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Charging up Hainan's transition to electric vehicles

Assessment of current charging infrastructure deployment and projection of infrastructure needs through 2030

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ABOUT THE ICCT

The International Council on Clean Transportation (ICCT) is an independent nonprofit organization founded to provide first-rate, unbiased technical research and scientific analysis to environmental regulators. Its mission is to improve the environmental performance and energy efficiency of road, marine, and air transportation to benefit public health and mitigate climate change.

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Hainan New Energy Vehicle Promotion Center, founded under the guidance of Hainan Provincial Government, is a nonprofit public institution conducting new energy vehicle-related scientific and technological activities for public interests.

ABOUT CATARC

China Automotive Technology and Research Center (CATARC) is a science research institute established in 1985 to meet China's need of managing the automotive industry. It is China's centralized technical organization of the auto industry and the technical supporting body to the relevant national government departments.

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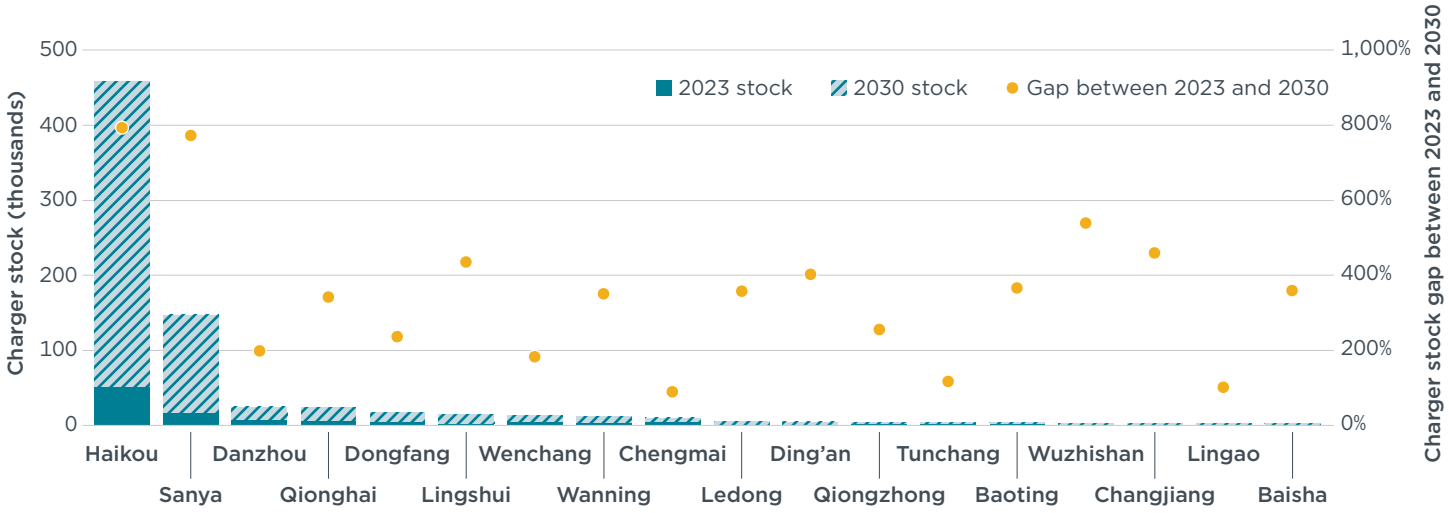
EXECUTIVE SUMMARY

In July 2023, Hainan province of China released a roadmap and proposed timeline for all vehicle categories except heavy-duty trucks to progressively shift to full electrification no later than 2030. These ambitious vehicle electrification targets would translate to a more than fourfold increase in the electric vehicle (EV) stock from 2023 to 2030. Such a rapid transition to EVs will require timely planning and the establishment of a comprehensive EV charging infrastructure network across the province.

This report investigates the status of EV deployment and EV charging infrastructure in Hainan and leverages the ICCT's EV CHARGE model to estimate future charging infrastructure needs to enable the rapid transition to EVs in the province. Figure ES1 shows the projected number of chargers needed in each city in Hainan in 2030 and identifies the gap between the required chargers and the stock in 2023.

