An Economic Feasibility Study of Electric Vehicle Charging Stations in India

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Abstract To address the ever-increasing issue of greenhouse gas emissions, reduce dependence on crude oil, and increase in fuel prices in the Indian context, electric vehicles (EV) are considered a possible solution in a long run. With incentive schemes initiated by the Government of India (GoI), the adoption of EVs is happening on a large scale. A core requirement for the mass adoption of EVs is the availability of charging infrastructure at an affordable rate and without intermittency to relieve range anxiety. However, the deficiency of public charging infrastructure is considered a major hindrance to a wide-scale adoption of EVs. This paper elaborates on factors affecting the location of charging infrastructure and highlights the existing EV charging standards in India. Also, the economic feasibility of establishing an electric vehicle charging station (EVCS) as per the standards and guidelines prescribed by the government is carried out using the net present value (NPV) method. With careful planning, establishing slow as well as fast EVCSs at existing parking stations with nominal parking fees at retail spaces, workplaces, street parking areas, and along highways can encourage extensive use of EVs, leading to a profitable business opportunity.

Keywords Electric vehicle charging station · Electric vehicles · Net present value

1 Introduction

The burning of fossil fuels for transportation releases large quantities of carbon into the environment leading to air pollution and global warming. Hence, alternative energy technologies are to be introduced on a large scale [1]. The most promising method to decarbonize the transport sector is to replace conventional vehicles with EVs which are energy efficient and clean [2]. With the increasing electrification of the transportation sector, EVs represent a promising way to alleviate the pollution

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and greenhouse gas emissions caused by conventional vehicles [3]. The market share of EVs is increasing globally and the GoI has also devised programs to enhance their market penetration. Economic charging solution needs to be in place to meet the rising charging requirement from transport sector. As per the infrastructure guidelines set by the GoI, in any case, one charging station must be accessible in a network of 3 km $\times$ 3 km in cities and at every 25 km on both sides of the highways. For heavy-duty EVs, like buses and trucks, there ought to be one charging station at every 100 km on both sides of the road along highways [4]. Studies reveal that the shortage of public charging infrastructure is a major deterrent to the widespread adoption of EVs [5]. The availability of publicly accessible chargers makes people show interest in EVs. To enhance the growth of public charging infrastructure, continuous support from the government, utility grid authorities, and EV manufacturers is necessary.

The major factor hindering EV adoption is range anxiety, which is the fear of running out of battery power before it can be recharged and this concern is amplified due to limited public charging infrastructure. A lack of sufficient charging infrastructure can lead to range anxiety among the EV users, impeding their widespread acceptance [6]. Hence a wide network of public charging infrastructure is essential. Installing EVCSs at several locations can overcome range anxiety. At lower EV adoption rates, the investment in EVCSs will be hardly profitable. Hence, the EVCS investors are unsure of investing now or waiting till the critical mass of EVs is reached. The economic feasibility of establishing EVCS from an investor's point of view is not widely discussed in the literature. In the current study, we carry out an economic feasibility study on establishing an EVCS in the Indian scenario using the NPV method. Higher power rates for fast-charging stations are desired by the customers so that a time similar to the refueling time of the conventional vehicles could be obtained for EV charging [7]. Fast and ultra-fast-charging stations can reduce the charging time to a minimum level, thereby enhancing the acceptance level of EVs [8]. The study has been carried out for establishing both slow and fast-charging stations taking into account the varying amounts of incentives provided by GoI for the purchase of EV charging equipment commonly known as electric vehicle supply equipment (EVSE).

2 Methodology

EV chargers vary from 0.50 kW to as high as 500 kW, and with advances in battery chemistry, higher charging rates can be achieved in the future [9]. At lower EV adoption rates, the investment in EVCSs will be hardly profitable. Hence, the EVCS investors are unsure of investing now or waiting till the critical mass of EVs is reached. The GoI has delicenced EVCS business for EVs, whereby individuals can set up such facilities but at a regulated tariff, provided they meet the technical, safety, and performance standards as laid down by the Ministry of Power and Central Electricity Authority [10]. The government has categorized the EVCSs to provide demand incentives under the Faster Adoption and Manufacturing of Hybrid and

Table 1 Demand incentive provided for EVCS under FAME scheme

Category	Incentive	Location
I	70%	Public place for commercial purpose: Municipal parking lot Petrol stations Streets Malls Market Complexes Airports/Railway/Metro stations Bus stops
II	100%	Premises of state or central government office complexes: Government hospitals/Clinics/Dispensaries Government educational institutions Public offices for non-commercial use
III	50%	Semi-restricted premises for commercial or non-commercial purpose: Taxi aggregators for charging of taxis Co-operative housing societies

