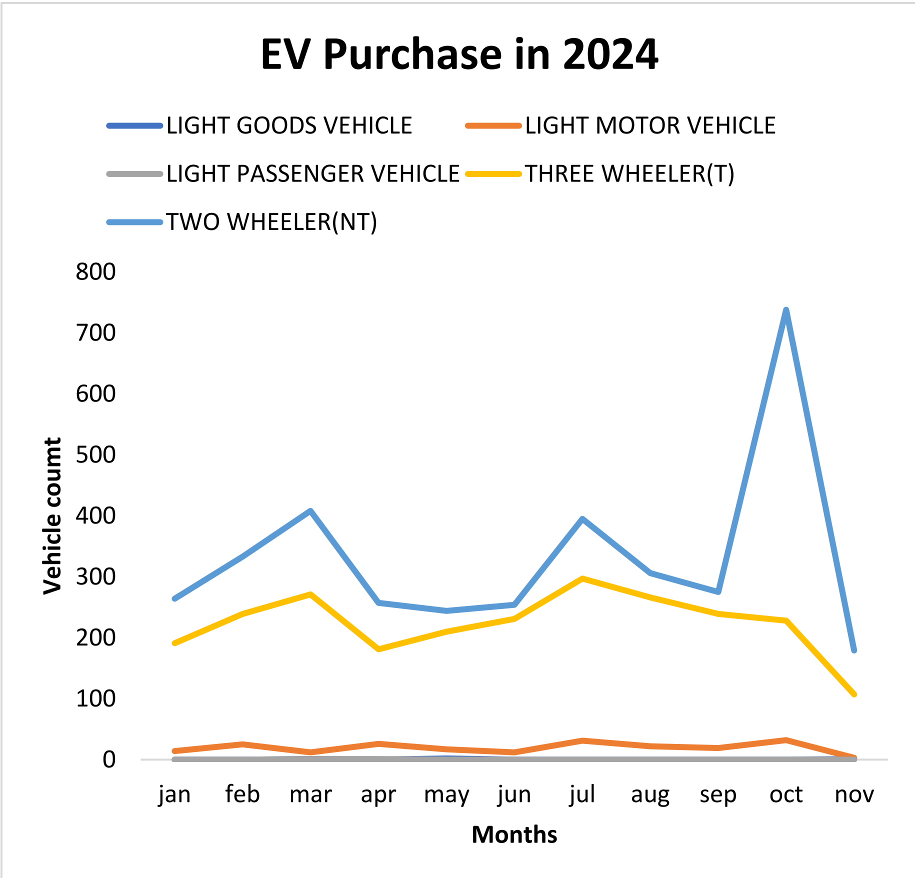


**Figure 5.** Monthly EV demand in Kota City.

As the number of EVs in the market is increasing every year, the load and electricity requirement will also increase in the upcoming years [26]. Figure 4 shows the analysis of the last 5 years' report on electric vehicles in Kota City. By this, we can analyze the load profile of EVCSs in Kota City. By the graph, we can see that the two-wheelers and motor cabs are increasing rapidly in comparison to other vehicles, which will clearly affect the load profile. Figure 5 shows the monthly EVs purchased in Kota City. By comparing both graphs, we can see that people are purchasing more two-vehicles, three-wheelers, and motor cabs. The two-wheelers' battery capacity is less as compared to three-wheelers and the battery capacity of motor cabs is highest compared to the other two. These three types of EVs are used in day-to-day life and, because they have small to medium batteries, they need to charge every day and night [27].