Figure ES1

Projected number of EV chargers needed in each city of Hainan province in 2030 and gaps from 2023



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Our analysis supports the following conclusions:

Hainan stands out as a leader in China's transition to EVs. Hainan has made remarkable progress in EV deployment in the past five years. The province's EV stock increased from 33,000 in 2019 to 293,000 in 2023. Correspondingly, the EV share of the vehicle stock in Hainan rose from 2.4% in 2019 to 15% in 2023, a share that was more than twice the national average and second only to Shanghai among all provinces in China. Around 189,000 EVs were sold in Hainan in 2023, accounting for 49% of the province's new vehicle sales that year—almost twice the national average EV sales share and the highest among all provincial-level jurisdictions in China.

Hainan has made solid progress on EV charging infrastructure network development. Hainan's charger stock rapidly increased from 16,000 in 2019 to 110,000 in 2023, which included 72,000 home chargers and 38,000 public chargers. The total rated power of Hainan's public charging infrastructure exceeded 1.4 gigawatts (GW) in 2023. On average, there is 4.9 kilowatts (kW) of power per public charger for each EV in Hainan. Moreover, widely distributed public charging networks have been established in the two cities that are leading the province's EV deployment, Haikou and Sanya: in around 67% of the city area in Haikou and 35% in Sanya, EV drivers can reach a public charging pool with a drive time of less than 20 minutes.

Hainan's EV stock would increase rapidly under the province's ambitious vehicle electrification targets. Based on the province's official projections, if the electrification targets proposed in Hainan's most recently released roadmap were met, Hainan's EV stock would increase from 293,000 in 2023 to 500,000 in 2025 and 1.55 million by 2030. This would result in an increase of the EV stock share in Hainan from 15% in 2023 to 21% in 2025 and 45% in 2030. Haikou and Sanya would remain the two leading cities for EV deployment, representing 60% and 19% of the province's EV stock in 2030, respectively. Private cars and light-duty trucks would continue to dominate Hainan's EV stock, accounting for 81% and 10%, respectively, of the total in 2030.

Charging demands are projected to increase substantially apace with Hainan's continuously expanding EV fleet. Our modeling results indicate that the number of EV chargers needed in Hainan would increase from 110,000 in 2023 to 256,000 in 2025 and 750,000 in 2030. Of the 750,000 chargers needed in 2030, 662,000 would be home chargers while 89,000 would be public chargers, representing 88% and 12%, respectively, of the province's total charger needs. The largest gaps between projected EV charger demands in 2030 and the status quo in 2023 were projected to be in Haikou and Sanya. Haikou would need to add 407,000 chargers to its existing infrastructure network by 2030, while Sanya would need to add 107,000 chargers, representing increases of 794% and 773%, respectively, from 2023 levels.

