WORKING PAPER

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

AUGUST 2025

Charging infrastructure needed to support India's full transition to battery electric trucks by 2050

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INTRODUCTION

At the 2021 United Nations Climate Change Conference, the Government of India pledged to achieve net-zero emissions by 2070 (Press Information Bureau [PIB], 2022). Research by the International Council on Clean Transportation estimated that India must achieve 100% zero-emission truck sales by no later than 2050 to achieve that goal (Singh & Yadav, 2024). Unlike harder-to-abate sectors such as steel and cement production or aviation, there are commercially viable zero-emission technologies for road transport already emerging at scale. Decarbonizing trucks well in advance of 2070 will provide a buffer for sectors that are expected to take longer to decarbonize.

To support the transition to cleaner vehicles, the Ministry of Road Transportation and Highways implemented the first phase of fuel consumption regulations for heavy-duty vehicles (HDVs) in April 2023 and the Bureau of Energy Efficiency (BEE) is currently working on the next phase. In October 2024, the launch of the Ministry of Heavy Industries' PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) scheme marked the first time that a national-level incentive scheme included funds (₹500 crore, about US$60 million) to subsidize the purchase of battery electric trucks (BETs). Along with purchase subsidies for other vehicle segments, the scheme also incentivizes setting up public electric vehicle (EV) chargers in cities and on highways, with a budget of ₹2,000 crore for all vehicle segments (Ministry of Heavy Industries, 2024a). Such policies are critical, and a robust charging infrastructure deployment plan is key to ensuring a successful transition to electrified road freight.

Medium- and heavy-duty trucks are equipped with much larger batteries than passenger cars and light commercial vehicles, and they range from 100 kWh–300 kWh across different segments and applications.[1] To minimize operational downtime and maintain efficiency, high-power chargers of 100 kW–240 kW and higher are needed, and freight corridors, terminals, and rest locations must be ready with chargers as the BET fleet rolls out. Without these chargers, there is the risk of slower BET adoption despite government policies supporting it.

States control several levers of charging infrastructure rollout, including land allocation, power distribution, electricity tariffs, and regulatory approvals for installing chargers. Additionally, there are various freight profiles and varied industrial clusters across different Indian states. Infrastructure bottlenecks such as grid constraints, land availability at logistics hubs, and fragmented permitting processes require targeted state-level solutions. Thus, a state-level assessment of future charging infrastructure needs is important for planning.

This study assesses the private charging needs at depots and public charging needs along highways for medium- and heavy-duty BETs in India. We estimate the number of chargers required in the near term (2030) and long term (2050) and use data on road-freight traffic and its distribution across states to determine state-level charging needs.

1 Medium-duty trucks are in the N2 category and have a gross vehicle weight (GVW) between 3.5–12 tonnes. Heavy-duty trucks are in the N3 category and have a GVW above 12 tonnes.

Acknowledgments: The authors thank Jakob Schmidt, Hussein Basma, Oscar Delgado, Hongyang Cui, and Sumati Kohli of the ICCT for helpful reviews, and Jennifer Callahan for editing.

CHARGING INFRASTRUCTURE POLICY DEVELOPMENT

There were 703 medium- and heavy-duty BETs sold in India up to June 2025 (Ministry of Road Transport & Highways, 2025); all have been deployed in closed-loop operations in the cement or steel industries or at ports. As of December 2024, India had about 28,000 chargers with a power rating of 22 kW–150 kW (International Energy Agency, 2025). Although data for chargers with a power rating above 150 kW is not publicly available, several charge point operators have installed chargers catering to BETs:

- ChargeZone, with a network of 13,500 charging stations, is currently the largest EV charging provider in India. Their charging stations include both AC chargers (3.3 kW–10 kW) and DC chargers (30 kW–360 kW) that cater to light-duty and heavy-duty vehicles, and they cover metro cities, Tier 2 cities, major highways, and inter-city corridors (Datta, 2025).
- Statiq partnered with BluWheelz, a logistics service provider, to establish comprehensive charging infrastructure at customer sites (ETAuto, 2024).
- Tata.ev set-up 10 chargers (120 kW–400 kW) on Mumbai-Ahmedabad highway, Delhi-Jaipur highway, and Pune-Nashik highway, and they offer fast charging for Tata EV owners. These chargers were set up in collaboration with ChargeZone and Statiq and can also support BETs (TOI, 2025).
- Ampvolts Ltd. set up one BET charging hub in Khalapur in Maharashtra and one in Mundra and Rajula in Gujarat (Construction World, 2025).

The Ministry of Power issued revised guidelines for charging infrastructure in 2024 (Ministry of Power, 2024).[2] Additionally, according to draft guidelines for deployment of charging infrastructure under the PM E-DRIVE scheme, there are plans to support about 72,300 EV chargers, of which 1,800 will be deployed to charge battery electric buses and BETs. The scheme supports a minimum charger capacity of 240 kW Combined Charging System (CCS) Type 2 (Ministry of Heavy Industries, 2024b). Some state EV policies also include provisions for the development of charging infrastructure for buses and trucks (summarized in Table 1).

Table 1

Incentives for fast chargers under state EV policies

State	Eligibility	Incentive	Source
Karnataka	Public fast charger	25% of the cost of the charger capped at ₹10 lakhs for first 500 chargers	Government of Karnataka (2025)
Madhya Pradesh	Public fast charger	30% of the cost of the charger capped at ₹10 lakhs for first 200 chargers	Government of Madhya Pradesh (2025)
Maharashtra	Public DC charger (50–250 kW)	15% of the cost of charger capped at ₹5 lakhs	Government of Maharashtra (2025)
	Public DC charger (250–500 kW)	15% of the cost of charger capped at ₹10 lakhs	
Rajasthan	Public fast charger	100% of the cost of upstream infrastructure capped at ₹5 lakhs	Government of Rajasthan (2022)
Tamil Nadu	Public fast charger	25% of the cost of charger capped at ₹10 lakhs for first 200 chargers	Government of Tamil Nadu (2023)

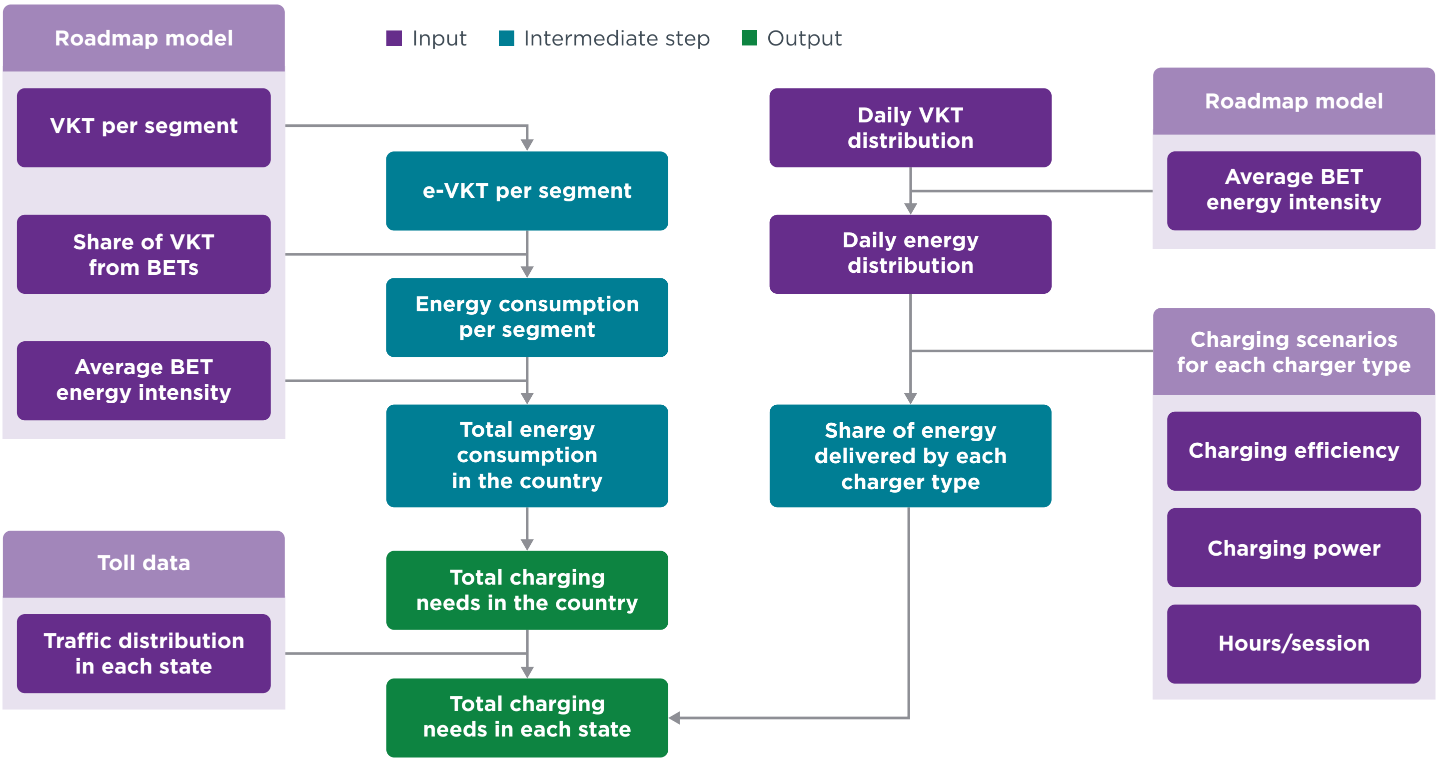
Note: Maharashtra's EV Policy is the only one that defines the power rating of a fast charger.