**Table 4.** The capacity of various types of EVs in Kota City.

| EV types | Model | Recharge time | Travel range | Battery capacity |
|---|---|---|---|---|
| Four-wheelers | Tata-Nexon EV | 65 min (FC) | 312 km | 30.2 kWh |
| | MG-ZS EV | 50 min (FC)<br>6–8 hrs (SC) | 340 km | 44.5 kWh |
| | Tata-Tigor EV | 90 min (FC)<br>6 hrs (SC) | 142 km | 30 kWh |
| | Hyundai-Kona EV | 57 min (FC)<br>6 hrs (SC) | 452 km | 39.2 kWh |
| | Mahindra-e2oPlus | 75 min (FC)<br>6 hrs (SC) | 99.9 km | 10.08 kWh |
| Three-wheelers | Mahindra-e-Verito | 1.45 hrs (FC) | 140 km | 21.2 kWh |
| | Mahindra-TREO (AUTO) | 3 hrs (SC) | 130 km | 7.37 kWh |
| Two-wheelers | Revolt-RV400 | 4.5 hrs (SC) | 80–150 km | 3.2 kWh |
| | TVS-iQube | 5 hrs (SC) | 75 km | 4.5 kWh |
| | Bajaj-Chetak | 5 hrs (SC) | 85–95 km | 3 kWh |
| | Ola-S1/S1 Pro | 6.5 hrs (SC) | 121–181 km | 2.98–3.97 kWh |
| | Pure EV-Epluto 7G | 4 hrs (SC) | 90–120 km | 2.5 kWh |
| | Hero-Photon HX | 5 hrs (SC) | 80 km | 1.8 kWh |

Table 4 shows that the EV battery size ranges between 1.8 kWh to 44.5 kWh, whereas the range of the vehicles area minimum of 75 km and a maximum is 452 km. These are the vehicles that come under either Pure EV or electric (BOV), so the only source of energy is the battery. The market share of the vehicles will be different and depend on a myriad of factors such as driving range, prices, policy, incentives, etc. Now, as we know the population of each area of Kota City, the density of the area, the number of EVs present in Kota City, and their charging time and battery capacity, we can further estimate the energy demand, assuming that a single electric vehicle chooses whether to use the nearby charging station each day and that the capacity for charging is allocated at random [2,28]. A certain charging station's daily influx of EVs for recharging fulfills the statistical distribution, whose power distribution function is:

$$PD_E\{K = x_m\} = \frac{\delta e^{-\delta}}{x_m!}, x_m = 0,1,2, \dots m \quad (1)$$

The total energy consumed by the charging station over a specific period is calculated as:

$$T_{ec} = \int Q(t)dt \tag{2}$$

where $T_{ec}$ is the total energy consumption (kWh), $t$ is the time interval in hours, and $Q(t)$ is the instantaneous power demand (kW) (function of time).

By analyzing the load factor, we can seehow effectively the charging station is being used.

$$L_f = \frac{L_a}{P_L} \tag{3}$$

where

$$\text{Average Load, } L_a = \frac{E_{total}(kWh)}{Time\ period(h)} \tag{4}$$

Peak load is the max power demand during the period (kW).

The demand factor ($D^f$) evaluates the station's installed capacity in relation to its peak load:

$$D^f = \frac{P_L}{C^p} \tag{5}$$

The utilization factor calculates the proportion of time spent using the charging station during periods of high demand.

$$U_f = \frac{E_t\ Delivered}{P_L \times T_{total}} \tag{6}$$

Out of the total EVs present, there are a total of 2116 E-Rickshaw (passenger), which consume daily energy on average of 6 kWh (short distances, frequent stops), having a slow charging type (3 kW). We can analysis that in weekdays, the E-Rickshaw passenger vehicles are charged mainly at night after daily operations and E-Rickshaw with cart (goods) are charged during afternoon breaks. Goods carriers are charged at night, and bikes and scooters are charged mostly at night. Whereas motor cabs are charged multiple time/day spaced evenly according to the situation. Personal cars are charged during the morning and evening. The highest demand occurs at night when the most E-Rickshaws, two-wheelers, and cars are charged after traveling for the whole day. There is minimal load during late morning and early afternoon times.

Figure 6 shows the hourly load profile of charging various EVs at charging stations in Kota City. The highest demand occurs at night (9 pm–12 am) at 22.8 MW, as most vehicles charge at that time after operations are done for the day. Whereas in the off-peak periods, the minimal load demand occurs during late mornings and early afternoons (9 am–4 pm).