Source [11]

Electric Vehicle (FAME) Phase II scheme and the guidelines are shown in Table 1 [11]. This demand incentive is provided for the cost of EVSE excluding the upstream infrastructure including the cost of transformer required for bringing power supply to the EVCS. The economic feasibility of EVCSs is analyzed using the NPV method. The NPV is calculated using Eq. (1).

$$\mathrm{NPV} = \sum[(\mathrm{C_t}/(1+\mathrm{r})\mathrm{t})] - \mathrm{C_0}, \tag{1}$$

where C_t represents the net cash flow for a period 't'; C_0 is the total initial investment; r is the discount rate. The discount rate considered in this study is 15%, which is higher than the usual percentage of 10% as the EVCS industry is novel in India and therefore, the associated risk involved is comparatively high [12]. The sum of the present values (PV) of all the cash inflows and outflows determines the NPV of an investment. A positive sign is assigned to cash inflows whereas the cash outflows are assigned a negative sign. The knowledge of the amount of each cash flow, as well as the time of occurrence of the cash flow, is necessary for the accurate calculation of NPV. A positive NPV means the investment makes sense financially. As explained in Table 2, when multiple options are available, an investor will select the option with maximum NPV, as it provides a maximum value addition for the firm.

The EVSE for the charging stations is selected as per the guidelines laid down by the Ministry of Power, GoI for establishing EVCSs in India [4]. In both slow- and fast-charging stations, we have assumed that the Bharat DC001 charger is provided to meet the demand of EVs currently in the Indian automobile market. The slow-charging station consists of four Bharat DC001 chargers and two Bharat AC001 chargers which can charge four and six EVs simultaneously. In the slow-charging

Table 2 NPV decision table

	Outcome	Decision
NPV > 0	The investment would add value to the firm	The project may be accepted
NPV < 0	The investment would subtract value from the firm	The project should be rejected
NPV = 0	The investment would neither gain nor lose value for the firm	The project adds no monetary value. Decision should be based on some other criteria such as strategic positioning

stations, 4W, 3W, and 2W vehicles can be charged. This is significant in a country like India, where there is a larger preference towards 2 W vehicles followed by 3Ws as a means of public transport. In case of fast-charging stations, two CCS chargers and four Bharat DC001 chargers are provided which can charge two and four EVs simultaneously. CCS charger can be used to charge 4W EVs only, whereas 4W, 3W, and 2W EVs can be charged using a Bharat DC001 charger.

The cost components for an EV charging station comprise capital as well as operational expenditures. The cost estimates for EVSE are obtained from [13] as shown in Table 3. Apart from the procurement cost of EVSE, the capital expenditure involves costs associated with new electricity connection including transformer, associated civil works, EVSE software procurement, and CCTV setup. The details are summarized in Table 4.

The safety provisions for EVCSs in India are detailed in the Measures Relating to Safety and Electric Supply (Amendment) act 2019 [14]. This specifies the general safety necessities for EVCSs which include earth protection systems, fire safety,

Table 3 Cost estimates and specifications of EVSE for EVCSs

Type of Charger	Output Power (kW)	Number of EVs that can be charged simultaneously	Charging vehicle type	Cost of equipment (Rs)
Bharat DC 001	15	1	4W, 3W, 2W	230,000
Bharat AC 001	10	3	4W, 3W, 2W	55,000
CCS	60	1	4W	1,200,000

Source [13]

Table 4 Capital expenditure associated with establishing an EVCS

Particulars	Capital expenditure (Rs)
New electricity connection	400,000
Civil works	250,000
EVSE software	40,000
CCTV setup	30,000

testing of EVSE, inspection and periodic assessment, and maintenance of records as per international standards that need to be followed. In the guidelines for establishing EVCSs in India [4], it is specified that the EVSE is to be type tested by an agency accredited by the National Accreditation Board for Testing and Calibration Laboratories (NABL) from time to time. EVSE are provided with safety measures that protect EV users from potential electric as well as fire hazards. In case of any fault, the EVSE will stop the power transfer to the EV immediately and deenergize the cable.

The annual operating expenditure consists of the salary for the EVSE technician at Rs.25000 per month and the annual maintenance cost is assumed as 10% of the total EVSE cost. Even though the procurement of land, either purchased or lease agreement involves a huge amount, depending on the location and availability of land, in this paper, it is assumed that land will be made available by the government or municipal bodies free of cost. This involves a policy decision from the government to encourage the mass adoption of EVs into the market. In course of time, as EV charging becomes a profitable business, the land can be procured by the business operators.