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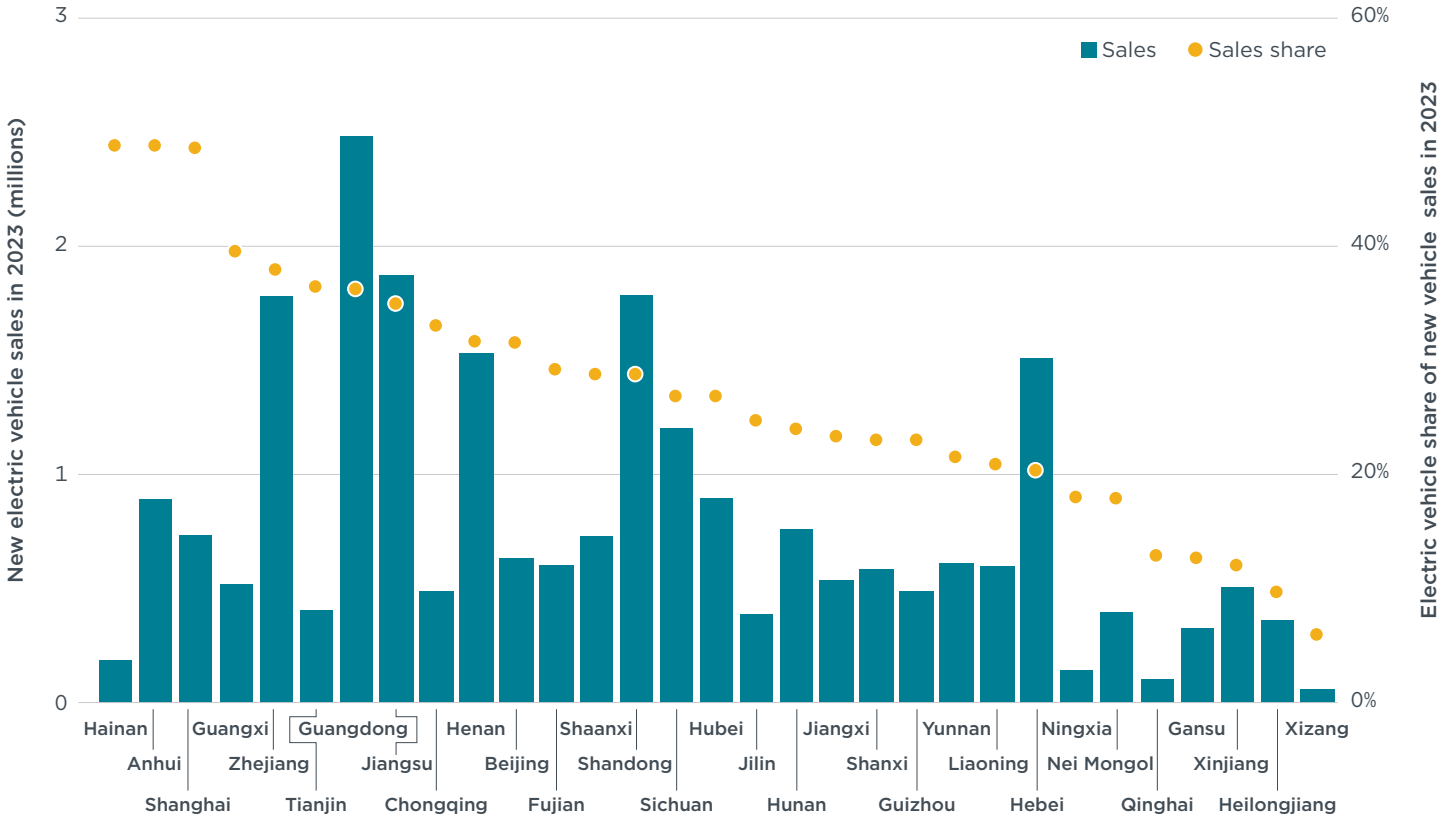
INTRODUCTION

As the first and only Chinese province to announce an official target for the phaseout of internal combustion engine vehicles, Hainan stands at the cutting edge of China's transition to electric vehicles (EVs; Hainan Provincial People's Government, 2019). As shown in Figure 1, around 189,000 EVs, including battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), were sold in Hainan in 2023. This represented 49% of new vehicle sales in the province in 2023, almost twice the national average EV sales share and the highest among all provincial-level jurisdictions in China (China Automotive Technology and Research Center [CATARC], 2024).

Figure 1

New EV sales and EV share of new vehicle sales in provincial-level jurisdictions in China in 2023



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In July 2023, Hainan released an electrification roadmap to further accelerate the province's transition to EVs (Joint Meeting Office of Hainan Province on New Energy Vehicle Popularization and Application, 2023). In the roadmap, Hainan classified all vehicles into 11 categories and proposed a timeline for all categories except heavy-duty trucks to progressively shift to 100% new sales of new energy vehicles (NEVs) by 2030 (Table 1). New energy vehicles here include EVs and fuel-cell electric vehicles. Based on the province's official projections, Hainan's 100% NEV sales targets would translate to an EV stock of 1.55 million in the province by the end of 2030, more than four times Hainan's EV stock in 2023 (Joint Meeting Office of Hainan Province on New Energy Vehicle Popularization and Application, 2023).

Table 1

Hainan's 2023 sales share of NEVs and sales share targets for 2025 and 2030

Vehicle category		2023 NEV sales share (%)	2025 NEV sales share target (%)	2030 NEV sales share target (%)
Passenger vehicles	Private cars	49	60	100
	Government vehicles	100	100	100
	Taxis	100	100	100
	Ride-hailing vehicles	100	100	100
	Rental cars	67	100	100
Buses	Public buses	100	100	100
	Tour coaches	74	50	100
	Intercity coaches	90	50	100
Trucks	Sanitation trucks	8.7	60	100
	Light-duty trucks (< 4.5 t)	38	100	100
	Heavy-duty trucks (≥ 4.5 t)	22	N/A	N/A

Alongside this rapid transition to EVs, the design and establishment of a comprehensive charging infrastructure network is critical. This report assesses the deployment of EVs and EV charging infrastructure in Hainan as of 2023 and projects the EV charging infrastructure needed in each city by 2030 based on the expected growth of the province's EV stock under its officially announced sales targets. This research is a joint effort between the International Council on Clean Transportation (ICCT), Hainan New Energy Vehicle Promotion Center, and CATARC.