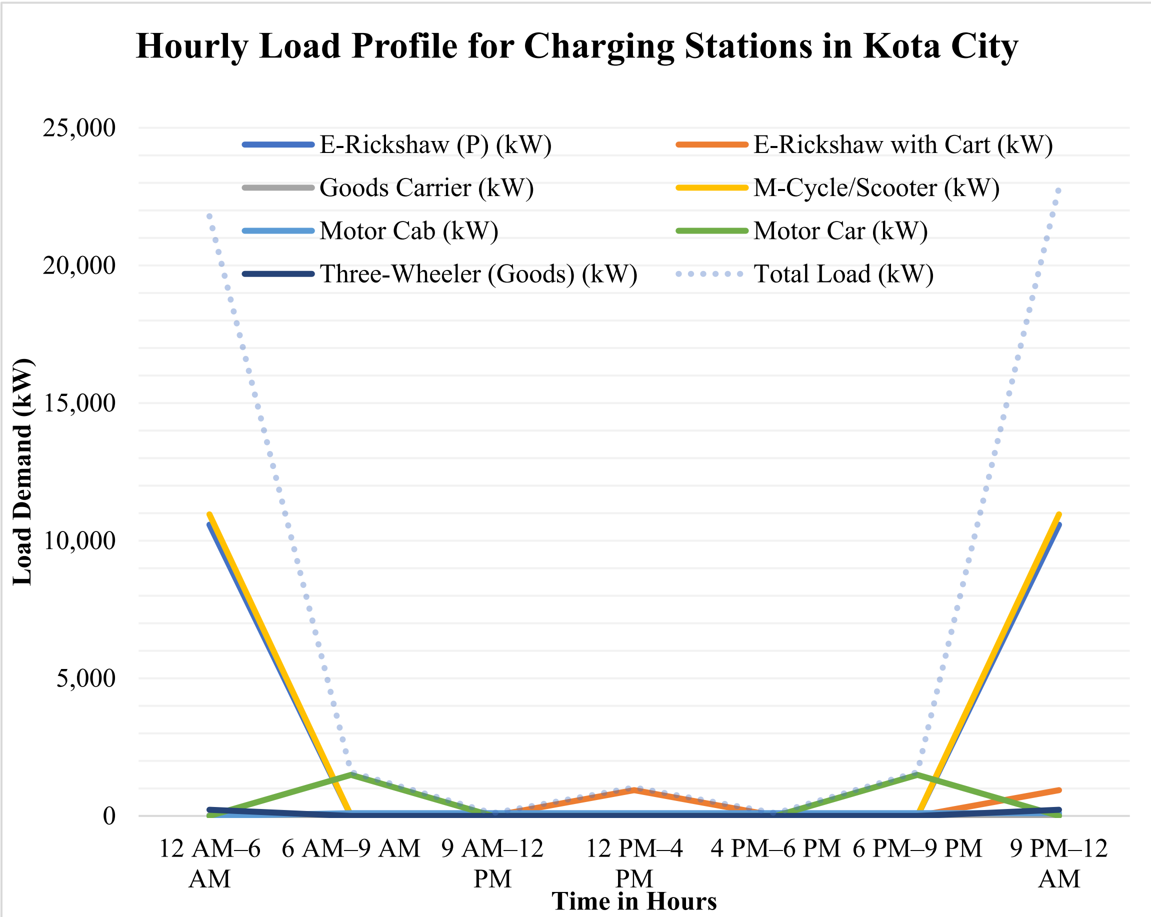


**Figure 6.** EV charging load profile of Kota City (w.r.t.time).

### *3.2. Revenue and cost estimation*

Understanding the expected expenses is crucial when deciding how to deploy charging infrastructure. The energy that charges stations can give, the functionality they provide, and the quality of their construction all affect how much hardware costs [29,30]. Depending on the amount of electricity needed for the charging stations, installation prices might vary. The total amount of kWh passing through a unit multiplied by the price per kWh defines the electricity cost. There will probably be some maintenance needed to make sure the charging station stays functional [31,32]. The majority of reliable suppliers will give some sort of maintenance and/or extended warranties [33].