The following assumptions are made in the analysis:

1. The hours of charging per day are 20.
2. Capacity utilization factor for the EVCSs increases from 10 to 100% over a time span of 10 years.
3. Electricity tariff paid to the Discom by the EVCS operator is fully passed on to the consumer.
4. The existing electrical utility has spare capacity.

3 Results and Discussion

This section provides an insight into the economics of fast- and slow-charging technologies in India which may guide the investors as well as policymakers in framing policies for setting up EVCSs from a broader perspective. We first analyze the case in which a flat tariff is applied across the year and see the margin on electricity tariff to be imposed on the customer by the EVCS service provider to achieve a profitable business. We find the amount of margin on electricity to be imposed on the customers to make EVCS a successful business opportunity. The feasibility of establishing EVCSs with various amounts of demand incentives for the purchase of EVSE for Categories I, II, and III with 70%, 100%, and 50% incentives for establishing charging infrastructure at various locations as shown in Table 1 is carried out for slow as well as fast-charging stations. The analysis is carried out for various amounts of incentives being provided for the purchase of the EVSE combined with parking fees being imposed for utilizing the EVCS as shown in Figs. 1, 2, and 3. This study considers parking fees of Rs.0.00, Rs.10.00, and Rs.20.00 per hour for slow- and fast-charging stations. S/0, S/10, and S/20 represent slow-charging stations imposing Rs.0.00, Rs.10.00, and Rs.20.00 per hour, respectively, as parking

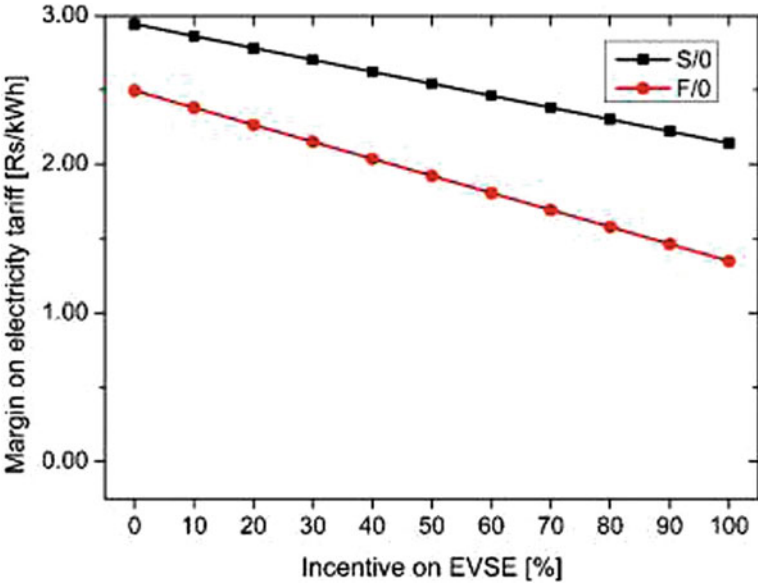

Fig. 1 Margin on electricity tariff required with various incentives on charging equipment with zero parking fee

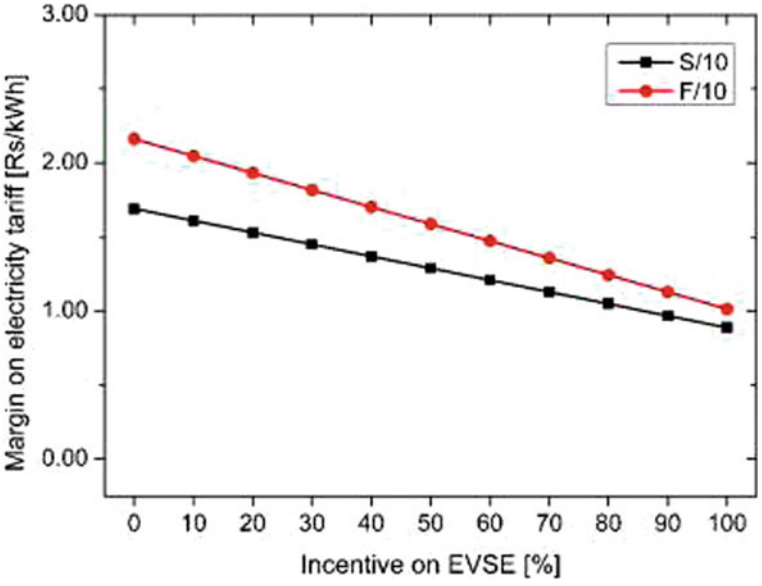

Fig. 2 Margin on electricity tariff required with various incentives on charging equipment with parking fee of Rs.10.00 per hour