2 The revised guidelines state that for trucks and buses, public fast-charging stations must be spaced every 100 km along highways and expressways, with each station equipped with at least one 240 kW CCS Type 2 charger, or two chargers totaling 500 kW capacity. To expedite deployment, distribution licensees must provide dedicated low-tension or high-tension connections within specified timelines, and EV charging tariffs are capped at the Average Cost of Supply (ACoS) with discounted solar-hour pricing of 0.7 × ACoS from 9:00 AM–4:00 PM. Additionally, the Bureau of Energy Efficiency will serve as the central nodal authority and maintain a national public charging database with open APIs to streamline network coordination.

MODELING METHODS AND ASSUMPTIONS

This analysis builds on methods described in ICCT (2025), Minjares et al. (2021), and Ragon et al. (2023). We analyze the charging needs for medium-duty BETs with a gross vehicle weight (GVW) of 3.5–12 tonnes, and heavy-duty BETs with a GVW above 12 tonnes. Trucks are divided into five segments based on GVW and body type: 3.5–7 tonnes, 7–12 tonnes, 12–16 tonnes, 16–25 tonnes, and 25 tonnes and above. We also consider tractor-trailers. Figure 1 illustrates the overall methodology.

Figure 1
Modeling method to assess nationwide charging needs



Note: VKT = vehicle kilometers traveled and e-VKT = electric vehicle kilometers traveled

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BET DEPLOYMENT PROJECTIONS

We relied on previous ICCT research that projected annual requirements for zero-emission heavy-duty trucks (HDTs) in new sales in India under two scenarios: one aligned with the country's 2070 net-zero target, which requires 100% zero-emission trucks for new sales by 2050, and another more aggressive scenario that is consistent with the Paris Agreement and requires 100% zero-emission trucks for new sales by 2045 (Singh & Yadav, 2024). As a target between these two scenarios aligns with a broader *Atmanirbhar Bharat* (Self-Reliant India) target of 2047 (PIB, 2024), here we assume a BET penetration trajectory that represents the average of these two. The resulting BET trajectory targets are a 13% electric heavy-duty truck sales share in 2030 and an 80% share by 2047. We maintain the assumption from the previous study that 20% of zero-emission truck sales are hydrogen fuel-cell electric trucks (FCETs), given some difficult-to-electrify use cases, consumer preferences, and policy development around the National Green Hydrogen Mission.

We also assume a similar zero-emission truck penetration trajectory for medium-duty trucks (MDTs); it is understood from market developments (Yadav, 2023) and corroborated by stakeholder interactions that there are no plans currently to introduce

FCETs in this segment. Hence, for medium-duty trucks, all the zero-emission truck requirements are fulfilled by BETs. This leads to a slightly faster pace of adoption. Figure 2 shows the projected sales share of BETs and Figure 3 shows the evolving stock of BETs in the projected years.

Figure 2

BET sales share projections

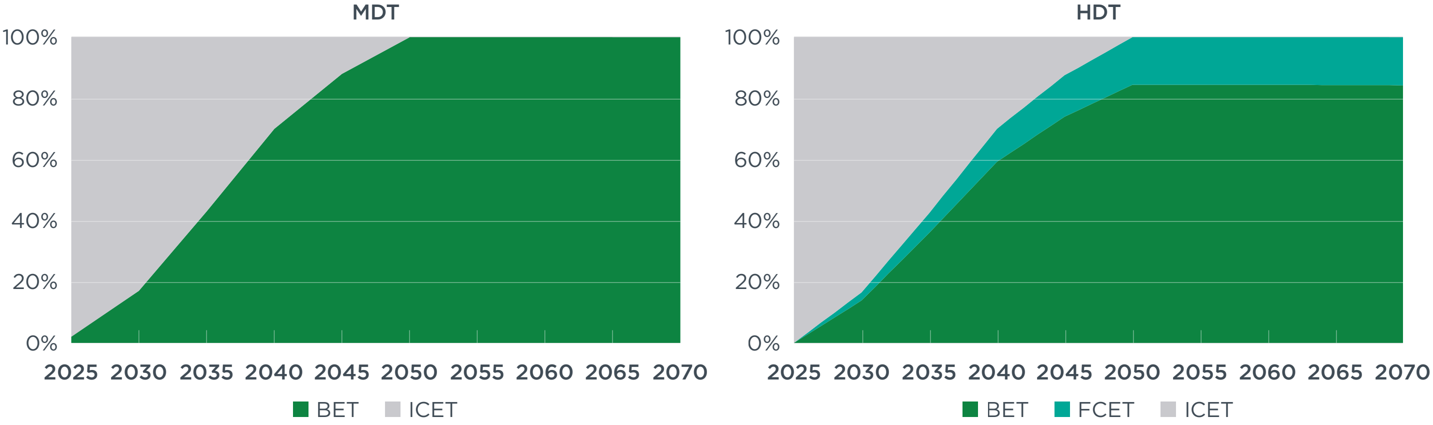

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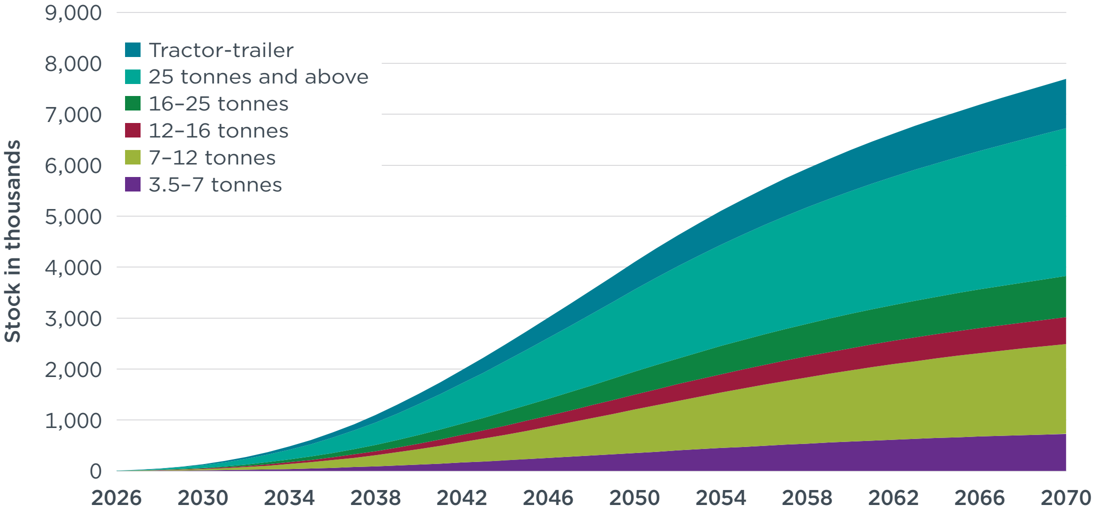
Figure 3

BET stock projections



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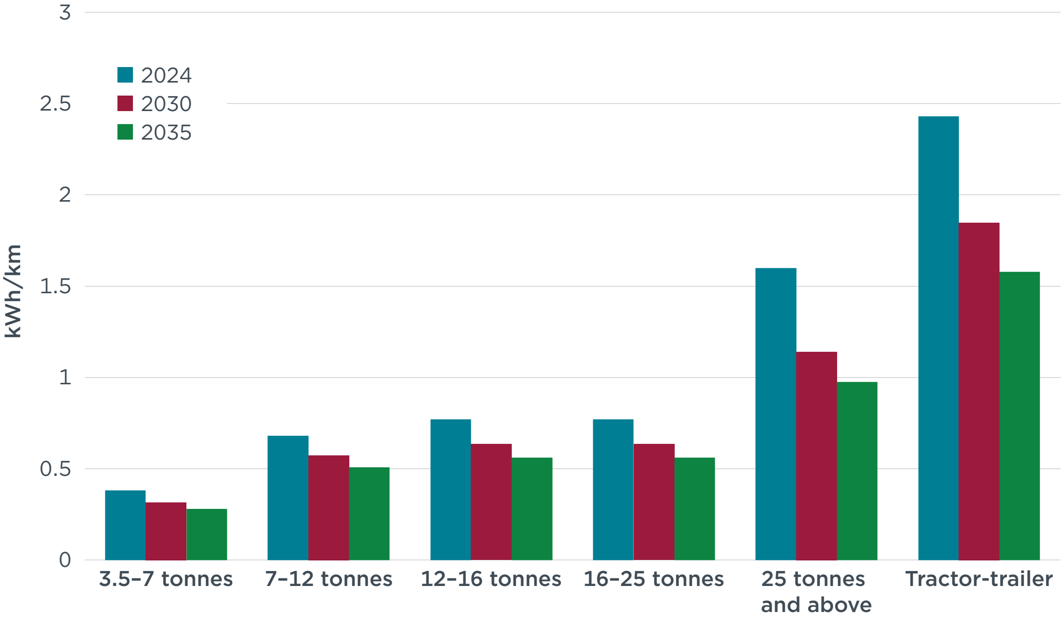
VEHICLE ENERGY CONSUMPTION AND BATTERY SIZE

Energy consumption assumptions are taken from previous ICCT publications (Kaur et al., 2024; Sen & Miller, 2023). We consider incremental improvement in the energy efficiency of BETs from improvements in tire rolling resistance and aerodynamic coefficients, as detailed in Kaur et al. (2024). Between 2024 and 2035, there are three improvements, in 2025, 2030, and 2035. The tire rolling resistance decreases from 8.8 kg/tonne in the base year 2024 to 7 kg/tonne in 2025, 6.2 kg/tonne in 2030, and 4.9 kg/tonne in 2035. The aerodynamic coefficient decreases from 0.7 in base year 2024 to 0.62 in 2030 and 0.55 in 2035 (no improvement in 2025). The energy consumption reduction (34%) is higher in the 25 tonne and above and tractor-trailer segments than in others because these segments have more tires and higher frontal areas. Figure 4 shows the energy consumption of BETs across different segments.

