BRIEFING

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India's public EV charging infrastructure readiness – A case study of Haryana state

Authors: Nibedita Dash and Sunitha Anup

INTRODUCTION

India's national commitment to achieving carbon neutrality by 2070 has put the spotlight on electric vehicles (EVs). This, in turn, has pushed Indian states to formulate EV policies.[1] As of May 2023, 27 states have drafted EV policies to promote the electrification of transport.[2] However, one of the main deterrents to EV adoption is the lack of sufficient charging infrastructure.[3] This paper assesses charging infrastructure readiness for EV users in the state of Haryana. We estimate the charging infrastructure across Haryana's 22 districts using several metrics. We also assess the existing types of chargers across the state to understand the distribution of fast and slow chargers.[4]

As one of India's leading states in terms of industrial growth, infrastructure development, and rapid urbanization, Haryana is an appropriate case study on the availability of public charging. More than 25 million people live in Haryana, which encompasses 44,212 square kilometers.[5] It is 65% rural and 35% urban, and surrounds the capital territory of Delhi on three sides. Haryana has set targets for phasing out fossil-fueled government vehicles, public buses, commercial fleets, and logistics

1 EVs are defined as battery electric and plug-in hybrid electric vehicles.

2 "Electric Vehicle," Government of India, Ministry of Power, accessed August 18, 2023, https://powermin.gov.in/en/content/electric-vehicle.

3 Ministry of Power, "Government of India to Expand Public Electric Vehicle Charging Infrastructure Across the Nation" (February 19, 2022), https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1799464.

4 Based on guidelines from the Ministry of Power in India, classification is specified as slow or fast based on the power rating of chargers (both AC and DC). For DC chargers: Up to 50 kW – slow charger, 50 kW and above – fast charger. For AC chargers: Up to 22 kW – slow charger, 22kW and above – fast charger. Government of India, Ministry of Power, "Charging Infrastructure for Electric Vehicles – The Revised Consolidated Guidelines and Standards-Reg" (2022), https://evyatra.beeindia.gov.in/wp-content/uploads/2022/07/Final_Consolidated_EVCI_Guidelines_January_2022_with_ANNEXURES.pdf.

5 "Demography," Government of Haryana, accessed December 6, 2023, https://haryana.gov.in/demography/.

www.theicct.org

communications@theicct.org

@theicct

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vehicles; it has also set a target for 100% electrification of public transport vehicles in the cities of Gurugram and Faridabad by 2029.[6]

The government of Haryana also aims to reduce the carbon footprint of transportation by motivating its citizens to use EVs.[7] It launched a draft EV policy in 2021 and announced the final EV policy in 2022. The policy is in effect for 5 years, starting in July 2022. [8] Along with other fiscal and nonfiscal strategies, the final policy focuses on developing widespread and accessible public and private charging infrastructure.[9] These charging initiatives include investments from government departments and private infrastructure developers as well as the modification of city building codes.

Although the EV policy incentivizes the development of privately owned public charging stations, little information is available about existing charging stations in Haryana. Missing information includes the number of public EV charging stations in relation to the number of EVs and the number of people in each district, as well as charging station density in Haryana's urban built-up areas. Also missing is information on the distribution of slow and fast charging stations. To aid in decision-making about future charging stations, this briefing uses the best available data on EV public charging infrastructure at the end of 2022. While the focus is on Haryana, we include some comparisons to charging infrastructure in other states.

In this analysis, public charging infrastructure refers to electric vehicle supply equipment (EVSE) which the general public can access to recharge their EV batteries.[10] Privately owned charging stations, which are not accessible to the general public, are not included. Data on public charging stations was retrieved from the EV Yatra portal launched last year by the Bureau of Energy Efficiency, the central agency for public charging infrastructure in India.[11] Information on EVs was obtained from the government-run VAHAN database for the districts of Haryana.[12] Population and urban area data was obtained from IndiaCensus.net, a website providing information from the 2011 national census and 2023 population estimates.[13] The Haryana district vector map was obtained from the open ArcGIS portal.[14]

PUBLIC CHARGING INFRASTRUCTURE PROGRESS ACROSS THE STATES IN INDIA

By the end of 2022, India's public EVSE stock reached 8,738; Maharashtra led all states with 2,361 EVSEs followed by Delhi with 1,619 and Karnataka with 736. These three states account for 54% of public charging stations nationwide in 2022. Haryana has 454 charging stations or 2.9% of charging stations in India.

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6 Haryana Government Industries and Commerce Department, "Haryana Electric Vehicle Policy" (July 8, 2022), https://investharyana.in/content/pdfs/EV%20Policy%202022.pdf.

7 "State-level Electric Vehicle Policies in India," Transportpolicy.net, accessed on August 16, 2023, https://www.transportpolicy.net/standard/india-state-level-ev-policies/.

8 Haryana Government Industries and Commerce Department, "Haryana Electric Vehicle Policy."

9 Sunitha Anup and Zifei Yang, *Evaluation of Non-fiscal Incentives to Promote Electric Vehicles Across Indian States and Union Territories*, (Washington, DC: International Council on Clean Transportation, 2023), https://theicct.org/publication/evs-non-fiscal-incentives-indian-states-jun23/.

10 EVSE is defined as charging equipment that connects an EV and main electric supply. Charging station is defined as a station which supplies power to charge the batteries of an EV.