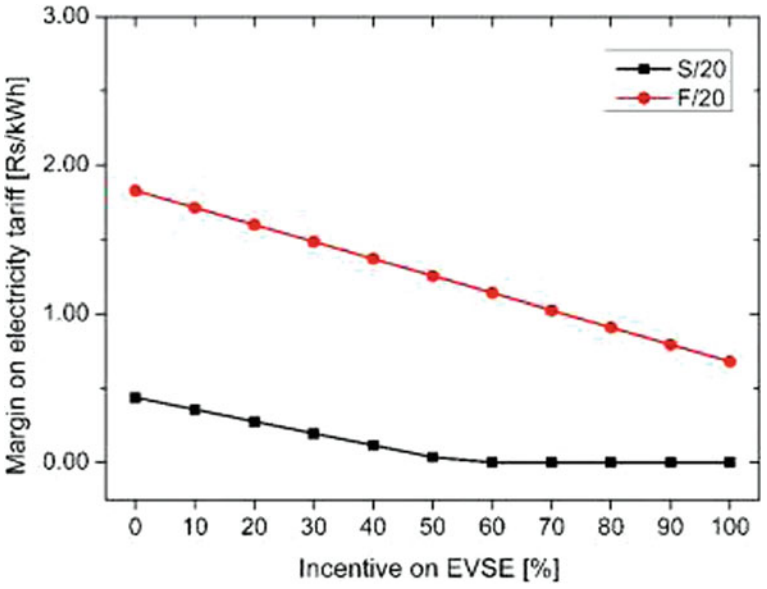

Fig. 3 Margin on electricity tariff required with various incentives on charging equipment with parking fee of Rs. 20.00 per hour

fee, whereas F/0, F/10, and F/20 represent the same for fast charging stations. To find out the breakeven for the EVCS business, when the cash flows become equal to the initial investment, we set NPV equal to zero in Eq. (1). This gives the condition required to achieve a non-profit and no-loss situation.

As seen in Fig. 1, with zero parking fees, the margin on electricity tariff required for the EV charging business to be profitable is higher for slow-charging stations when compared to fast-charging stations. Even though a higher capital expenditure is associated with a fast-charging station, the amount of electricity sold from a fast-charging station daily would be higher when compared to slow-charging stations. This makes the margin on electricity for slow-charging stations to be higher when compared to fast-charging stations with zero parking fees.

However, when a parking fee is imposed for utilizing the facility, the margin on the electricity required for fast-charging stations becomes high in comparison to slow-charging stations as seen in Figs. 2 and 3. This is because a greater number of vehicles could be charged simultaneously in slow charging stations when compared to fast-charging stations. With a parking fee of Rs. 20 per hour as shown in Fig. 3, it would be possible to forgo the margin on the electricity tariff required by slow-charging stations. This makes electricity much cheaper for charging the vehicle. In malls, parking lots, bus depots, railway stations, and airports, where the customers park the vehicle for a long duration of time, the slow-charging stations may be established which are more economically feasible, especially in India where there is a preference for low-cost vehicles in the two-, three-, and four-wheeler segments.

Also, the onboard charger used in Indian vehicles cannot take power more than 3 kW, which further limits the use of charging equipment with higher charging rates.

The minimum incentive to be provided for the purchase of EVSE to make EVCS profitable for slow- and fast-charging infrastructure for various fixed margins on electricity tariff is shown in Tables 5 and 6. As seen in Table 5, a slow-charging station imposing zero parking fee, with the margin on electricity tariff varying from Rs.0.00 to Rs. 2.00 per kWh, even with 100% incentive on EVSE, the EVCS business will be non-profitable. With an incentive above 55.23%, the EVCS can become profitable with a margin of Rs. 2.50 per kWh without imposing any parking fee, whereas with a margin of Rs. 3.00 per kWh, no incentive will be required to make the business profitable. In charging stations where a parking fee of Rs. 10 per hour is imposed, incentives above 85.94 and 23.73% for a margin of Rs. 1.00 and Rs. 1.50 per kWh, respectively, will be required for EVCS to become profitable. By imposing a margin on electricity of Rs. 2.00 per kWh and above, no incentives will be required for a profitable business opportunity. With a lower margin on electricity up to Rs. 0.50 per kWh, the charging station is not profitable even with a 100% incentive. By imposing a higher parking fee of Rs. 20 per hour, an incentive above 54.45% is required to offer zero margins on electricity to be imposed on the customers. Further, no incentive on

Table 5 Inventive required to slow charging station for profit (fixed margin on tariff)