Figure 4
BET energy consumption



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Based on the energy consumption of BETs specified in Figure 4, we modeled battery sizes based on design ranges for different GVW segments, as gleaned from current BET models available in India and globally. The design ranges and resulting battery sizes in base year 2024 are summarized in Table 2.

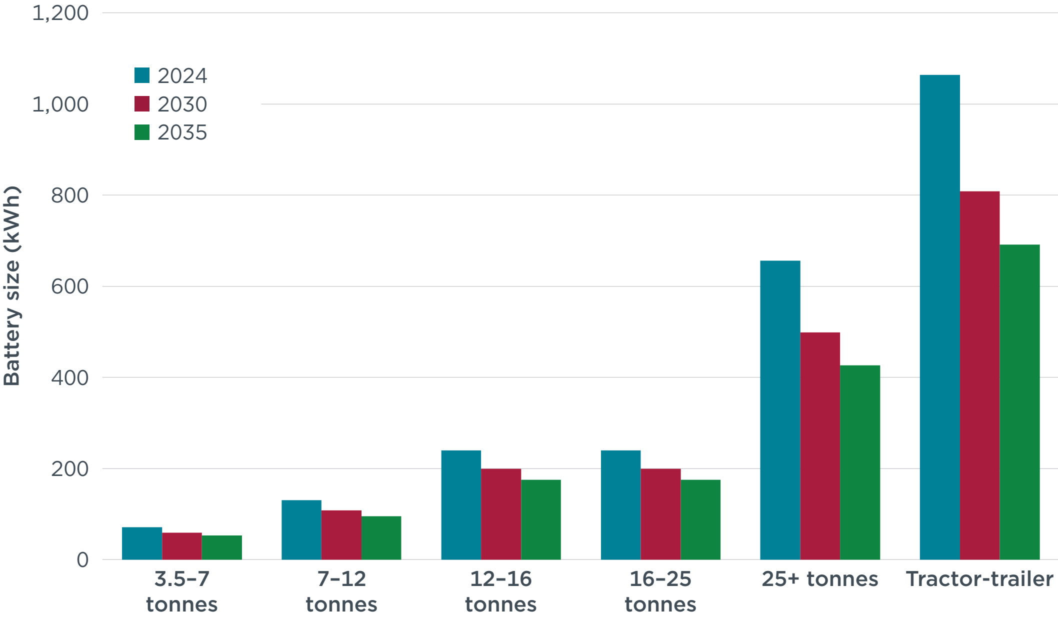
Table 2
Battery size assumptions for base year 2024

GVW segment	Battery design range	Battery size
3.5–7 tonnes	150 km	72 kWh
7–12 tonnes		131 kWh
12–16 tonnes	250 km	241 kWh
16–25 tonnes		241 kWh
25+ tonnes	350 km	657 kWh
Tractor-trailer		1,064 kWh

We further assume that battery design ranges remain the same over different model years and that batteries reduce in size over time. This is owing to the reality that India's truck market is price sensitive and the purchase price of current BET models is 2–3.5 times higher than an equivalent diesel truck model (Bhatt & Kaur, 2025). Thus, declining battery sizes, combined with declining battery prices, can help bring down upfront costs. A previous ICCT study estimated that the combined effect of these two factors could bring down upfront costs by 45%–50% between 2023 and 2030 (Kaur et al., 2024). Figure 5 shows the battery size in base year 2024, and then in 2030 and 2035. Battery size for the same design range is reduced by 17%–24% between 2024 and 2030, and another 10%–15% between 2030 and 2035.

Figure 5

Projected battery sizes



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VEHICLE ACTIVITY

Energy consumption is modeled based on segment-specific vehicle activity and technical characteristics. Table 3 summarizes the vehicle activity considered; these values are based on interviews conducted with fleet operators and drivers traversing the Delhi-Jaipur Corridor (Hildermeier et al., 2024; Kaur et al., 2024). We considered both intra-city and inter-city movement of trucks for logistics purposes.

Annual vehicle activity is measured in vehicle kilometers traveled (VKT). We assumed an average VKT per vehicle per year of around 59,300 km for HDTs and 55,843 km for MDTs, based on default input of the ICCT Roadmap model that relies on data from the International Energy Agency's mobility model database (ICCT, 2023; International Energy Agency, 2020). Daily VKT and energy consumption (calculated from the product of VKT and energy intensity) were assumed to follow a lognormal distribution. We used energy demand distributions to assess the share of each charger type needed for each truck segment. However, overall annual energy demand was informed by the energy consumption and annual VKT of each segment.

Table 3

Vehicle activity

<table>
<tr><th>GVW segment</th><th>Daily VKT</th><th>Standard deviation VKT</th><th>Annual VKT</th></tr>
<tr><td>3.5–7 tonnes</td><td rowspan="2">200 km</td><td rowspan="2">50 km</td><td rowspan="2">55,843 km</td></tr>
<tr><td>7–12 tonnes</td></tr>
<tr><td>12–16 tonnes</td><td rowspan="2">300 km</td><td rowspan="2">100 km</td><td rowspan="4">59,300 km</td></tr>
<tr><td>16–25 tonnes</td></tr>
<tr><td>25+ tonnes</td><td rowspan="2">400 km</td><td rowspan="2">100 km</td></tr>
<tr><td>Tractor-trailer</td></tr>
</table>

This analysis does not account for the payload penalty (15%–20%) of BETs, which could reduce effective carrying capacity. As a result, potential increases in trip frequency to compensate for reduced payload are not reflected in the estimates of VKT or energy demand. Incorporating such operational adjustments would require detailed fleet-level data on load types and weight constraints that are not currently available at the national level.

CHARGING CHARACTERISTICS

This analysis focuses on stationary wired charging infrastructure, which aligns with the current trajectory of market and policy developments. We consider three kinds of chargers—overnight chargers at depots and at public charging stations, fast chargers, and ultra-fast chargers for en-route charging. Power ratings for each are listed in Table 4. We modeled charging behaviors to represent those of the average Indian truck fleet for each truck segment. In practice, however, truck use cases can vary greatly within each segment, and some fleets experience operational constraints that mandate different charging behaviors. We assumed that chargers operate with 90% efficiency.

Table 4
Types and power ratings of the chargers considered

Segment	Overnight charger	Fast charger	Ultra-fast charger
3.5–7 tonnes	22 kW	120 kW	—
7–12 tonnes	22 kW	120 kW	—
12–16 tonnes	60 kW	120 kW	—
16–25 tonnes	60 kW	120 kW	—
Above 25 tonnes	120 kW	240 kW	500 kW
Tractor-trailer	120 kW	240 kW	500 kW

While pilots are underway for the two other charging options being explored—charging through overhead catenary systems and battery swapping (Rajon Bernard et al. 2022)—as of July 2025, there were no commercially deployed battery swapping or overhead catenary projects for BETs in India (Karthik, 2024; Montra Electric, 2025; Hussain, 2023). Therefore, we did not include battery swapping and overhead catenary charging in the analysis.

OVERNIGHT CHARGING

To minimize the cost of charging, we assumed all fleets maximize the use of overnight charging, either at depots or public charging locations. Charging overnight at a lower power than required for opportunity charging at fast or ultra-fast chargers enables access to lower charging rates per kWh (Kaur et al., 2024). Charging overnight also makes use of nighttime idle hours without interfering with the normal operating hours of the trucks.

We assumed overnight charging is carried out over 10 hours, with a nominal charger power ranging from 22 kW to 120 kW, depending on the truck segment. To reduce the cost of charging, we assumed that BETs with smaller batteries charge with overnight chargers of lower power ratings, as shown in Table 4. We assumed all BETs start their operational day with a full battery and assumed a 20% depth of discharge, so that the batteries operate between 20% and 100% state of charge.

Considering the battery sizes shown in Figure 5, we estimated the daily maximum number of charge sessions in the 10-hour charging duration for each segment as shown in Table 5. We assumed the overnight chargers deployed at the depots were used optimally in the 10-hour overnight charging window from the time they are deployed. As the BETs considered in the analysis can achieve a full charge in fewer than 10 hours, multiple BETs can be charged during that time. The utilization rate at the overnight depot charging station is thus 41.7%.

Similarly, we assumed the public overnight chargers charged only one vehicle overnight, which means the charger is used only for the effective time needed for the BET to fully charge. This is because these chargers are co-located at rest stops along highways and, unlike depot chargers, are not optimized for maximum utilization through managed charging. The public overnight chargers thus have one charging session per day, and a utilization rate varying from 14% to 37% (see Table 6).