11 "Public Charging Stations," Government of India, Ministry of Power, Bureau of Energy Efficiency, accessed August 2023, https://evyatra.beeindia.gov.in/public-charging-stations/.

12 "Vahan Dashboard," Government of India, accessed August 2023, https://vahan.parivahan.gov.in/vahan4dashboard/vahan/vahan/view/reportview.xhtml.

13 "Haryana Population Density," IndiaCensus.net, accessed August 2023, https://www.indiacensus.net/states/haryana/density.

14 "Haryana: Rural Development," ArcGIS Hub, accessed August 2023, https://hub.arcgis.com/datasets/7b9f700003074255b5afe4e3871b2cfb.

Figure 1 depicts the share of the public EVSE stock among the states in India (left), with a special focus on the top 16 districts of Haryana (right). As shown, the top 16 districts of Haryana have 2.7% of the overall public EVSE stock in India.[15] The highest concentration of EVSEs in Haryana is in Gurugram, with 25.1% of EVSEs statewide, followed by Faridabad, with 7.6%.

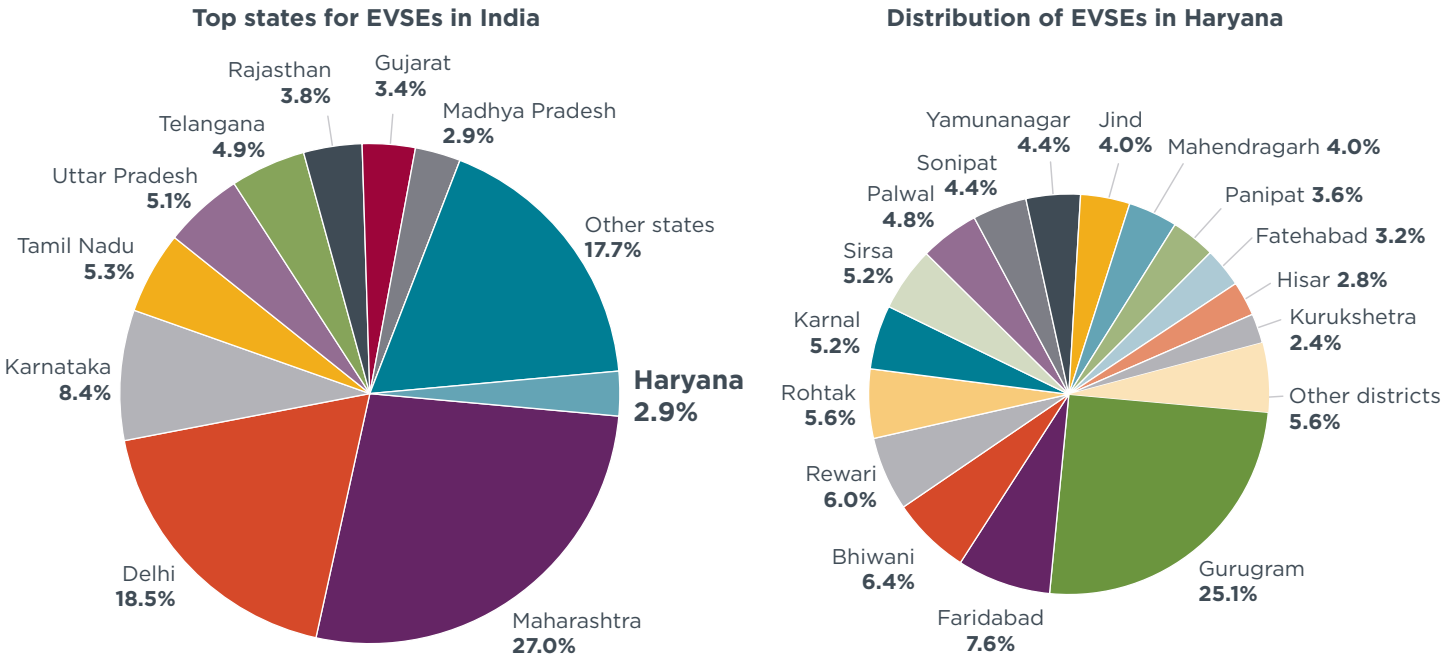


Figure 1. Percentage share of India's public charging stations by state at the end of 2022, and the percentage share of Haryana's public charging stations by district.

PUBLIC CHARGING AVAILABILITY IN HARYANA

Figure 2 illustrates the number of EVs in Haryana's 22 districts. (Chandigarh is not included because it is a union territory not administered by the state of Haryana.)[16] Gurugram had the highest number of EVs in Haryana at 4,157 by the end of 2022.[17]

15 The remaining six districts have 0.2% of India's chargers.

16 "Districts of Haryana," Government of Haryana, accessed July 5,2023, https://haryana.gov.in/districts.

17 "Vahan Dashboard," Government of India.