Margin on tariff (Rs/kWh)↓	Parking fee (Rs/h)		
	S/0	S/10	S/20
0.00	NP[a]	NP	54.45%
0.50	NP	NP	0.00%
1.00	NP	85.94%	0.00%
1.50	NP	23.73%	0.00%
2.00	NP	0.00%	0.00%
2.50	55.23%	0.00%	0.00%
3.00	0.00%	0.00%	0.00%

[a] Not profitable

Table 6 Inventive required to fast-charging station for profit (fixed margin on tariff)

Margin on tariff (Rs/kWh)↓	Parking fee (Rs/h)		
	F/0	F/10	F/20
0.00	NP	NP	NP
0.50	NP	NP	NP
1.00	NP	NP	72.12%
1.50	86.63%	57.60%	28.58%
2.00	43.09%	14.07%	0.00%
2.50	0.00%	0.00%	0.00%
3.00	0.00%	0.00%	0.00%

EVSE will be required for a margin on electricity greater than or equal to Rs. 0.50 per kWh for EVCS to be profitable.

As shown in Table 6, a fast-charging station imposing zero parking fee, with the margin on electricity varying from Rs.0.00 to Rs. 1.00, even with 100% incentive on EVSE, the EVCS business will be non-profitable. With incentives above 86.63% and 43.09%, the EVCS can become profitable with a margin of Rs.1.50 and Rs.2.00 per kWh, respectively, without imposing any parking fee, whereas with a margin of Rs. 2.50 per kWh and above, no incentive will be required to make the business profitable. In charging stations where a parking fee of Rs. 10 per hour is imposed, incentives above 57.60 and 14.07% for a margin of Rs. 1.50 and Rs. 2.00 per kWh respectively will be required for EVCS to become profitable. By imposing a margin on electricity of Rs. 2.50 per kWh and above, no incentives will be required for a profitable business opportunity. With a lower margin on electricity up to Rs. 1.00 per kWh, the charging station is not profitable even with a 100% incentive. By imposing a higher parking fee of Rs. 20 per hour, incentives on EVSE above 72.12 and 28.58% for a margin of Rs. 1.00 and Rs. 1.50 per kWh respectively will be required for EVCS to become profitable. By imposing a margin on electricity of Rs. 2.00 per kWh and above, no incentives on EVSE will be required for a profitable business opportunity. With a lower margin on electricity up to Rs. 0.50 per kWh, the charging station is not profitable even with a 100% incentive.

The fixed margin on electricity tariff required for EVCSs to become profitable under the categories I, II and III as shown in Table 1, for slow as well as fast-charging stations for various parking fees considered in this study are shown in Fig. 4. As seen in Fig. 4a, for slow charging stations, the highest margin on the electricity required for a profitable business is Rs. 3.00 per kWh for category III with zero parking fee. The margin on the electricity required for a profitable business for a slow-charging station is zero for categories I and II when a parking fee of Rs.20.00 per hour is imposed. As shown in Fig. 4b, for fast-charging stations the highest margin on electricity tariff required for a profitable business is Rs.2.00 per kW h for categories I and III, with zero parking fee, whereas with a parking fee of Rs. 20.00 per hour the lowest margin is Rs. 1.00 per kWh for category II.

From Fig. 4a, b, it is observed that the highest margin required on electricity tariff for a profitable charging station business is for category III whereas the lowest margin is obtained for category II for all parking fees considered in this study. The EV customers will prefer a lower margin on electricity tariff and hence a wider acceptance for using the EVCSs can be obtained by establishing them at category II locations which include the premises of state and central government office complexes as mentioned in Table 1.

We now consider the case in which there is a yearly escalation on the margin of electricity tariff with increments of Rs. 0.25, 0.30, 0.35, 0.40, 0.45, and 0.50 per kWh of electricity. The profitability for slow- and fast-charging stations with yearly increments in the margin on electricity varying from Rs. 0.25 to Rs. 0.50 per kWh for various parking fees considered are as shown in Tables 7 and 8, respectively.

As seen in Table 7, for a slow-charging station, with zero parking fees, the EVCS business will not be profitable up to annual increments in the margin of electricity up