$$R = C_c - C_v - C_E - G_R - C_M \tag{7}$$

It is crucial to first pinpoint the primary factors influencing the income streams and how these factors affect the overall value in order to appropriately evaluate the revenue streams from the standpoint of public charging infrastructure [34]. The revenue generated is calculated by using Eq 7 in which the investment cost ($C_v$), cost of electricity ($C_E$), ground rental cost ($G_R$), and cost of maintenance ($C_M$) are subtracted by the income cost ($C_c$) [35,36].

$$C_c = Subsidy + EVChargingCost \tag{8}$$

$$EV\ Charging\ Cost = C_D * C_P \quad (9)$$

In Eq 9, the cost of income is a function of the subsidy and the EV charging cost, and the EV charging cost depends upon the charging price ($C_P$) and charging demand ($C_D$). The charging demand varies with time [37]. At the peak time, the charging demand is high, whereas in the daytime, the charging demand is less [38,39].

There are three chargers at a station—two type-1 AC chargers of level 2 chargers, whose power input would be 3 phase 415 V provided by CESE Rajasthan electricity distribution board and which gives an output between 3.3 kW and10 kW per installation unit, which may cost together around Rs. 150,000, and one DC fast charger, whose input will be provided by CESE Rajasthan and whose output will be 25 kW, which will cost around Rs 700,000. Further, by adding all the costs such as a new electricity connection (50 kW), LT cables, circuit breakers, energy meters, control panels, etc., this may cost around 200,000 and the civil construction work of the infrastructure would cost around 75,000. If we add the cost of data-collecting software systems and CCTV camera systems, then the overall cost for installing the charger would be around Rs. 117,0000 and the maximum power sold per day would be 842 kWh, assuming 20 hours per day of charging. By adding another expenditure of Rs. 155,000 for maintenance and a technician, considering Rs. 25,000 as the monthly salary for the first six months, the total cost for the first year would be Rs. 215,000. This would be followed by Rs. 65,000 for subsequent years. As a result, we can calculate the entire investment for installing EVSE charging stations [40,41]. Hence we conclude that the total investment to set up EVCS in Kota City will be approx. Rs. 8 cr.

According to the study, the minimum number of charging stations required in Kota City is 21 and there are 45 petrol pumps located in Kota City, where collected data came from references from the MNRE (2023) and Rajasthan EV tariff guidelines, so if we consider on average 30 charging stations needed in Kota City to fulfill the demand for charging EVs. By this, we can calculate the entire investment to set up the required number of charging stations to complete the demand of customers in Kota City [42]. Now we will calculate the revenue. If we consider 20 hours of charging operations for 25 days/month, then 365 days × 20 hrs. = 7300 hrs. max capacity.

In Scenario A, an electricity pricing margin of Rs. 3.5 is taken into consideration. In Scenario B, we take into account a margin of Rs. 4 in the first and second years, Rs. 3.5 in the third and fourth years, and Rs. 3 from the fifth year onward. The total electricity sold to charge an EV per year is 842 kWh per day × 365 = 307,330 kWh, so if we consider a margin of Rs. 3 on the electric tariff and no land cost included, then the net revenue in 5 years will be Rs. 7.25 cr. Consequently, based on our evaluation of the existing market construction of EV charging, infrastructure will be challenging as a first-time investment of Rs. 8.25 cr. The net cumulative cost to build up the EVSE facilities is Rs. 7.25 crore to be returned in 5 years with a tolerance of eachsingle unit of power costing Rs. 3. There is no motivation for EVSE to be installed and operated by other parties [43].

Currently, investing by people or businesses in the PCS industry is not financially feasible. In order to speed up the adoption of electric mobility, the government could fail to push third parties to build public charging stations. In contrast, GNCTD could offer a capital subsidy covering the price of chargers and installation costs in Kota [44,45]. Given the cost estimates in Table 3, installing a public charging station in Kota would have a favorable internal rate of return (IRR) if the cost of chargers were fully subsidized [46]. The net present value is a discounted cash flow that considers the time value of money as mentioned in Eq 10 to calculate the inflow and outflow of the invested cash in EVCSs in Kota City.

$$P_v = F_v \frac{1}{(1+r)^n} \tag{10}$$

So, by the hypothesis decision rule, we can say if NPV > 0, then it is acceptable, and if NPV < 0, then we have to reject that model. In Table 5, we calculated that the NPV of Scenario A is Rs. 175,385 and the IRR is 16.07%, and the NPV of Scenario B is Rs. 120,963 and the IRR is 14.03%. So, we can consider this acceptable.