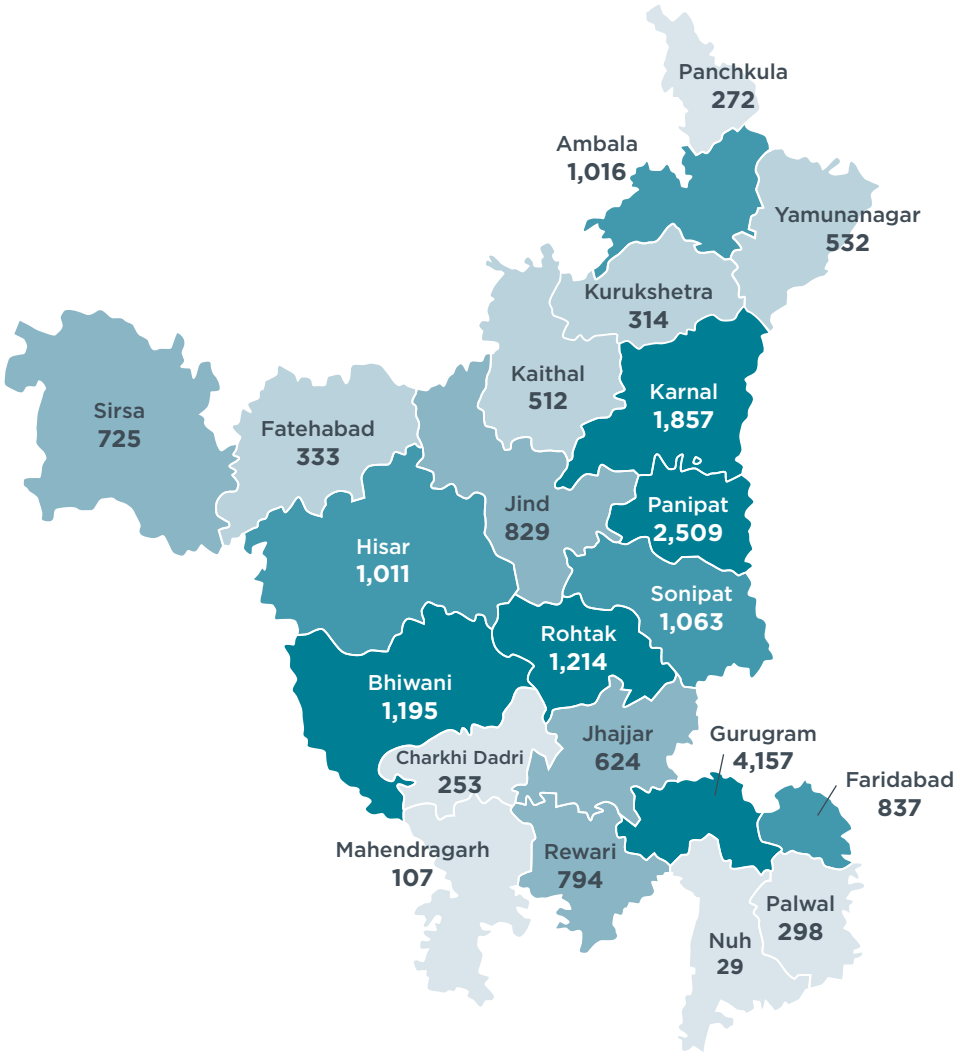


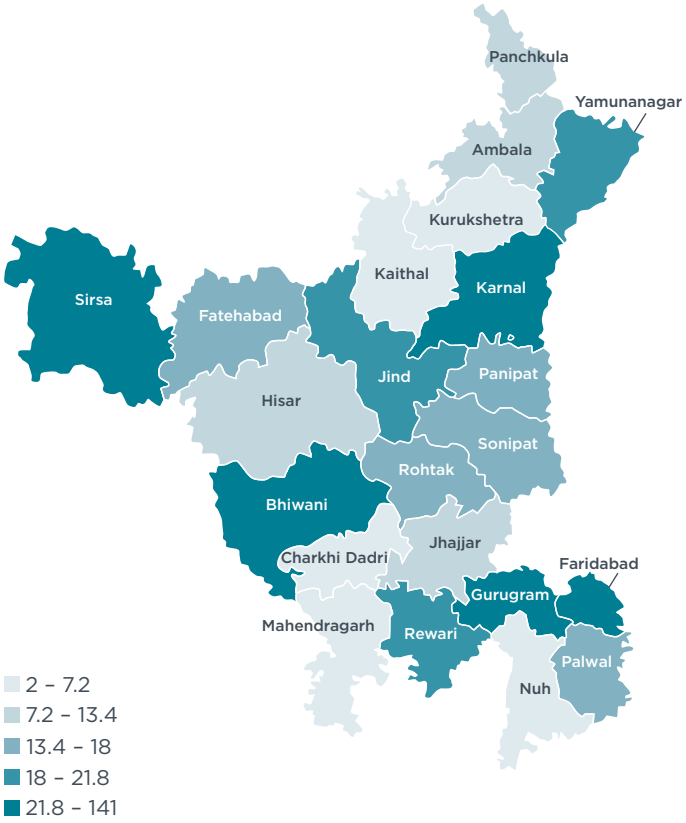
Figure 2. EV distribution among districts in Haryana.

Figure 3 shows several metrics that impact how available chargers may be for EV users in different parts of the state:

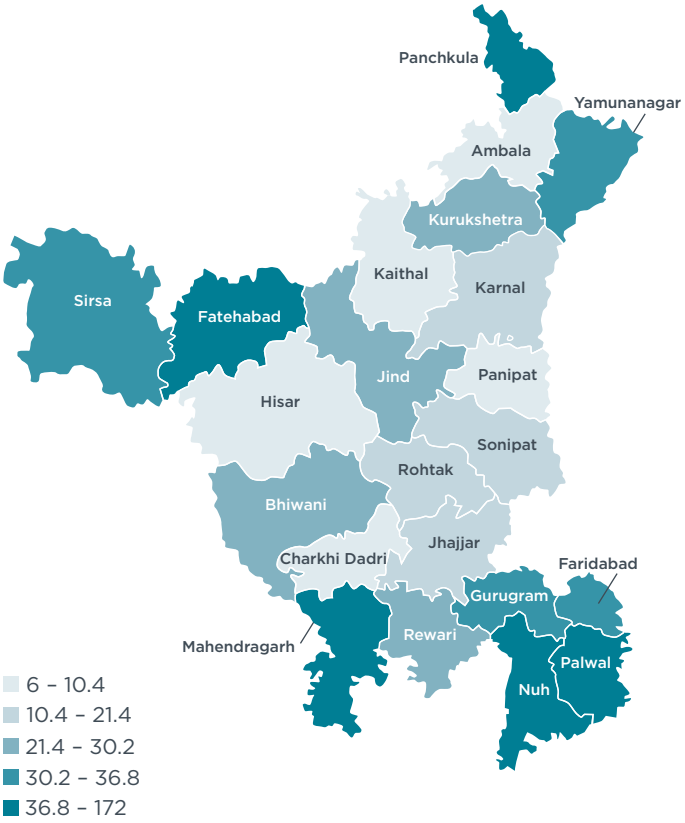
- Figure 3a shows the number of charging stations in each district. Gurugram has the most with 141, while Bhiwani is second with 30 charging stations.
- Figure 3b depicts the number of public charging stations for every 1,000 EVs. The highest ratios of EVSEs to EVs are in the districts of Nuh (172 charging stations per 1,000 EVs), Palwal (57 stations per 1,000 EVs), and Mahendragarh (65 stations per 1,000 EVs). Fatehabad and Panchkula have 45 and 37 public charging stations per 1,000 EVs respectively. Gurugram and Sirsa have 34 stations per 1,000 EVs, and Faridabad has 33.
- Figure 3c shows the density of charging stations in each district's urban built-up areas. Gurugram's urban areas have 0.11 charging stations per square kilometer, the highest density in Haryana. All other districts have less than 0.1 EVSEs per square kilometer of urban area.
- Figure 3d shows the distribution of public charging stations in relation to population. Gurugram has the highest ratio of 0.93 charging stations for every 10,000 people. This metric ranged from 0.05–0.18 for all other districts.

In summary, Gurugram had more charging stations and more charging stations per 10,000 people and per square kilometer of urban area than any district at the end of 2022. However, it had fewer charging stations per 1,000 EVs than five districts.