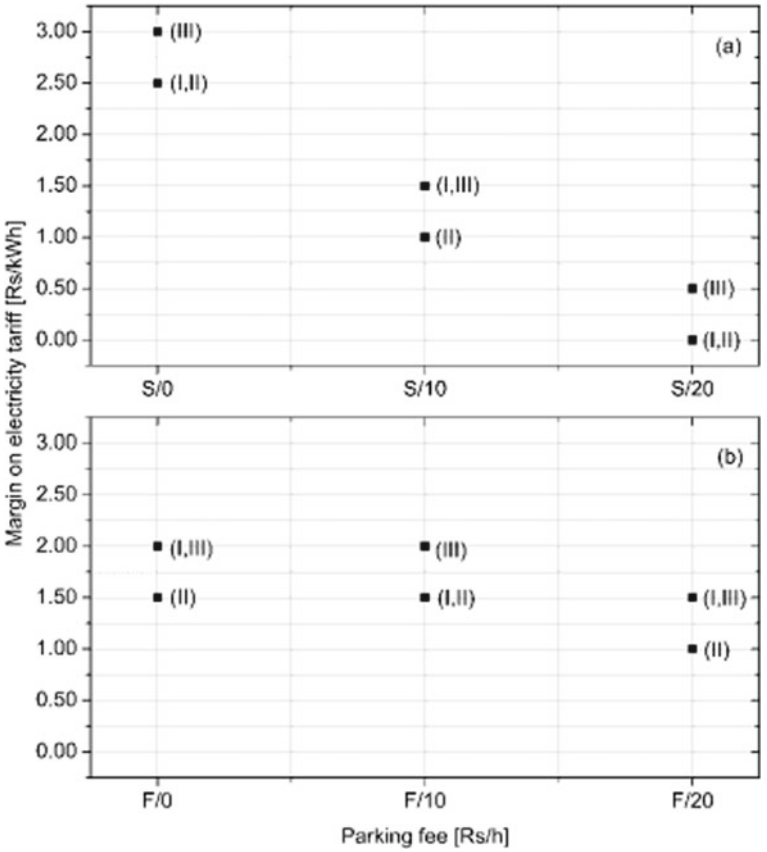

Fig. 4 Fixed margin on electricity tariff required for EVCSs to become profitable under the categories I, II, and III

Table 7 Incentive required to slow-charging stations to become profitable (incremental margin on tariff)

Annual increment (Rs/kWh)↓	Parking fee (Rs/h)		
	S/0	S/10	S/20
0.25	NP	20.84%	0.00%
0.30	NP	0.00%	0.00%
0.35	NP	0.00%	0.00%
0.40	63.03%	0.00%	0.00%
0.45	25.13%	0.00%	0.00%
0.50	0.00%	0.00%	0.00%

Table 8 Incentive required to fast-charging stations to become profitable (incremental margin on tariff)

Annual increment (Rs/kWh)↓	Parking fee (Rs/h)		
	F/0	F/10	F/20
0.25	84.60%	55.58%	26.55%
0.30	58.07%	29.05%	0.03%
0.35	31.55%	2.53%	0.00%
0.40	5.02%	0.00%	0.00%
0.45	0.00%	0.00%	0.00%
0.50	0.00%	0.00%	0.00%

to Rs. 0.35 per kWh. Incentives above 63.03 and 25.13% on EVSE will be required to support the EVCS business to become profitable with annual increments in electricity tariff of Rs.0.40 and 0.45 per kWh, respectively. With an increment of Rs.0.50 per kWh annually, no incentive on the purchase price of the EVSE is required for a profitable business. By imposing a parking fee of Rs.10 per hour, incentive above 20.84% will be required for annual increment of Rs.0.25 per kWh on the margin on electricity for a profitable business. With annual increments of Rs. 0.30 per kWh and above on margin on electricity, no incentive for EVSE is required for a profitable business. There is no requirement of incentive for EVSE on imposing a parking fee of Rs.20 per hour for all increments in the margin of electricity for a profitable EVCS business.

As seen in Table 8, for a fast-charging station, varying amounts of incentives for EVSE will be required for increments up to Rs. 0.40 per kWh for the business to become successful without imposing any parking fee. With increments above Rs. 0.45 per kW h, no incentives on EVSE will be required for a successful business proposition. With an hourly parking fee of Rs.10, there is no incentive to be provided for an annual incremental margin on electricity of Rs. 0.40 per kWh and above. The incentives required for profit with Rs.0.25, Rs. 0.30, and Rs.0.35 per kWh annual increments are above 55.58%, 29.05%, and 2.53%, respectively. With an hourly parking fee of Rs.20.00, no incentives will be required for the annual increment of Rs. 0.35 per kW h and above for the business to become viable. An incentive above 26.55% on EVSE is required for an incremental margin of Rs. 0.25 per kWh for a successful business, whereas a negligible amount of incentive may be required for tariff rise of Rs.0.30 per kWh of electricity annually.