STATUS QUO ANALYSIS

This section investigates Hainan's progress in EV deployment and EV charging infrastructure development by the end of 2023. For the analysis of EV deployment, the technical parameters we consider include the stock, daily vehicle kilometers traveled (VKT), and energy efficiency of EVs, as well as charging patterns of EV drivers in Hainan. These parameters have direct and significant impacts on the total energy consumed and charging infrastructure needs of a market's EV fleet (ICCT, n.d.). For the EV charging infrastructure assessment, our analysis focuses on the number, coverage, capacity, and utilization of chargers, which together determine the user convenience of EV charging in a market (Cui, et al., 2024). We assess these factors based on data on EV registration, real-world EV usage, charger registration, and real-world charger usage in Hainan, all of which were compiled and processed by Hainan New Energy Vehicle Promotion Center (2024).

EV DEPLOYMENT

Hainan's EV stock has continuously increased since 2019, when the province became China's first to announce an official target for the phaseout of internal combustion engine vehicles (Hainan Provincial People's Government, 2019). As shown in Figure 2, Hainan's EV stock reached 293,000 by the end of 2023, almost nine times higher than in 2019. The EV share of Hainan's vehicle stock also increased, from 2.4% in 2019 to 15% in 2023, more than twice the national average and second only to Shanghai among all provincial-level jurisdictions of China.

Figure 2

Hainan's EV stock and EV share of total vehicle stock from 2019 to 2023

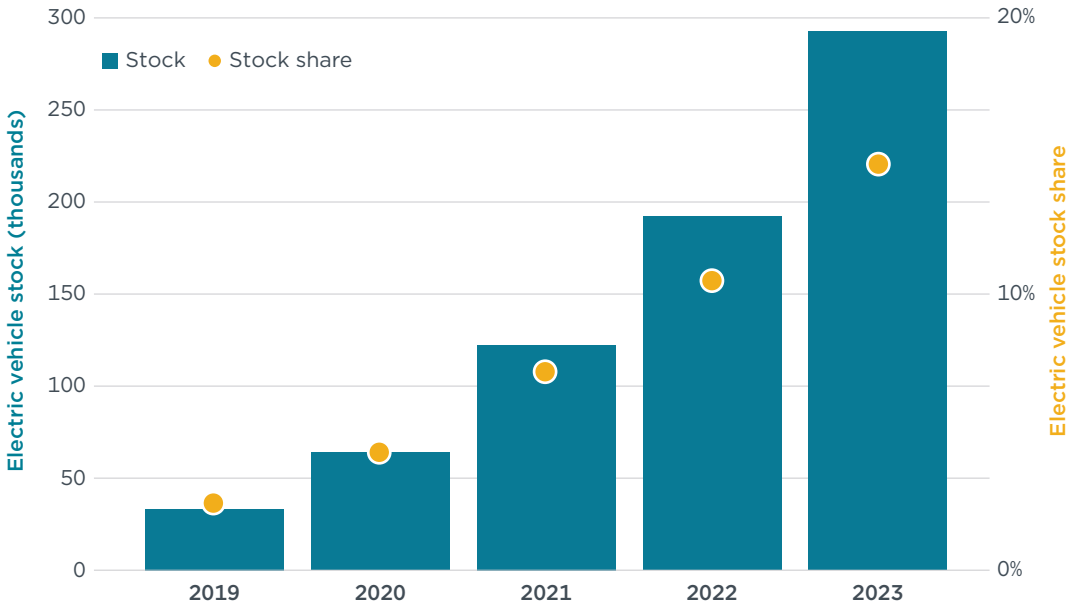

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Figure 3 breaks down Hainan's EV stock by city (top) and vehicle category (bottom). Hainan's EV stock has been concentrated in two leading cities—Haikou and Sanya—although shares in other cities have been steadily increasing in the past five years. As of 2023, Haikou and Sanya accounted for 61% and 20% of Hainan's EV stock, respectively, followed by Danzhou (3.3%), Qionghai (3.3%), Dongfang (2.5%), and Lingshui (2.1%). The majority of EVs on Hainan's roads are private cars, ride-hailing vehicles, and light-duty trucks. These categories made up 80%, 16%, and 7.1% of Hainan's EV stock as of 2023, respectively, followed by taxis (1.7%) and buses (1.3%).