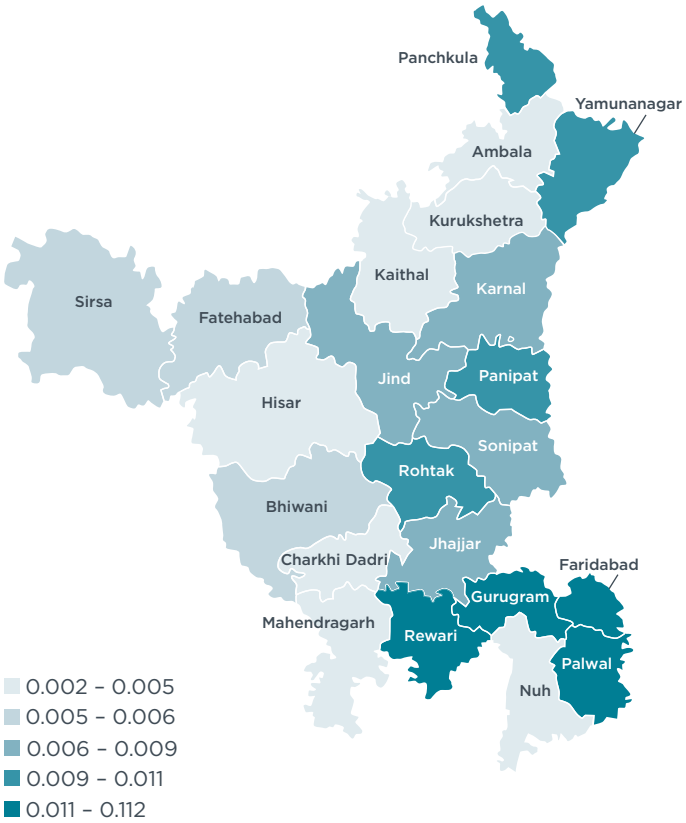
3a. Number of public EVSEs



3b. Public EVSEs per 1,000 EVs



3c. Public EVSEs per sq. km of urban built-up area



3d. Public EVSEs per 10,000 people

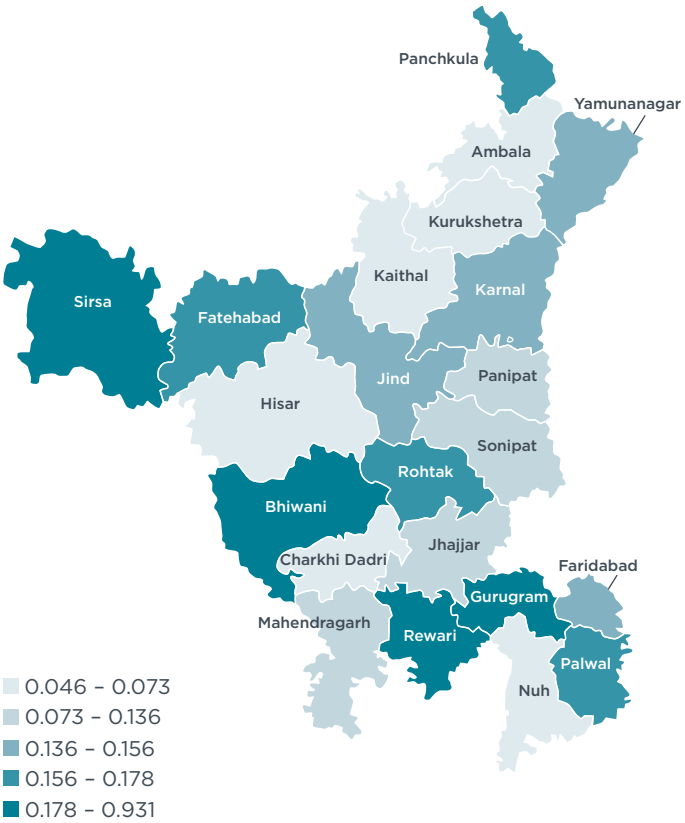


Figure 3. Public charging availability in Haryana according to different metrics.

MINIMUM DISTANCE TO PUBLIC CHARGING STATIONS

Next, we assessed how far EV users must travel to the nearest public charging station. To estimate this, we divided each district into a grid of 3 km by 3 km sections. The grid size was chosen to align with the Ministry of Power's guidelines calling for at least one charging station in each section of a 3 km by 3 km grid.[18] Next, the centroid, or geometric center, was determined for each section.[19] The distance from each centroid to the nearest EVSE was then calculated and plotted. The resulting plot shows the minimum distance an EV user must travel to find at least one charging station.

Figure 4 illustrates the process used to calculate the minimum distance from each centroid to the nearest charging point, using the district of Gurugram as an example. There are four steps in this process: Step 1: Create a district map in vector form; Step 2: Insert points for the locations of EVSEs; Step 3: Divide the district map into a 3 km by 3 km grid and find the centroid of each square; and Step 4: Measure the aerial distance from the centroid of each square to the nearest EVSE point.

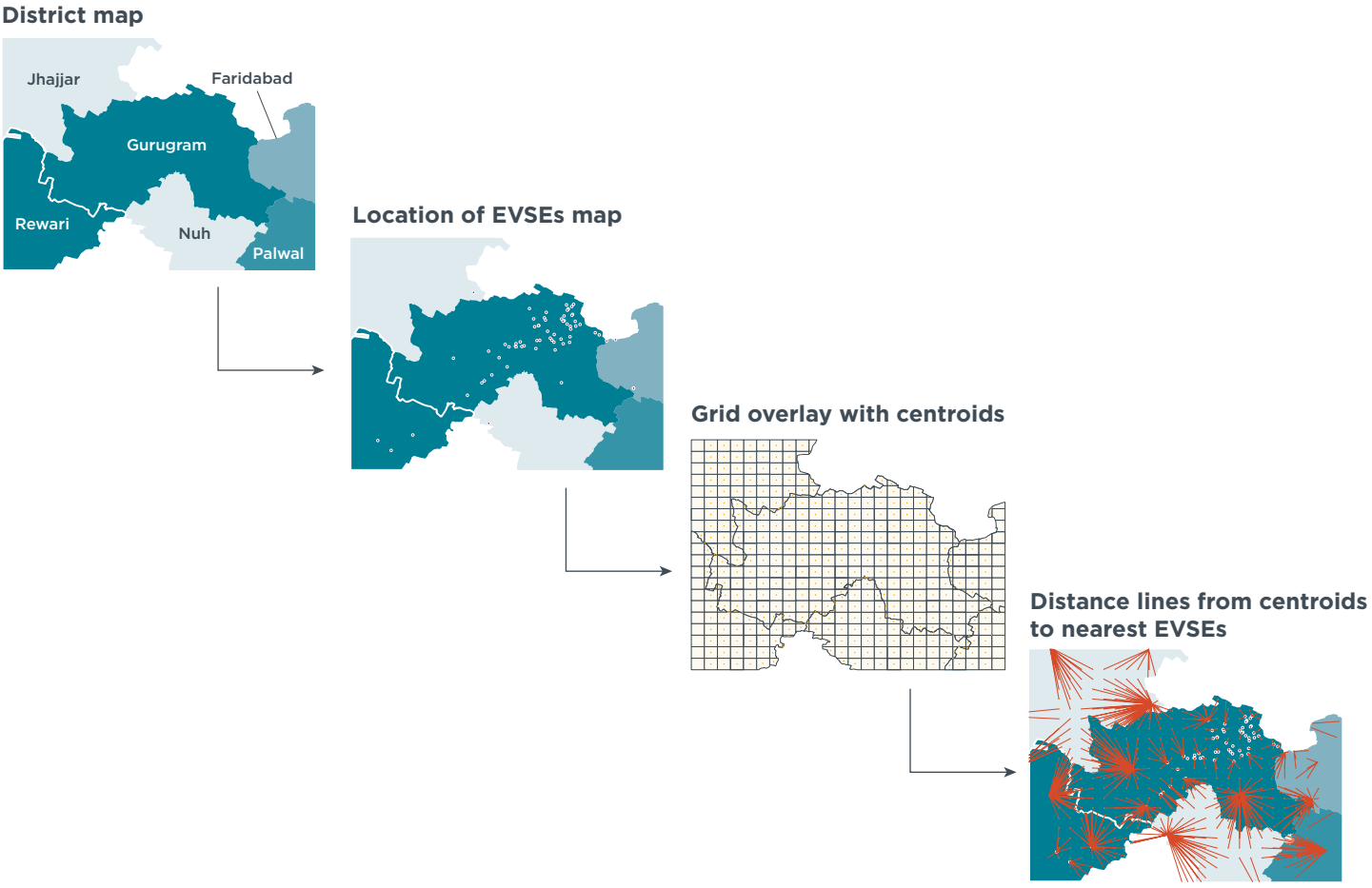


Figure 4. Illustration of methodology used to calculate the minimum distance to the nearest EVSE in the district of Gurugram.