Table 5
Utilization rate at depot overnight chargers

Segment	Battery size in 2024	Overnight charger nominal power	Hours for full charge	Charging window hours	Charging sessions daily	Utilization rate
3.5–7 tonnes	72 kWh	22 kW	3.3	10	3.0	41.7%
7–12 tonnes	131 kWh	22 kW	6.0		1.7	
12–16 tonnes	241 kWh	60 kW	4.0		2.5	
16–25 tonnes	241 kWh	60 kW	4.0		2.5	
Above 25 tonnes	657 kWh	120 kW	5.5		1.8	
Tractor-trailer	1064 kWh	120 kW	8.9		1.1	

Table 6
Utilization rate at public overnight chargers

Segment	Battery size in 2024	Overnight charger nominal power	Hours for full charge	Charging window hours	Charging sessions daily	Utilization rate
3.5–7 tonnes	72 kWh	22 kW	3.3	10	1	14%
7–12 tonnes	131 kWh	22 kW	6.0			25%
12–16 tonnes	241 kWh	60 kW	4.0			17%
16–25 tonnes	241 kWh	60 kW	4.0			17%
Above 25 tonnes	657 kWh	120 kW	5.5			23%
Tractor-trailer	1,064 kWh	120 kW	8.9			37%

A study conducted on the 300 km Delhi-Jaipur corridor, one of the corridors with the most truck traffic in India, found that 70% of the trucks did roundtrips, meaning 70% of the trucks went back to the depots where they started (Office of the Principal Scientific Adviser to the Government of India, 2023). Thus, we assumed that 70% of overnight charging events occur at depots and the remaining 30% at public chargers.

The analysis does not account for overlapping use cases of chargers. For example, a 120 kW unit serving as both a public overnight charger for certain segments and as a fast charger for others might be double counted. Ours is a conservative approach that ensures infrastructure adequacy under high-demand scenarios and reflects uncertainties in real-world charger utilization patterns. Future studies can refine our estimates by incorporating dynamic charger sharing and time-of-use modeling.

OPPORTUNITY CHARGING

Remaining charging needs are met by opportunity charging with fast or ultra-fast chargers. We assumed fast chargers can provide a maximum of 240 kW charging power. Based on interviews with charge point operators, we assumed an ultra-fast charger of 500 kW will be deployed in India starting in 2030. Opportunity charging can occur at a variety of public locations, including logistics hubs, industrial areas, and along freight corridors. At present, all opportunity charging stations in India are deployed in public charging stations along key freight corridors.

Based on interviews with fleet operators and drivers traversing the Delhi-Jaipur Corridor, we found that, on average, drivers spend 1.5 hours at a rest stop (Hildermeier et al., 2024; Kaur et al., 2024). Therefore, we considered each fast-charging session to be 1.5 hours in duration and assumed each ultra-fast charging session to be 0.5 hours.

Given the early stages of BET adoption in 2024, we assumed opportunity chargers are deployed along routes where BETs are deployed or being planned; this ensured at least one session per day at the fast charger in the base year 2024 and resulted in a utilization rate of 6%. As BET deployments increase, we assumed utilization grows to 25%, in other words, four sessions per day by 2040, when the market has matured. Similarly, in the case of the ultra-fast charger, we assumed a utilization of 2% (one session per day) in 2030 that grows to 21% (10 sessions per day) by 2040. The maximum daily utilization at both the fast and ultra-fast chargers is based on observed truck driver patterns at a rest stop through a survey conducted on the Delhi-Jaipur corridor (Hildermeier et al., 2024). Assuming driver patterns remain the same, based on truck parking profiles at public rest stops along highways, a maximum utilization of 25% for fast chargers and 21% for ultra-fast chargers can be achieved.

Table 7
Assumed utilization of fast and ultra-fast chargers in 2024, 2030, and 2040

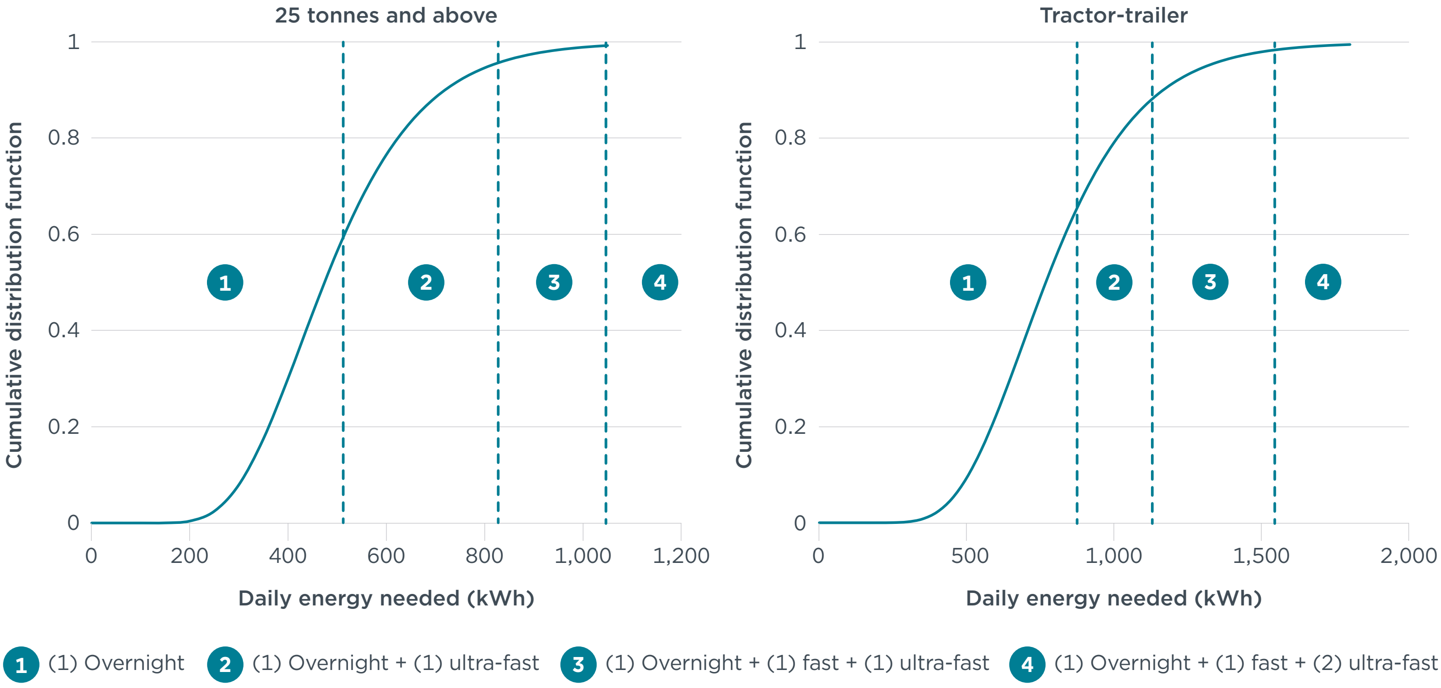
<table>
<tr><th rowspan="3">Segment</th><th colspan="3">Fast charger</th><th colspan="3">Ultra-fast charger</th></tr>
<tr><th rowspan="2">Nominal power</th><th colspan="2">Utilization rates</th><th rowspan="2">Nominal power</th><th colspan="2">Utilization rates</th></tr>
<tr><th>2024</th><th>2040</th><th>2030</th><th>2040</th></tr>
<tr><td>3.5–7 tonnes</td><td rowspan="3">120 kW</td><td rowspan="6">6%
(one session of 1.5 hours daily)</td><td rowspan="6">25%
(four sessions of 1.5 hours each daily)</td><td rowspan="4">—</td><td rowspan="4">—</td><td rowspan="4">—</td></tr>
<tr><td>7–12 tonnes</td></tr>
<tr><td>12–16 tonnes</td></tr>
<tr><td>16–25 tonnes</td><td rowspan="3">240 kW</td></tr>
<tr><td>Above 25 tonnes</td><td rowspan="2">500 kW</td><td rowspan="2">2%
(one session of 0.5 hours daily)</td><td rowspan="2">21%
(10 sessions of 0.5 hours each daily)</td></tr>
<tr><td>Tractor-trailer</td></tr>
</table>

When ultra-fast chargers become available in 2030, we assumed that not all BETs will prioritize opportunity charging at ultra-fast chargers. The high capital and grid requirements of ultra-fast chargers mean their deployment will be initially concentrated along select freight corridors and high-traffic zones and scale progressively as infrastructure and power availability improve. Such a phased adoption reflects the heterogeneous nature of India's trucking sector and avoids overestimating the near-term feasibility of universal ultra-fast charging access. We assumed BET operators' use of ultra-fast chargers will grow gradually between 2030 and 2035. The share of the 25+ tonne BET and tractor-trailer fleet that need to use ultra-fast chargers grows from 0% in 2029 to 50% in 2033, and 100% in 2035.

With these utilization assumptions, we calculated the share of energy provided by each charger type for each truck segment based on the methods detailed in Ragon et al. (2022). Figure 6 is an example of the minimum combination of charging events required to meet the energy needs of a BET in the 25+ tonne and tractor-trailer segments in 2035. A tractor-trailer with daily energy needs of 1,000 kWh would need overnight charging and one instance of ultra-fast charging at a public charger. However, a tractor-trailer with daily energy needs of 1,500 kWh would need overnight charging and two stops en-route for opportunity charging, one at a fast charger with a slightly longer duration and another at an ultra-fast charger. Drivers reported in interviews that they typically make two or three daily stops. BETs with high daily energy needs can thus conveniently top-up their batteries at rest stops without obstructing normal operations.

Figure 6

Charging patterns of 25+ tonne BETs and tractor-trailers in 2035



Note: The numbers in the parenthesis indicate the number of instances of charging.