Figure 3

Composition of Hainan's EV stock by city (top) and vehicle category (bottom) from 2019 to 2023

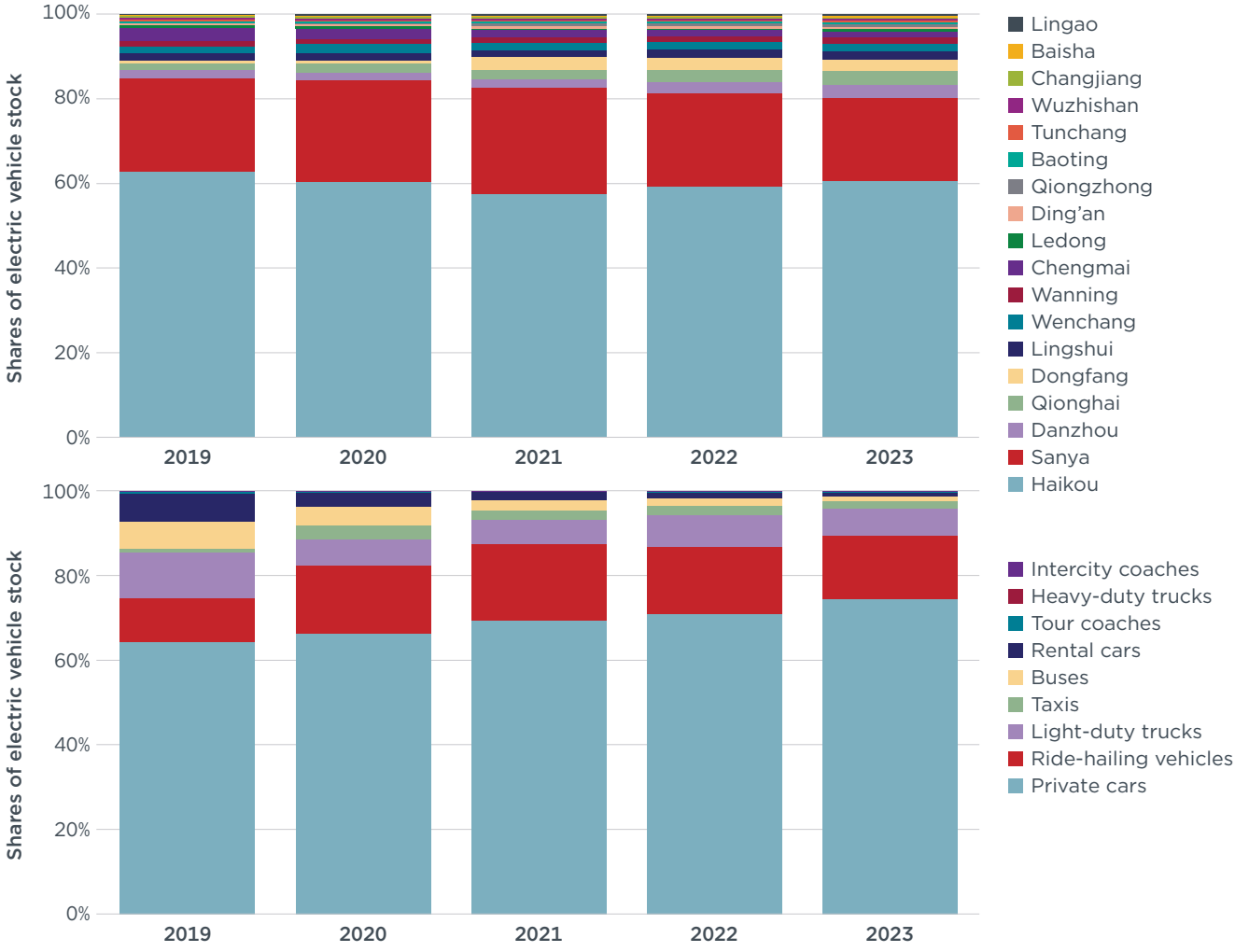

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Figure 4 and Figure 5 illustrate the progress made in different cities and vehicle categories in the transition to EVs. Dongfang ranked first among all cities in the province with an EV stock share of 21% as of 2023, followed by Sanya (19%), Lingshui (19%), and Haikou (15%). The EV stock shares in the other 14 cities were lower than the provincial average (15%). By vehicle category, ride-hailing vehicles, buses, and taxis achieved EV stock shares of 90%, 84%, and 73% as of 2023, and were well on their way to hit 100% EV stock shares by 2030. Meanwhile, with much larger fleet sizes, private cars and light-duty trucks had EV stock shares of 14% and 11%, respectively. Heavy-duty trucks had the lowest EV stock share as of 2023, at 2%.