18 "Guidelines and standards for EV charging infrastructure," Government of India, Ministry of Power, accessed July 4, 2023, https://pib.gov.in/PressReleasePage.aspx?PRID=1799464.

19 Geometric center of a 3km by 3km grid within a particular district boundary.

Figure 5 shows the minimum aerial distance from every centroid in each district of Haryana to the nearest EVSE.

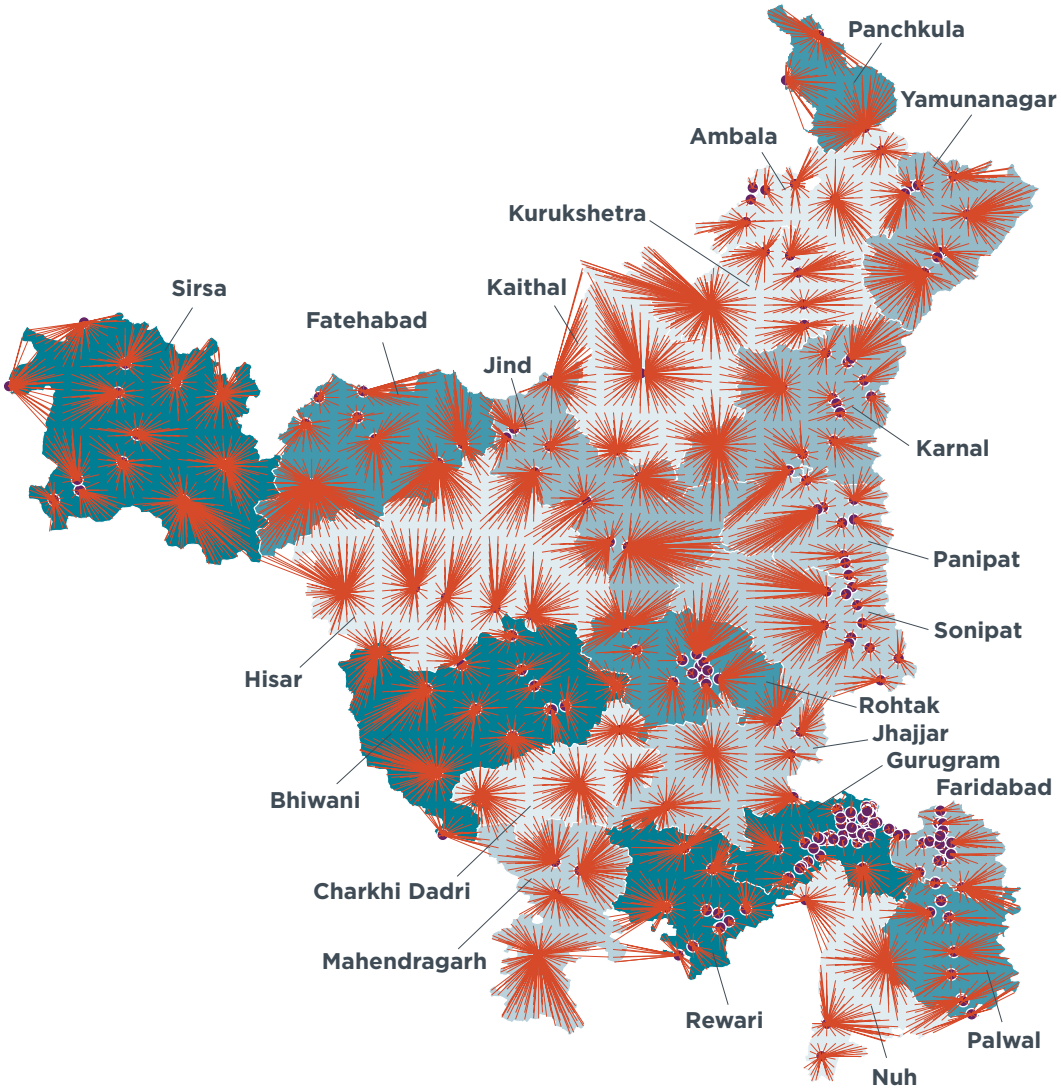


Figure 5. Shortest distance from each grid-section centroid to the nearest charging station in Haryana.

Figure 6 shows the geographic distribution of chargers in 2022 for three districts with a high number of charging stations compared to other districts. Gurugram has 141 EVSEs, Faridabad has 28, and Bhiwani has 30.

The plot shows the percentage of each district within a certain distance of a charging station in that district or an adjacent district in Haryana. In Gurugram, for example, EV users located in 19.92% of the district can find at least one public charger within 1.65 km. EV users in 100% of the district will find at least one public charger within 14.46 km. However, some EV users in Bhiwani will need to travel 25.69 km to find a public charging station. For Faridabad, the maximum distance is 15.34 km.