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STATE-LEVEL TRUCK ACTIVITY

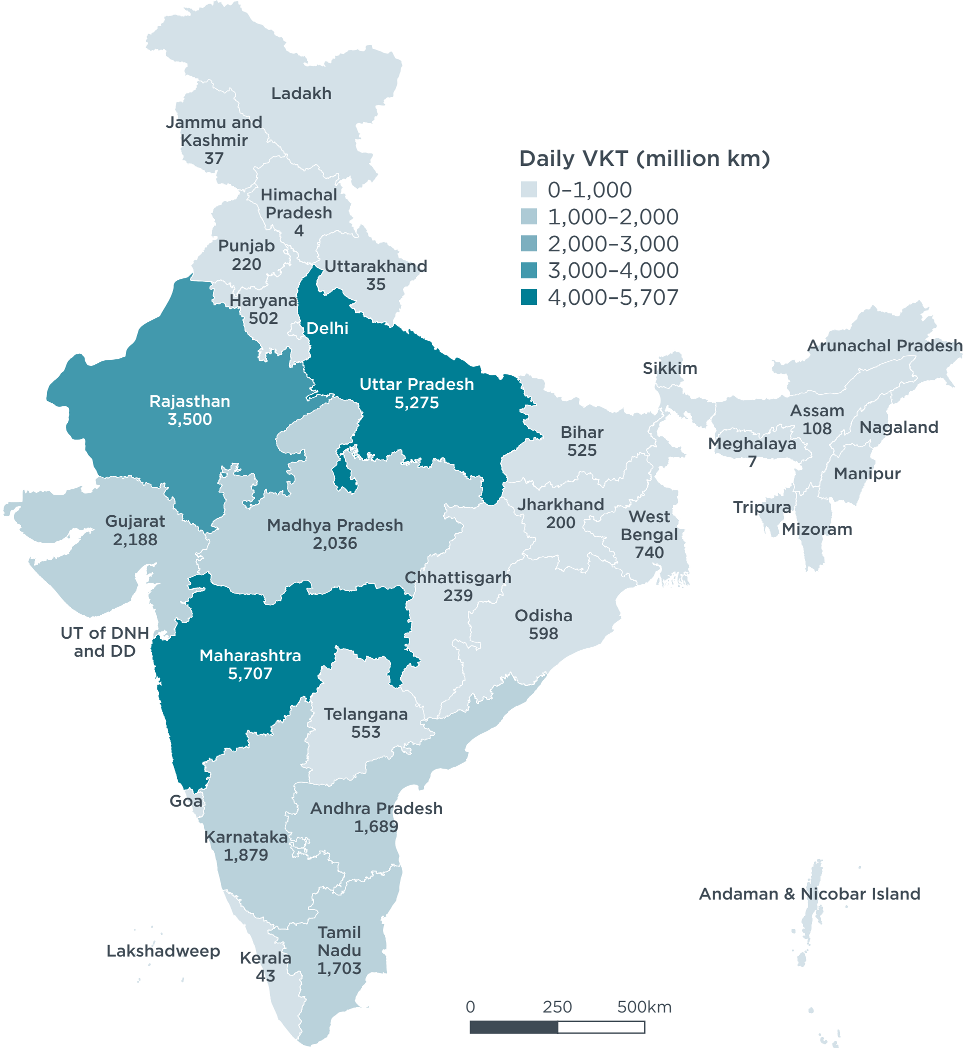
To understand state-level truck activity in India, we used publicly available monthly toll transaction data from the Indian Highways Management Company Limited (IHMCL), which operates the FASTag-based National Electronic Toll Collection (NETC) system. The dataset captures traffic counts and transaction volumes at toll plazas across all Indian National Highways. This dataset is available in two formats: (1) toll plaza-level monthly toll transactions and toll amounts and (2) monthly toll transactions by different categories of vehicles. We combined these two datasets to arrive at toll transaction counts by different truck segments across different toll plazas in India. The data used covers the 12 months of vehicle activity across different truck categories from October 2023 to September 2024 (IHMCL 2024a, IHMCL 2024b).

We converted the total truck counts to VKT by multiplying them by the length of the road segments covered by the tolls in the dataset. We then attributed these highways to each state. As the trucks are categorized as 2-axle, 3-axle, and so on, we first mapped them to the GVW segments considered in the study using Segment Y truck sales data.

Maharashtra and Uttar Pradesh lead in truck VKT, each exceeding 5,000 million km daily. Rajasthan, Gujarat, and Madhya Pradesh also show substantial movement. In northeastern and hill states and Delhi, there is minimal activity, and freight movement is highly concentrated in central and western India (see Figure 7). Figure 8 shows a map of key freight corridors in India—the Golden Quadrilateral, North-South, and East-West corridors. It also maps the key cement and steel plants, ports, and industrial zones that are the source of freight activity across states.

Figure 7

Daily vehicle kilometers traveled in million kilometers



Note: This map is presented without prejudice to the status of or sovereignty over any territory, the delimitation of international frontiers and boundaries, and the name of any territory, city, or area.

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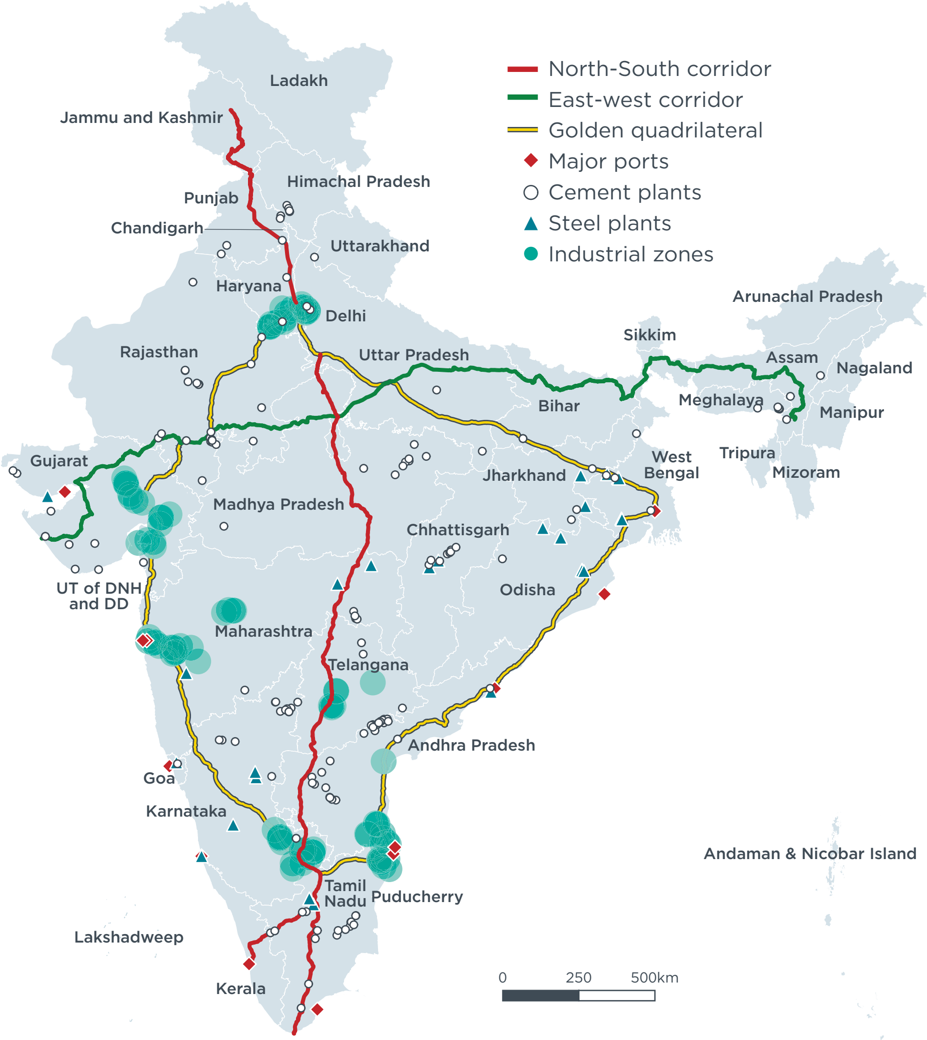
Figure 8

Map of key freight corridors and industrial corridors



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MAPPING CHARGING NEEDS TO STATES

To map national level-charging needs to states, we used the state-level truck activity data to map national results to states outside the model. As described in the previous section, we used total truck counts across different truck categories from IHMCL data to calculate the relative distribution of truck activity across different states. Since the dataset is restricted to NETC-enabled toll plazas on national highways, it excludes non-tolled segments, state highways, rural roads, and intra-city freight corridors, and consequently underrepresents the full extent of truck activity across India. This is abated by adjusting the truck counts at each toll plaza by multiplying them with the kilometers of highway connected to each toll plaza, as it creates a more representative proxy for state-level highway VKT. This allowed us to use the IHMCL dataset for relative state-level shares while maintaining consistency with nationally modeled totals. We used the relative distribution of percentage shares of truck activity across states for analyzing state-level daily energy needs and installed capacity of chargers. Table A1 in the appendix shows the distribution of truck activity across different segments and states in India.