**Table 5.** The cash flow of EVCS costs.

| Year | Cash flow in scenario A | Cash flow in scenario B | Discounted factor@10% |
|---|---|---|---|
| 0 | 1,170,000 | 1,170,000 | 1 |
| 1 | 324,600 | 232,300 | 0.909 |
| 2 | 94,000 | 130,500 | 0.826 |
| 3 | 322,200 | 324,000 | 0.751 |
| 4 | 473,400 | 473,400 | 0.683 |
| 5 | 656,000 | 521,780 | 0.621 |

*3.3. Suitability score analysis*

The appropriateness ratings of five potential sites in Kota for the expansion of electric vehicle charging stations (EVCS) are displayed in Figure 7 using a GIS-FAHP-MABAC multi-criteria decision-making framework. Road networks, population density, land usage, and sun irradiation were among the geographical data mapped using the GIS. The following choice criteria were given weights using the fuzzy analytical hierarchy process (FAHP) like closeness to traffic centres, separation between substations, potential for cost, and availability of land.

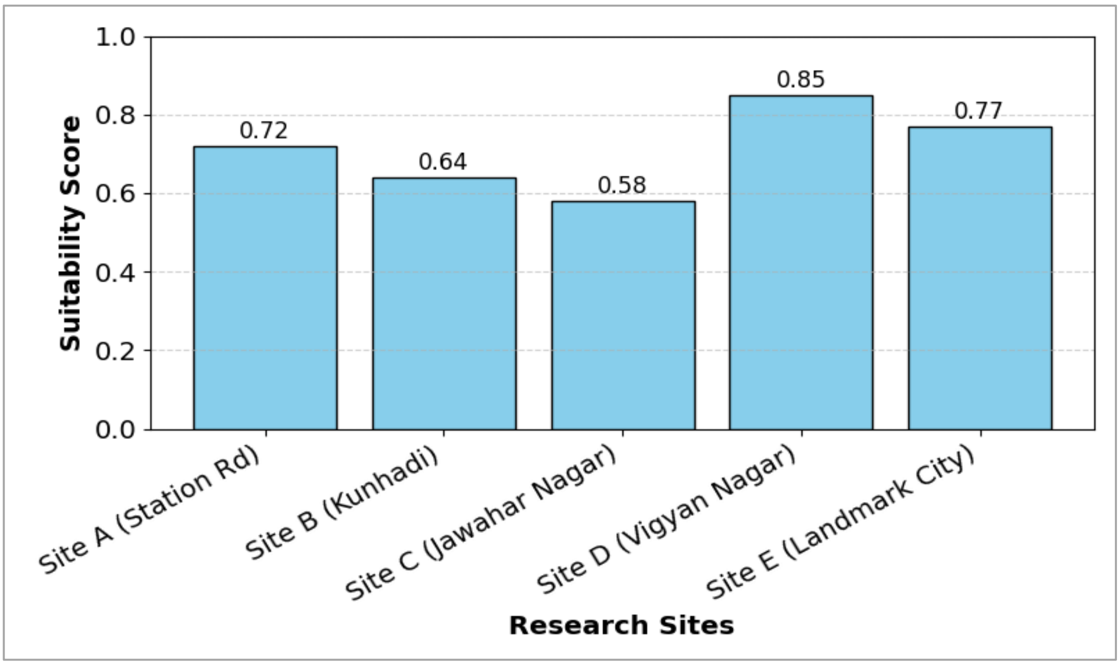


**Figure 7.** Suitability scores.

These weighted criteria were used by the MABAC (multi-attributive border approximation area comparison) to rank the options. With the best appropriateness score (0.85), Site D (Vigyan Nagar) shows excellent alignment with demand, infrastructure, and energy availability. Additionally, Site E (Landmark City) exhibits great potential (0.77), most likely as a result of its accessible main highways and ample land. The lowest score (0.58) is obtained by Site C (Jawahar Nagar), indicating constraints such as insufficient grid connection. Significant variation can affect system efficiency and financial sustainability, as seen by the appropriateness range of 0.58 to 0.85 across locations.