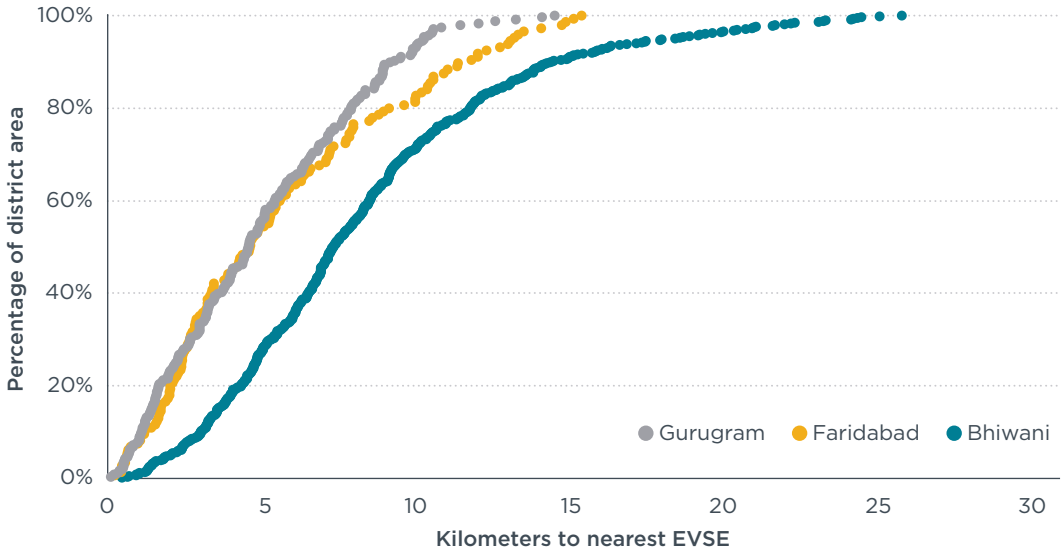


Figure 6. Percentage of area in Gurugram, Faridabad, and Bhiwani by distance to the nearest public charging station in 2022.

In addition to the availability of public charging stations, public charger capacity and speed are critical. Figure 7 shows the distribution of public chargers in Haryana by power rating and electric current type. Figure 7a depicts the power rating of all public chargers available in the state. Slow chargers with a power rating of 30 kW or lower make up 97.4% of EVSEs in Haryana. Fast chargers with a power rating of 50 kW are just 1.3% of EVSEs. Figures 7b and 7c depict the connector variability in the state. Alternating current (AC) chargers make up 76% of Haryana's public chargers. Of these AC chargers, 38% have rated power of 3.3 kW and 61% have rated power of 7.4 kW. Direct current (DC) chargers, 24% of all Haryana's chargers, have rated power of 15 kW, 25 kW, 30 kW, or 50 kW.[20]

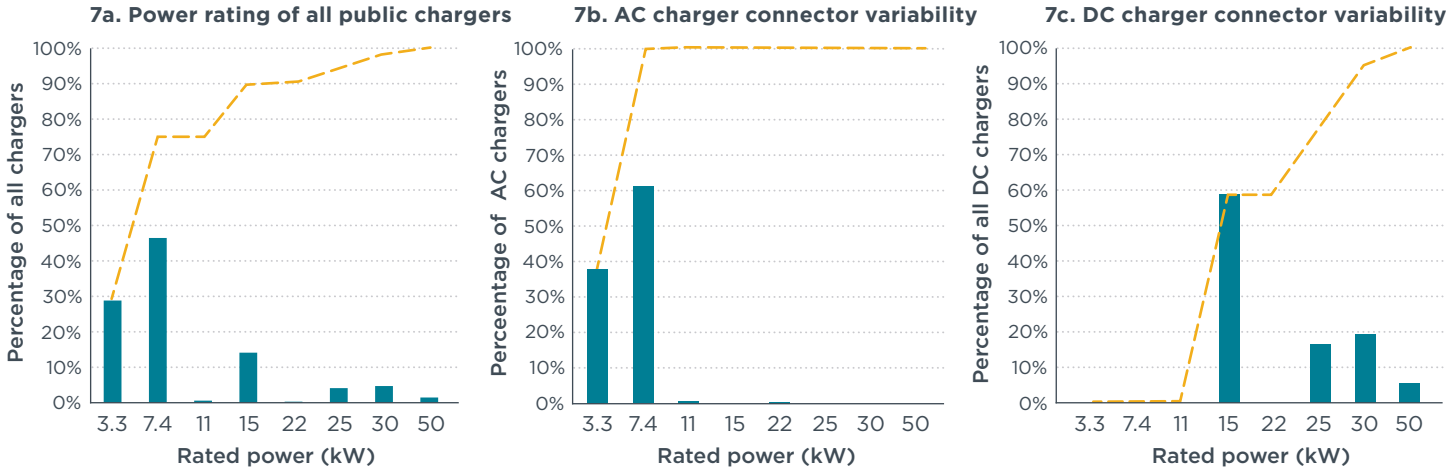


Figure 7. Rated power of public charging stations in Haryana by the end of 2022.

Figure 8 displays the distribution (density) of public chargers by rated power at the district level in four districts in Haryana that all have a population greater than 1.5 million—Faridabad, Gurugram, Hisar, and Karnal.

» **Faridabad:** The 23 chargers in the district include nine AC chargers and 14 DC chargers. Three of the AC chargers are 3.3 kW and six are 7.4 kW. The DC chargers include ten 15 kW, three 25 kW, and one 30 kW.