The incremental margin on electricity tariff required for EVCSs to become profitable under the categories I, II, and III as shown in Table 1, for slow- as well as fast-charging stations for various parking fees considered in this study are shown in Fig. 5. As seen in Fig. 5a, for slow-charging stations, the highest margin on annual increment in electricity tariff required for profitable business for EVCS is Rs. 0.45 per kWh for category III with zero parking fee. The least incremental margin required is Rs.0.25 per kWh for slow-charging stations with a parking fee of Rs.10.00 and Rs.20.00 per hour. As shown in Fig. 5b, for fast-charging stations, the highest incremental margin on the electricity tariff is Rs.0.35 per kWh for category III with zero

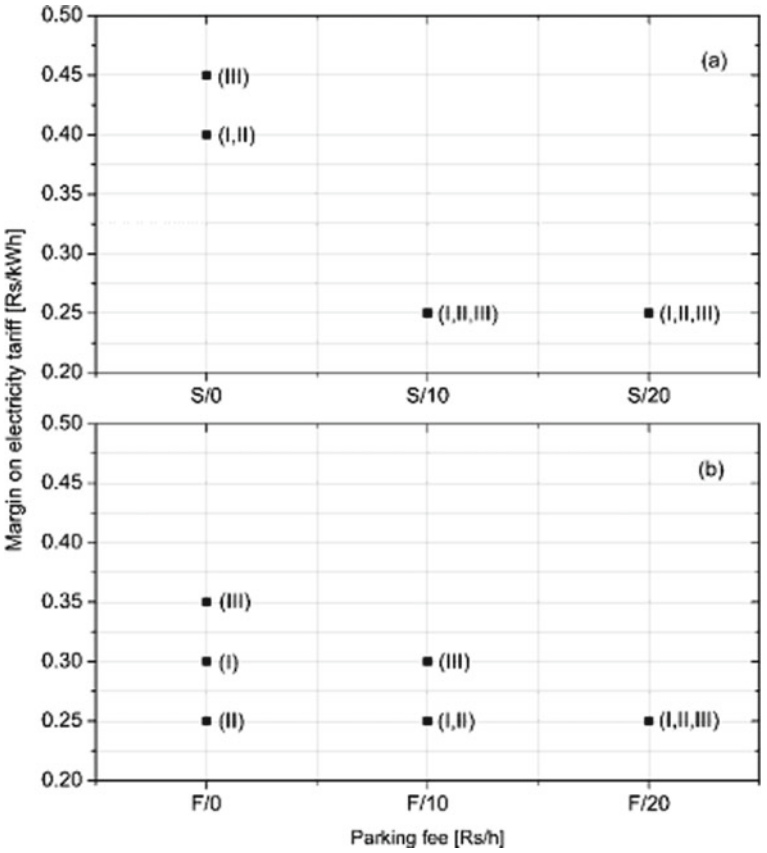

Fig. 5 Incremental margin on electricity tariff required for EVCSs to become profitable under the categories I, II, and III

parking fee, whereas the least margin required is Rs. 0.25 per kWh for all categories of charging stations with a parking fee of Rs. 20.00 per hour.

From Fig. 5a, b, it can be observed that the least incremental tariff required for a profitable charging station business is Rs. 0.25 per kWh, which is the same for all categories with S/10, S/20, and F/20 and for categories I and II for F/10. In the case of F/0, category II has the same lowest incremental tariff required for a profitable charging station business.

Thus, while establishing a slow or fast-charging station with incremental tariff, with parking fee applied, the incremental tariff to be employed is the same for all categories except for category III with F/10, for which a slightly higher incremental tariff is required for a profitable business. For fast charging stations with zero parking fees, the incremental margin required for a profitable business can be reduced to Rs.0.25 per kWh, if the incentive on the purchase of EVSE could be increased to 100% as that for category II. In doing so, the incremental margin on electricity tariff

can be reduced for category I and category III, which can attract EV users on a large scale, thereby increasing the market penetration of EVs.

In general, it is suggested that an incentive of 100% for the purchase of EVSE must be provided for category I, instead of category II, which includes municipal parking lots, petrol stations, malls, market complexes, airports, railway stations, metro stations, and bus stops, which are public places used for commercial purposes where the customer spends more amount of time. This helps the customer to utilize their time, while the vehicle is getting charged. This can help to improve the market acceptance of EVs on a large scale as they have an opportunity to charge their EVs at much lower rates. Category III, which includes the location for setting up charging stations for taxi aggregators, is provided with an incentive of only 50% on the purchase of EVSE. Under the FAME India scheme, public transportation is to be given incentives in respect of reduction in their upfront cost of the vehicle.

As shown in Figs. 4 and 5, the highest margin in electricity tariff for all parking fees is for category III and hence they have to pay a higher margin on the electricity tariff leading to a higher operating cost. Hence, it is suggested that a higher incentive on the purchase of EVSE for category III as that of category II is to be implemented to decrease the margin on electricity tariff so that it becomes beneficial for the taxi aggregators thus encouraging public transportation.