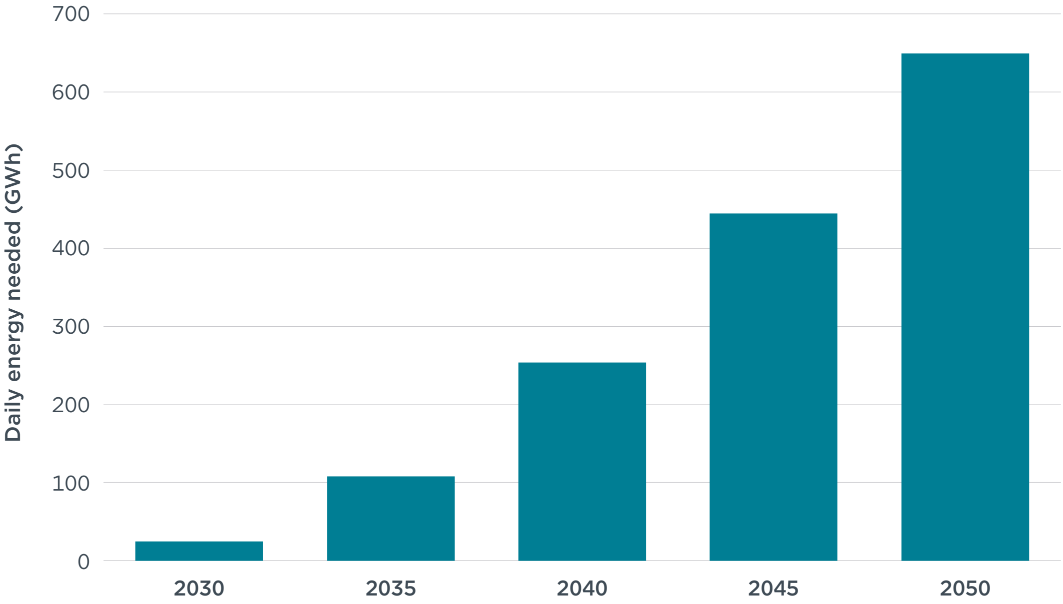
RESULTS

Based on the projected volume of the BET market, we estimate that BETs will consume 25 GWh of electric energy daily by 2030 and 650 GWh daily by 2050. To accommodate the charging needs of 133,361 BETs in 2030, 43,347 overnight chargers, 26,229 fast chargers, and 3,567 ultra-fast chargers would be needed nationwide (assuming ultra-fast chargers only become available beginning in 2030). By 2050, 1.3 million overnight chargers, 293,445 fast chargers, and 65,077 ultra-fast chargers would be needed for the 4 million BETs that would make up 62% of on-road truck stock.

DAILY GRID ENERGY NEEDS

The projected share of BETs in the total vehicle stock increases from 3% in 2030 to 27% in 2040, and to 62% in 2050. We also project that the daily energy needs of BETs will grow 10 times between 2030 and 2040, from 25 GWh to 108 GWh in 2040. For context, the Central Electricity Authority (CEA) projects a total electricity demand of 2,377,646 GWh in 2030 and 3,776,321 GWh in 2040 (CEA, 2022). The projected daily energy demand from charging BETs is only 0.4% in 2030 and increases to 2.5% by 2040. Between 2040 and 2050, the daily energy needs grow 2.5 times to 650 GWh. Figure 9 shows the daily energy needs for BETs in different years.

Figure 9
Projected daily energy needed from the grid for BETs



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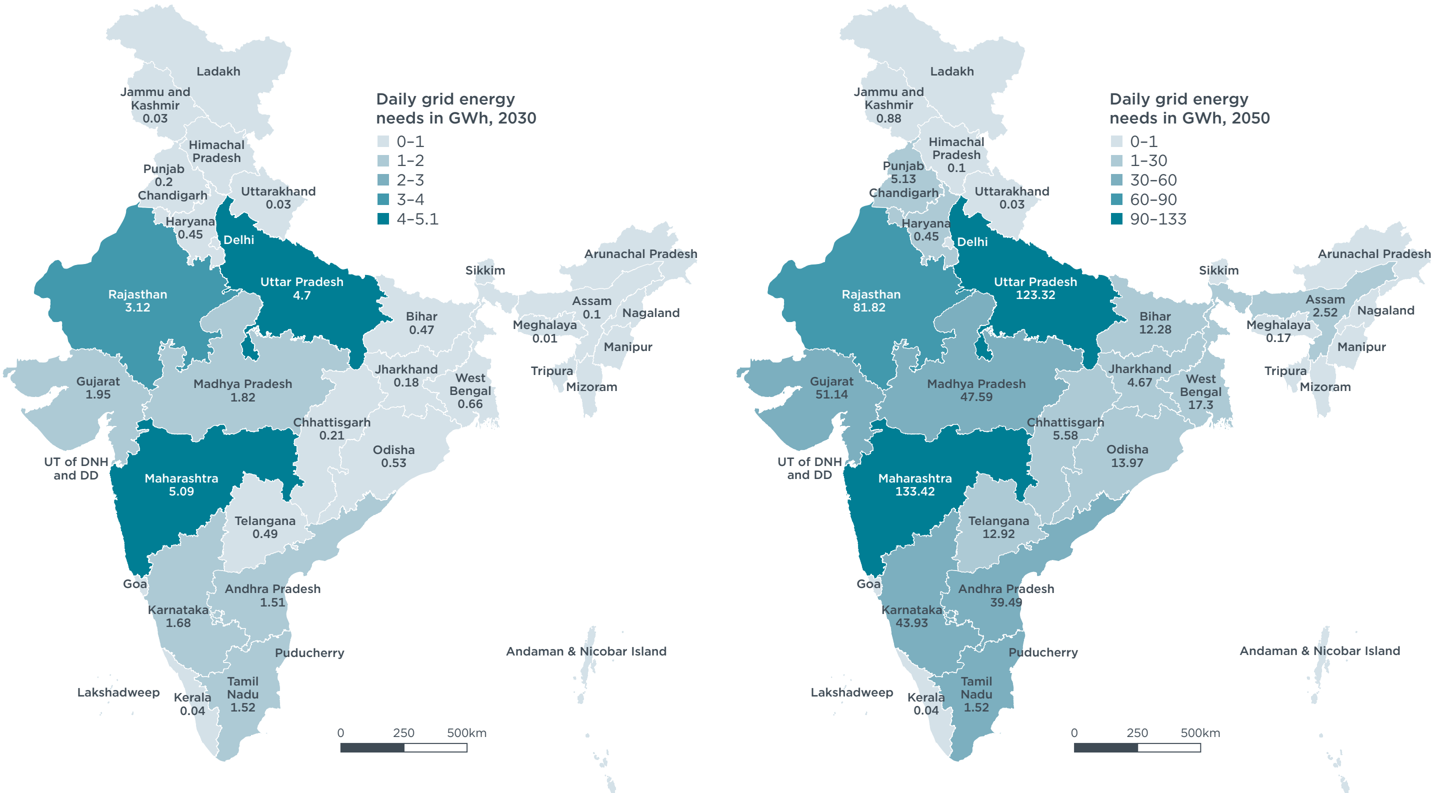
On the state level, Maharashtra is projected to have the highest daily grid energy needs followed by Uttar Pradesh and Rajasthan. Karnataka, Tamil Nadu, and Gujarat also show considerable demand, while Himachal Pradesh and Meghalaya have minimal levels (see Figure 10). Table 8 shows the daily grid energy demand for the top 10 states in India. Maharashtra, Uttar Pradesh, and Rajasthan together account for 52% of the daily energy needs for BETs in the country.

Maharashtra houses many auto manufacturing plants, steel plants, and two major ports, Mumbai and Jawaharlal Nehru; this explains the high demand for electrical energy from trucking movement. Rajasthan, India’s largest cement producing state, houses 24 major cement plants and has mining centers, textile clusters, engineering component manufacturing, and major highways and industrial corridors that connect to the rest of the country with the south. Uttar Pradesh houses many key industries and connects the states in the north with the east through the Eastern Dedicated Freight Corridor and the Amritsar-Kolkata Industrial Corridor.

Figure 10
Projected daily grid energy needs in 2030 and 2050 (GWh)



Note: These maps are presented without prejudice to the status of or sovereignty over any territory, the delimitation of international frontiers and boundaries, and the name of any territory, city, or area.

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Table 8
Daily grid energy demand in 2030 and 2050 from the top 10 states

Rank	State	Daily energy needs in 2030 (MWh)	Daily energy needs in 2050 (MWh)	Percentage share of national total
1	**Maharashtra**	5,090	133,420	21%
2	**Uttar Pradesh**	4,705	123,321	19%
3	**Rajasthan**	3,122	81,825	13%
4	**Gujarat**	1,951	51,142	8%
5	**Madhya Pradesh**	1,816	47,594	7%
6	**Karnataka**	1,676	43,930	7%
7	**Tamil Nadu**	1,519	39,804	6%
8	**Andhra Pradesh**	1,506	39,486	6%
9	**West Bengal**	660	17,307	3%
10	**Odisha**	533	12,975	2%
Total		**22,578**	**591,804**	**91%**