20 Rated power refers to the power output of a charger rather than the power supply necessary to operate it.

» **Gurugram:** The 81 chargers consist of 30 AC chargers and 51 DC chargers. Nine of the AC charging stations are 3.3 kW, 20 are 7.4 kW, and one AC charger is 11 kW. The DC chargers include 29 that are 15 kW, three 25 kW, seventeen 30 kW, and two 50 kW.

» **Hisar:** This district has just nine public charging stations, of which six are AC and three are DC. Two of the AC chargers are 3.3 kW and four are 7.4 kW. One DC charger is 15 kW and two are 25 kW.

» **Karnal:** Of 23 charging stations in this district, 18 are AC chargers and five are DC chargers. Nine of the AC chargers are 3.3 kW and nine are 7.4 kW. The DC chargers include two 15 kW, two 25 kW, and one 50 kW.

The distribution of chargers by rated power varies widely in each of the four districts. Gurugram has the largest proportion of 7.4 kW chargers. However, 50 kW fast DC chargers represent only 2.5% of all chargers in Gurugram. Even though the districts of Faridabad, Hisar, and Karnal have populations comparable to Gurugram, they have much less public charger capacity. The public charger capacity—the number of chargers normalized or adjusted for the population—in both Faridabad and Karnal is 42.6% less than in Gurugram. Hisar has 52.9% less public charger capacity than Gurugram.

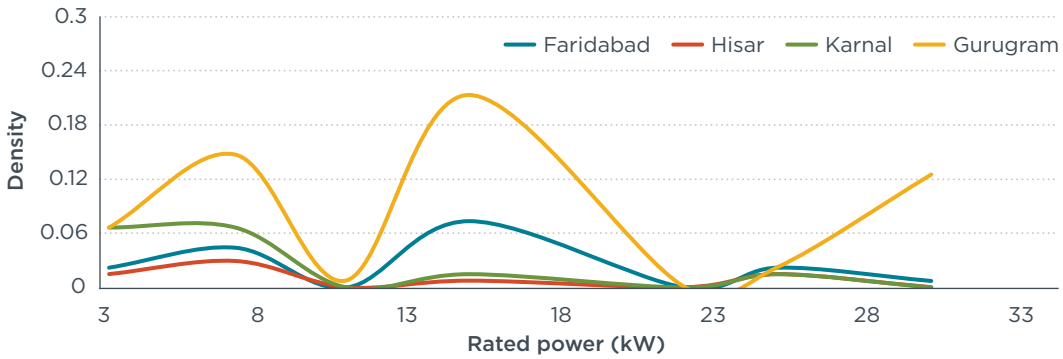


Figure 8. Rated power distribution (density) of public chargers in Gurugram, Faridabad, Hisar, and Karnal.

DISCUSSION

The analysis reveals that public charging infrastructure in Haryana, with just 2.9% of all charging stations in India, has room for improvement. Furthermore, the public charging stations are not equally distributed across all districts. A few districts have a higher number of public charging stations than others in comparable built-up areas. This is evident from the public charging availability. Out of 22 districts, only five show a high range for both the total number of public EVSEs and the number of EVSEs per 1,000 EVs. Similarly, only four districts show higher values for the number of EVSEs per kilometers of built-up area and per 10,000 people. Most districts could improve in these metrics.

Haryana's EV policy[21] calls for public charging stations every 30 km on highways. There is no mention of a minimum distance to a public charging station for intradistrict trips. Our minimum-distance analysis found best-case scenarios for Faridabad and Gurugram, where EV users may travel at most 15 km to reach a public charging station. The worst-case scenario was in Kaithal, where some EV users must travel 40 km to find a charger.

21 Industries and Commerce Department, "Haryana Electric Vehicle Policy."

CONCLUSION

This briefing is an initial attempt to provide an overview of available charging infrastructure in Haryana in 2022 at both the state and district levels. Haryana accounted for 3.5% of EV sales in 2022 but had only 2.9% of all public charging stations in India, lower than many other states. One of the main impediments to EV uptake is the lack of sufficient charging stations. The Haryana EV policy aims to electrify 100% of commercial passenger vehicles and buses. Achieving this target will require an extensive number of charging stations. We identified three possible options for addressing this charging infrastructure deficit in Haryana's districts.

1. The primary contributors to high opportunity costs are long distances to EV charging stations, along with long waiting times and long charging times at these stations. For the government to decide the next best actions, it could consider establishing and measuring metrics against benchmarks. These metrics could include tracking the minimum distance to public charging stations, the number of charging stations per 1,000 EVs, and the distribution of fast and slow chargers.
2. The states of Gurugram and Faridabad show the best-case scenarios, with a public charging station no more than 14.46 km and 15.34 km, respectively, from an EV user. Policymakers could consider adding EVSEs in districts where EV users must travel greater distances to charge their vehicles.
3. Fast chargers account for only 1.3% of all chargers in Haryana. The Haryana EV policy calls for electrifying all commercial and logistics vehicles by 2024 in Gurugram and Faridabad and by 2030 for all other districts. Policymaker could consider installing more fast chargers to avoid high opportunity costs for commercial vehicles from charging.

As Haryana promotes clean transportation through lucrative purchase incentives and tax exemptions for EVs, it is also important to establish a sufficient charging infrastructure network to encourage greater EV adoption. It is critical as well to track and measure the progress being made toward developing this charging network throughout the state.