4 Conclusion

With the government's intention to provide subsidies in the range of 50, 70, and 100% on the EVSE cost, a better return can be obtained from the EVCS business thereby enabling the service providers to establish a greater number of charging infrastructure, encouraging the use of EVs by relieving the customers of the range anxiety. Currently, as per the guidelines set by the government, the incentive for the purchase of EVSE for establishing EVCSs at the premises of state and central government offices (category II) is 100%, whereas that for public places for commercial purpose (category I) is 70% and for semi-restricted premises such as taxi aggregators for charging of taxis (category III) is 50%. The following conclusions are made from this study:

- The purchase incentive on EVSE in category I locations has to be enhanced from the current rate of 70 to 100% as provided for category II locations. This can lead to a decrease in the margin on electricity required for EVCSs established in municipal parking lots, malls, market complexes as well as airport, railway, metro, and bus stations, where the EV customers are expected to park their vehicle for an adequate amount of time required to charge the EVs while completing other tasks.
- Currently, the least incentive of 50% for the purchase of EVSE is offered to category III locations. This includes semi-restricted premises used by taxi aggregators for charging their electric taxis which leads to a higher margin on electricity tariff

required for charging EV used for taxi services which include 3Ws and 4Ws. With an increase in incentive for the purchase of EVSE for establishing EVCSs in category III locations, the margin on the electricity required for a profitable charging station business can be reduced making the taxi rides more economical thereby encouraging public transportation.

With the wider establishment of EVCSs, EV user confidence can be improved, leading to their wider adoption. Hence, the government should consider enhancing the incentive on the purchase of EVSE for category I and category III locations to 100% as that of category II locations leading to greater use of EVs.

References

1. Kasim H, Ibrahim ZA, Al-Ghaili AM (2020) Reducing climate change for future transportation: roles of computing. Comput Sci Technol, 43–54
2. Nunes P, Figueiredo R, Brito MC (2016) The use of parking lots to solar-charge electric vehicles. Renew Sustain Energy Rev 66:679–693
3. Jerome S, Udayakumar M (2021) Assessment of gasoline consumption and greenhouse gas emission reduction on using battery electric two-wheeler in India. J Braz Soc Mech Sci Eng 43(1):1–15
4. Charging Infrastructure for Electric Vehicles (EV)-Revised Guidelines and Standards. Ministry of Power, Government of India (2019). https://powermin.gov.in/sites/default/files/uploads/Revised_MoP_Guidelines_01_10_2019.pdf
5. Berkeley N, Jarvis D, Jones A (2018) Analysing the take up of battery electric vehicles: an investigation of barriers amongst drivers in the UK. Transp Res Part D: Transp Environ 63:466–481
6. Kim S, Lee J, Lee C (2017) Does driving range of electric vehicles influence electric vehicle adoption? Sustainability 9(10):1783
7. Gnann T, Funke S, Jakobsson N, Plötz P, Sprei F, Bennehag A (2018) Fast charging infrastructure for electric vehicles: Today's situation and future needs. Transp Res Part D: Transp Environ 62:314–329
8. Sadeghi-Barzani P, Rajabi-Ghahnavieh A, Kazemi-Karegar H (2014) Optimal fast charging station placing and sizing. Appl Energy 125:289–299
9. RMI India (2020) Electric vehicle charging infrastructure: a guide for discom readiness (2019). https://rmi.org/wp-content/uploads/2020/07/EV-Readiness Guide_Haryana_Lighthouse_Discom_Programme.pdf
10. Clarification on charging infrastructure for electric vehicles with reference to the provisions of the Electricity Act 2003, Ministry of Power, Government of India (2018). https://powermin.gov.in/sites/default/files/uploads/Clarification_EV.pdf
11. Expression of interest inviting proposals for availing incentives under FAME India scheme phase II for deployment of EV charging infrastructure within cities. Department of Heavy Industry, Ministry of Heavy Industries and Public Enterprises, Government of India (2019). https://dhi.nic.in/writereaddata/UploadFile/EOI%20for%20EV%20charging%20in%20cities%2012%20july.pdf
12. Rathnayake RMDIM, Jayawickrama TS, Melagoda DG (2020) Prospect of establishing electric vehicle charging stations at public hotspots. Intell Build Int 12(4):318–330
13. IESA (2021) India Energy Storage Alliance, Homepage, https://indiaesa.info/products?start=0, last accessed 2021/08/15

14. CEA (Central Electricity authority), Government of India, Measures relating to Safety and Electric Supply) (Amendment) Regulations, 2019 https://cea.nic.in/old/reports/regulation/measures_safety_2019.pdf