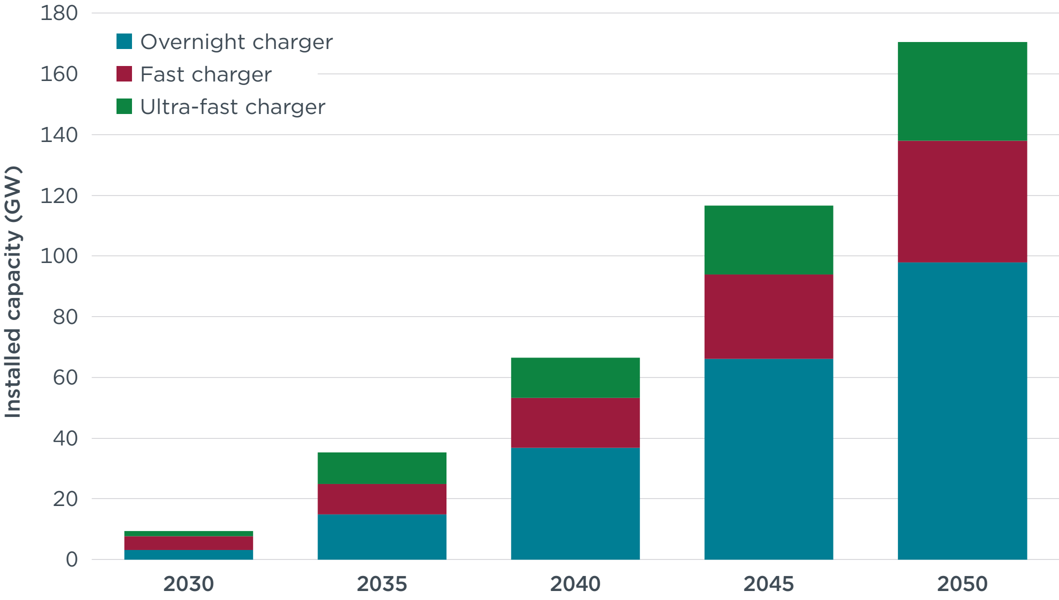
INSTALLED POWER CAPACITY

We estimate that India will need 9 GW of installed capacity of chargers to cater to the 133,361 BETs on the road in 2030. For context, a previous study for the United States estimated that its top 10 counties would require 69 GW of installed power capacity of chargers for BETs in 2030, to accommodate a substantially larger and more mature BET market (Ragon et al., 2023). This demand was projected to increase 7 times to 67 GW in 2040, and another 2.5 times between 2040 and 2050 (171 GW) to cater to 4 million BETs on the road.

Figure 11 shows the installed capacity of the chargers needed across different years in India. By 2050, overnight charging is 57% of the projected total installed public charging capacity. While fast chargers dominate in the early years (2024–2035) due to early public infrastructure rollout and flexible use cases, the long-term trend shifts toward overnight charging as depot-based and rest-stop charging becomes more cost-effective and preferred for operations. Despite the dominance of depot overnight charging, which is assumed to serve approximately 70% of BETs, public charging infrastructure remains essential to support small fleet operators and long-haul trucks that lack dedicated charging access. Public fast and ultra-fast chargers enable in-route flexibility and top-up charging, and public overnight chargers provide inclusive access for trucks operating beyond fixed depots.

Figure 11

Projected installed power capacity of different types of chargers in India



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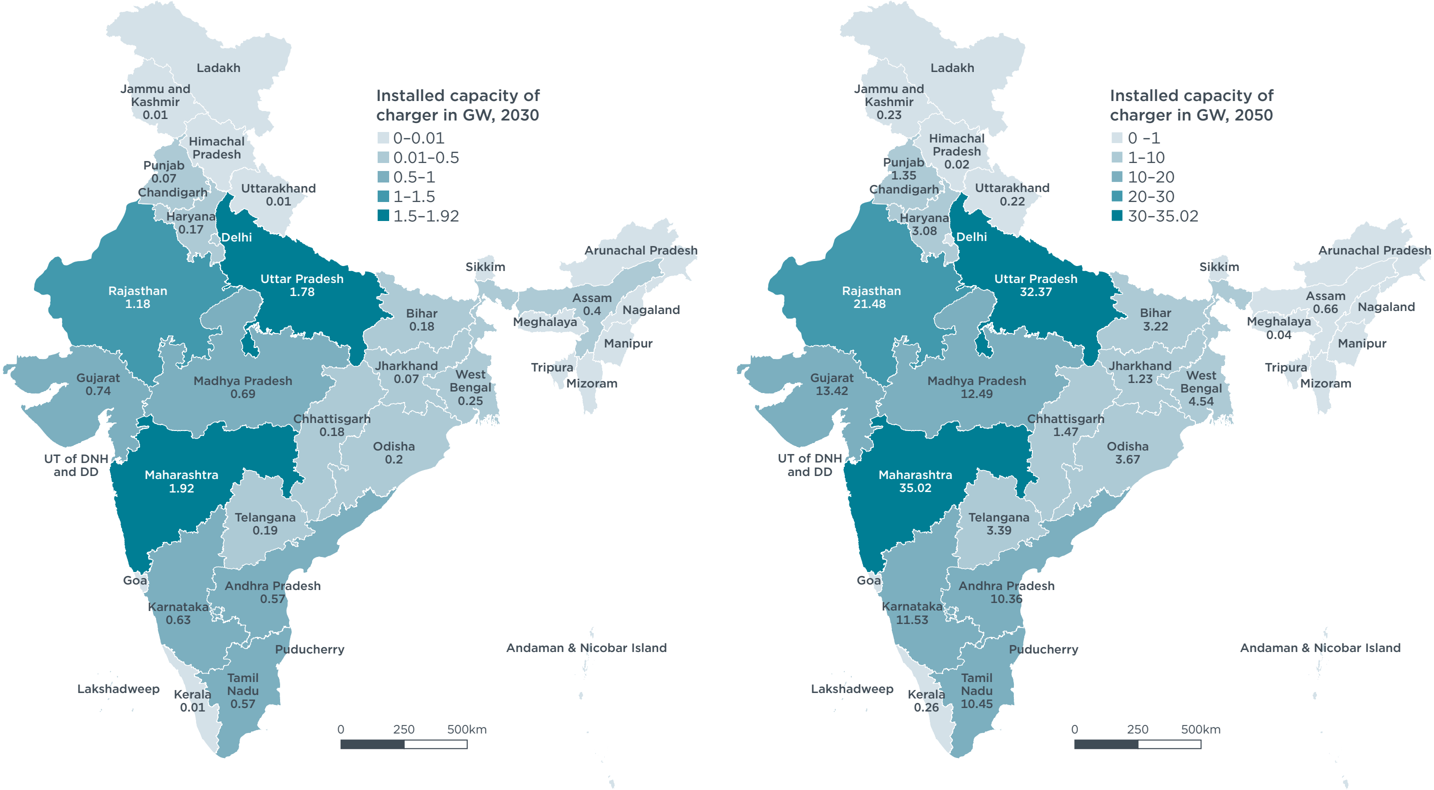
Maharashtra and Uttar Pradesh have the highest charging needs at an estimated installed capacity of 1.9 GW and 1.8 GW, respectively, in 2030 (Figure 12). These two states and the states of Rajasthan, Gujarat, and Madhya Pradesh together represent 6.3 GW of charging demand in 2030, and this rises to 115 GW in 2050. Table 9 shows the charging needs in terms of installed capacity and number of chargers in the top 10 states in 2030 and 2050.

Figure 12

Installed capacity of chargers in 2030 and 2050 (GW)



Note: These maps are presented without prejudice to the status of or sovereignty over any territory, the delimitation of international frontiers and boundaries, and the name of any territory, city, or area.

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Table 9

Installed power capacity and number of chargers needed by top 10 states in 2030 and 2050

Rank	State	2030				2050			
		Installed capacity (GW)	Overnight chargers (no.)	Fast chargers (no.)	Ultra-fast chargers (no.)	Installed capacity (GW)	Overnight chargers (no.)	Fast chargers (no.)	Ultra-fast chargers (no.)
1	Maharashtra	1.9	8,903	5,387	735	35.0	273,493	60,268	13,366
2	Uttar Pradesh	1.8	8,229	4,979	679	32.3	252,792	55,707	12,354
3	Rajasthan	1.2	5,460	3,304	450	21.5	167,730	36,962	8,197
4	Gujarat	0.7	3,413	2,065	282	13.4	104,835	23,102	5,123
5	Madhya Pradesh	0.7	3,176	1,922	262	12.5	97,561	21,499	4,768
6	Karnataka	0.6	2,931	1,774	242	11.5	90,051	19,844	4,401
7	Tamil Nadu	0.6	2,656	1,607	219	10.4	81,593	17,980	3,987
8	Andhra Pradesh	0.6	2,635	1,594	217	10.4	80,942	17,837	3,956
9	West Bengal	0.3	1,155	699	95	4.5	35,477	7,818	1,734
10	Odisha	0.2	933	564	77	3.7	28,647	6,313	1,400
Total		**8.5**	**39,489**	**23,895**	**3,258**	**155.3**	**1,213,120**	**267,330**	**59,286**

CONCLUSION AND POLICY RECOMMENDATIONS

Electrifying road freight is critical to achieving India's net-zero target. While policy momentum is growing through initiatives like PM E-DRIVE and state EV policies, there remains limited understanding of the charging infrastructure needed to support large-scale deployment of BETs. This study aims to help close that gap and provide actionable insights for infrastructure planning.