Innovative business strategies are needed to reward EVSE investors, while government and municipal initiatives in the form of preferential land allocation and other perks are also needed. The following is a list of some of the suggestions:

1. The allocation of space for EVSE networks on lengthy leases at discounted (or free) rates through a transparent selection process may be required of Kota City governments and municipalities to prevent the formation of monopolies.
2. The owners and operators of EVSE may get payments from EV manufacturers for marketing EVSE networks and collecting monthly membership fees from EV owners (Japanese model).
3. The admission of gasoline and diesel cars may be prohibited in commercial areas, tourist destinations, and places of worship, among other places. Shop owners may be motivated to contribute to EVSE infrastructure.
4. To qualify for capital expenditures for grid improvements, the Kota electricity distribution department and electric companies may be required to put up an EVSE network in key areas of their service region (regulated asset).
5. As there are new building construction works in process in Kota City, all kinds of buildings above a specific constructed area should be required to have EVSE; in this scenario, the influence of the infrastructure cost on the cost of the structures per square meter will be minimal.
6. EV producers are required to pay a portion of the vehicle's price to an EVSE fund that will be used to establish an EVSE network in Kota City.
7. The government should provide land in various parts of Kota City and permits for the construction of sizable EVSE stations in key areas, together with facilities (such as a cafés, gyms, gaming centers, and other utility centers), as well as providing a few basic car service facilities.
8. The installation of (or financial support for) EVSE charging stations in a large private company's operational region may be required.
9. The installation of EVSE at retail locations required of oil delivery companies and EVSE networks built up by car rental firms could be permitted.

## 4. Limitations

Government rules and incentive programs have a significant impact on the feasibility of EVCSs. Policies that significantly lower capital and operating costs include India's FAME-II initiative, state-specific subsidies for charging infrastructure, and concessional EV prices. When assessing commercial deployment plans, these enablers need to be taken into account.

## 5. Conclusions

This research examined different electric vehicle (EV) charging techniques, focusing on both conductive and inductive methods. Conductive charging connects the vehicle battery directly to the power source through cables, while inductive charging relies on electromagnetic energy transfer without physical contact between the vehicle and the charging infrastructure. To evaluate the feasibility of charging stations in Kota City, this study analysed the corresponding load profiles, providing insights for manufacturers and charging station operators on charging levels, modes, and suitable business strategies.

The analysis highlights the variation of load demand over time, which is crucial for balancing electricity generation and consumption. By identifying peak load periods, dynamic pricing strategies can be applied to reduce grid stress and improve operational efficiency. Furthermore, the research outlined the challenges of financing EV charging station (EVCS) networks in emerging markets, where initial utilization rates are typically low. Without government subsidies or partial capital cost support, establishing an independent EVCS network may prove unviable. Therefore, effective policy interventions and innovative business models will be essential to encourage private investment and ensure the sustainable development of public charging infrastructure (PCI) in Kota. The suggested system's generalizability and robustness may be increased by validating this technique in similar Tier-2 Indian towns like Udaipur and Bhopal. Land purchase costs, equipment depreciation, rising maintenance costs, and fluctuations in power prices are not yet included in the financial model. Future decision-making reliability will be increased by incorporating these variables into sensitivity analysis. Future approaches include developing a scalable GIS-driven business model toolset for multi-city replication, including complete lifecycle costs, and using uncertainty-based models.

## Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

## Conflict of interest

The authors declare no conflicts of interest. Mohan Lal Kohle is a guest editor for AIMS Energy and was not involved in the editorial review or the decision to publish this article. All authors declare that there are no competing interests.

## Author contributions

Methodology, writing—original draft preparation, software, Kamlesh Kumar Khedar; validation, Govind Rai Goyal; editing, Pushpendra Singh; Review and editing, Mohan Lal Kohle. All authors have read and agreed to the published version of the manuscript.

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