This is the first national-level assessment of India's public charging needs for BETs through 2050 under a scenario of 100% zero-emission trucks for new sales. Using real-world truck activity data from toll plazas, we mapped our national-level charging needs estimates to states and modeled energy requirements and charger needs by power level (overnight, fast, and ultra-fast) and truck segment. The result is a use-case-driven framework for infrastructure planning, and the following key findings emerge from the analysis:

- **India is projected to require 9 GW of installed public charging capacity for BETs in 2030, and this rises to 171 GW by 2050.** Under a 100% zero-emission trucks for new sales scenario by 2050, we estimate there will be 133,361 BETs on the road in 2030 (3% of the on-road fleet), 1.5 million BETs in 2040 (27% of the on-road fleet), and 4 million BETs in 2050 (62% of the on-road fleet). The projected capacity includes a significant share of high-power fast and ultra-fast chargers to meet the energy and operational demands of long-haul and time-sensitive freight movement. That the projected demand increases by 7 times between 2030 and 2040 and 2.5 times between 2040 and 2050 highlights the need for early infrastructure planning, especially in power-constrained regions.
- **Daily energy demand from BETs is estimated to reach 25 GWh in 2030, 254 GWh in 2040, and 650 GWh in 2050.** This is 0.4% of India's total projected energy demand in 2030 (2,377,646 GWh) and 2.5% of the total projected electricity demand in 2040 (3,776,321 GWh). The growth in demand from BETs will be unevenly distributed, with certain freight corridors and industrial zones emerging as high-load clusters. Proactively identifying these zones and ensuring local grid readiness will be help avoid bottlenecks and ensure reliable power supply for freight operations.
- **Charging demand is highly concentrated; five states account for more than 70% of the estimated national energy needs.** Maharashtra, Uttar Pradesh, Rajasthan, Gujarat, and Madhya Pradesh are projected to contribute more than 70% of the total BET electricity demand by 2050, based on current freight volumes and corridor usage. This geographic concentration underscores the importance of state-level infrastructure roadmaps that align with local freight patterns, industrial hubs, and logistics corridors. Prioritizing charger deployment and grid upgrades in these states can enable faster adoption and maximize early utilization.
- **Fast and ultra-fast chargers will dominate installed capacity despite limited utilization in early years.** Although fast and ultra-fast chargers are less utilized in the early years, when they often serve only 1 session per day with utilization rates of 2%–6%, they account for a significant share of the installed capacity by 2040 and beyond. These chargers are essential for supporting opportunity charging during operations, reducing dwell time, and enabling longer-range logistics. Higher utilization rates of 21%–25% are expected by 2040 as vehicle adoption increases, route optimization improves, and public-access charging becomes more viable for fleet operators.
- **Public infrastructure complements depot charging and is essential to accommodate India's diverse freight operations and prevent early exclusion of less-resourced operators.** While depot charging supports around 70% of

BETs, particularly for fleets with fixed routes and land access, public charging infrastructure remains critical, especially for small fleet operators, owner-operators, and trucks operating on dynamic or long-haul routes. Public overnight chargers play an important role in ensuring equitable access to charging, and fast and ultra-fast chargers support flexible, in-route top-ups. Planning for both depot and public infrastructure is key.

POLICY CONSIDERATIONS

These results support four policy considerations:

1. **Develop national and state-level charging infrastructure roadmaps**
   BEE is working on fuel consumption standards for HDVs that couple provide a clear policy signal to the charging infrastructure market to start making investments. Supply-side regulations such as these can be followed by a coordinated national vision to guide the scale-up of charging infrastructure for BETs that is backed by detailed, state-specific implementation plans. A national charging infrastructure strategy similar to the U.S. Department of Energy's National Zero-Emission Freight Corridor Strategy would identify priority highway corridors, logistics hubs, and industrial regions that require early infrastructure investments (Chu et al., 2024). This would also provide a unified framework for planning, financing, and grid coordination, while setting clear deployment milestones through 2030, 2040, and 2050. Such strategies additionally help avoid fragmented deployment and promote interoperability standards across the country that can help ensure that chargers are compatible with different vehicle types and use cases.

   In India, states control the land, power distribution, and permitting processes for charging infrastructure deployment. The national strategy, therefore, needs to be supported by state-level roadmaps tailored to regional freight intensity, industrial composition, and grid readiness. These roadmaps can prioritize high-impact corridors, forecast charging demand by truck segment, and outline policies for land provisioning and utility coordination. The central government can support states with technical guidance, and planning tools that enable them to develop a phased deployment plan that aligns with the national targets. This two-tiered planning approach will best ensure that India's BET infrastructure rollout is both ambitious and grounded in operational realities.

2. **Coordinate grid planning for high-capacity truck charging**
   Currently, most state-level EV policies do not account for the grid upgrades needed for opportunity charging. Our analysis estimates that the installed power capacity of BETs will increase from 9 GW in 2030 to 171 GW in 2050. Without early coordination, grid constraints could delay charger commissioning and increase project costs. Strategic grid planning is, therefore, critical to enabling timely and cost-effective infrastructure rollout.

   States can direct DISCOMs to identify high-load zones and preemptively upgrade transformers, substations, and feeder lines in coordination with charge point operators. Time-bound interconnection processes, priority approvals for charging projects, and the creation of "e-truck ready highways" and "e-truck ready zones" near freight hubs can be part of state electricity regulatory frameworks. E-truck ready highways and e-truck ready zones refer to freight corridors or industrial areas where charging infrastructure, grid capacity, and land availability have been pre-identified and proactively developed to support BET operations. As early deployment hubs, these zones could reduce lead times for charging installation and encourage private investment.

3. **Bridge data gaps in trucking movement through modern data systems**
   Accurate data is essential for planning charging infrastructure for BETs. However, current datasets remain fragmented, inconsistent, and often inaccessible to public

agencies and researchers. This can lead to poor infrastructure targeting and planning delays. For example, the NETC-based toll data used in this analysis exclude large parts of the freight network such as non-tolled highways, rural roads, and intra-city movement. Additionally, although the electronic waybill data is quite detailed and covers a number of variables pertaining to the trucking movement, it is inaccessible to charge point operators, fleet operators, and public agencies (Kaur & Anup, 2024).

To address this, India could increase access to the electronic waybill data and accelerate the rollout of GPS-based tolling, which provides detailed, real-time truck movement data across all road types—not just tolled corridors (Ramachandran & Chatterjee, 2025). The government could also ensure public access to anonymized FASTag and GPS tolling data through a central portal, and support states in integrating this into their EV infrastructure planning tools. A national freight data modernization initiative under the Unified Logistics Interface Platform or Bharatmala could standardize formats and improve coordination. These reforms would support efficient, data-driven charging infrastructure deployment for BETs.

4. **Integrate BET charging infrastructure in freight and logistics planning frameworks**
India's freight and logistics planning under initiatives like PM Gati Shakti and the National Logistics Policy has historically not accounted for the infrastructure needs of zero-emission freight vehicles. As BET adoption grows, failing to integrate charging infrastructure into broader logistics and infrastructure planning could result in mismatches between BET deployment and adequate availability of charging infrastructure.

   To address this, the Ministry of Commerce and Industry and the Ministry of Road Transport and Highways could support and guide the integration of BET charging infrastructure planning within logistics master plans at both the national and state levels. This includes reserving land, ensuring utility access in multimodal logistics parks, and integrating charger needs into economic zone planning (e.g., textile parks and cement clusters). PM Gati Shakti's GIS-based planning platform can be leveraged to map high-freight corridors alongside future charging infrastructure zones. This integration will help ensure that BET charging infrastructure is not an afterthought, but a core enabler of modern, clean logistics systems.

FUTURE RESEARCH

While this study focuses on estimating the scale and distribution of charging infrastructure needed for BETs, investment and financing are essential for translating these infrastructure targets into action. Future work could assess the cost of deploying chargers across power levels and geographies, and identify pathways to de-risk early investment, particularly for high-power public charging.

Another important area for future research is the integration of EV load forecasting, especially from BETs, into national and state-level power system planning. As daily energy demand from BETs rises to an estimated 650 GWh by 2050, this load will have implications for peak load management and distribution infrastructure upgrades. It is crucial that India's transmission and distribution system operators incorporate spatial and temporal EV charging demand projections into their load forecasting models and long-term planning exercises.

Addressing these aspects will require coordination between energy planners, transport regulators, utilities, and the private sector, and represents an essential area for follow-on work beyond this analysis.

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APPENDIX

Table A1
Share of truck activity across different states and truck categories

States	3.5–7 t	7–12 t	12–16 t	16–25 t	25 t and above	Tractor-trailer	Total
Andhra Pradesh	0.1%	0.2%	0.2%	2.1%	1.1%	2.3%	**6.1%**
Assam	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	**0.4%**
Bihar	0.0%	0.1%	0.1%	0.6%	0.4%	0.8%	**1.9%**
Chhattisgarh	0.0%	0.0%	0.0%	0.2%	0.1%	0.5%	**0.9%**
Delhi	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Gujarat	0.1%	0.3%	0.4%	1.4%	1.4%	4.2%	**7.9%**
Haryana	0.0%	0.1%	0.2%	0.5%	0.2%	0.7%	**1.8%**
Himachal Pradesh	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Jammu and Kashmir	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	**0.1%**
Jharkhand	0.0%	0.0%	0.0%	0.2%	0.2%	0.3%	**0.7%**
Karnataka	0.1%	0.4%	0.6%	2.2%	1.3%	2.2%	**6.8%**
Kerala	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.2%**
Madhya Pradesh	0.1%	0.3%	0.4%	2.7%	1.2%	2.5%	**7.3%**
Maharashtra	0.5%	1.4%	1.8%	6.0%	3.4%	7.4%	**20.5%**
Meghalaya	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Odisha	0.0%	0.0%	0.0%	0.6%	0.5%	1.0%	**2.2%**
Punjab	0.0%	0.1%	0.1%	0.3%	0.1%	0.2%	**0.8%**
Rajasthan	0.1%	0.4%	0.6%	3.0%	1.8%	6.6%	**12.6%**
Tamil Nadu	0.1%	0.4%	0.6%	2.0%	1.1%	1.9%	**6.1%**
Telangana	0.0%	0.1%	0.1%	0.7%	0.4%	0.7%	**2.0%**
Uttar Pradesh	0.3%	0.9%	1.2%	5.4%	3.0%	8.2%	**19.0%**
Uttarakhand	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.1%**
West Bengal	0.0%	0.1%	0.1%	0.8%	0.5%	1.0%	**2.7%**
Total	**1.7%**	**5.1%**	**6.5%**	**29.2%**	**16.8%**	**40.7%**	**100.0%**

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