Figure 4

EV share of vehicle stock in China, Hainan province, and cities of Hainan province as of 2023

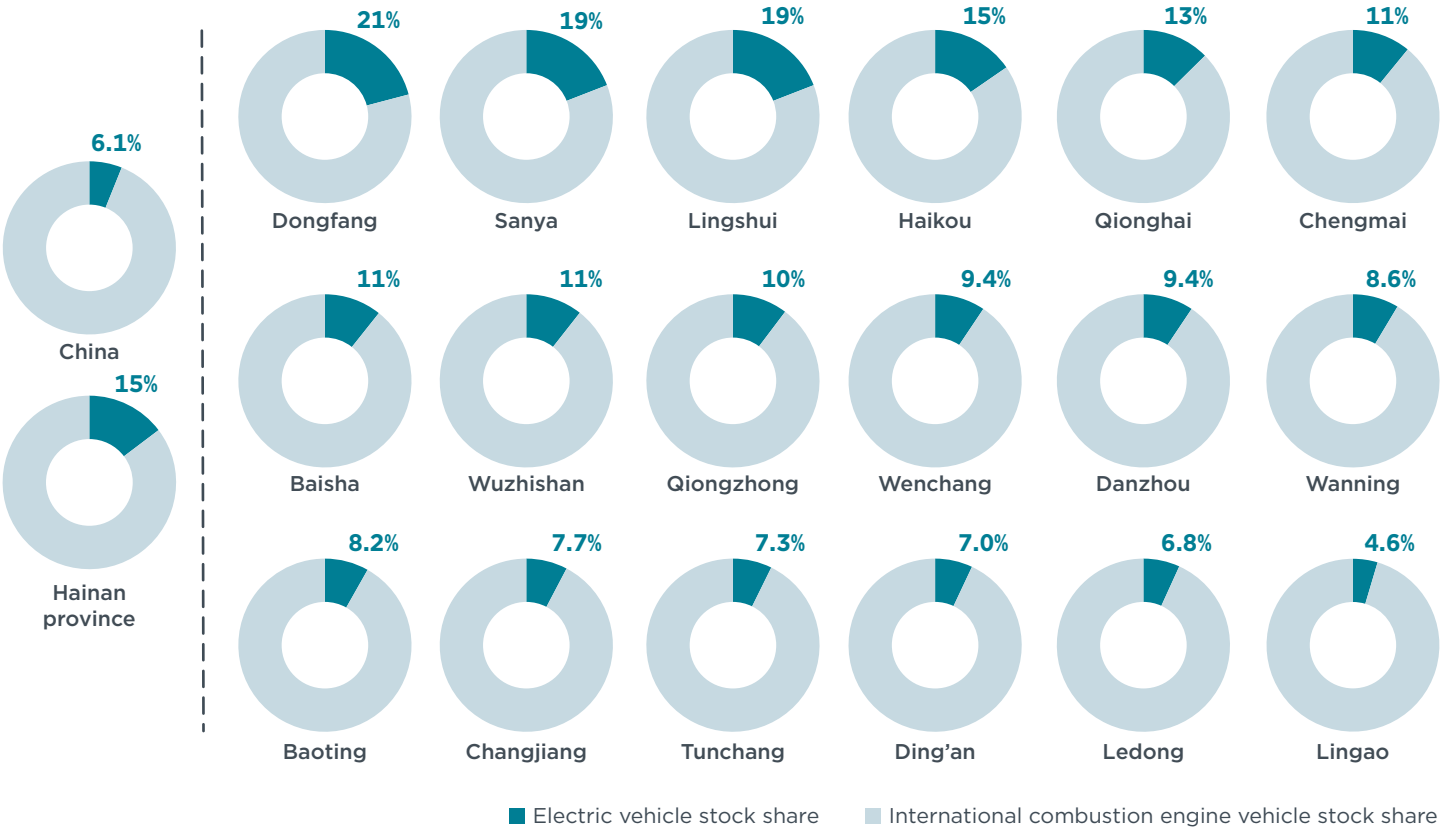

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Figure 5

Technology mix of vehicle stock by vehicle type in Hainan from 2019 to 2023

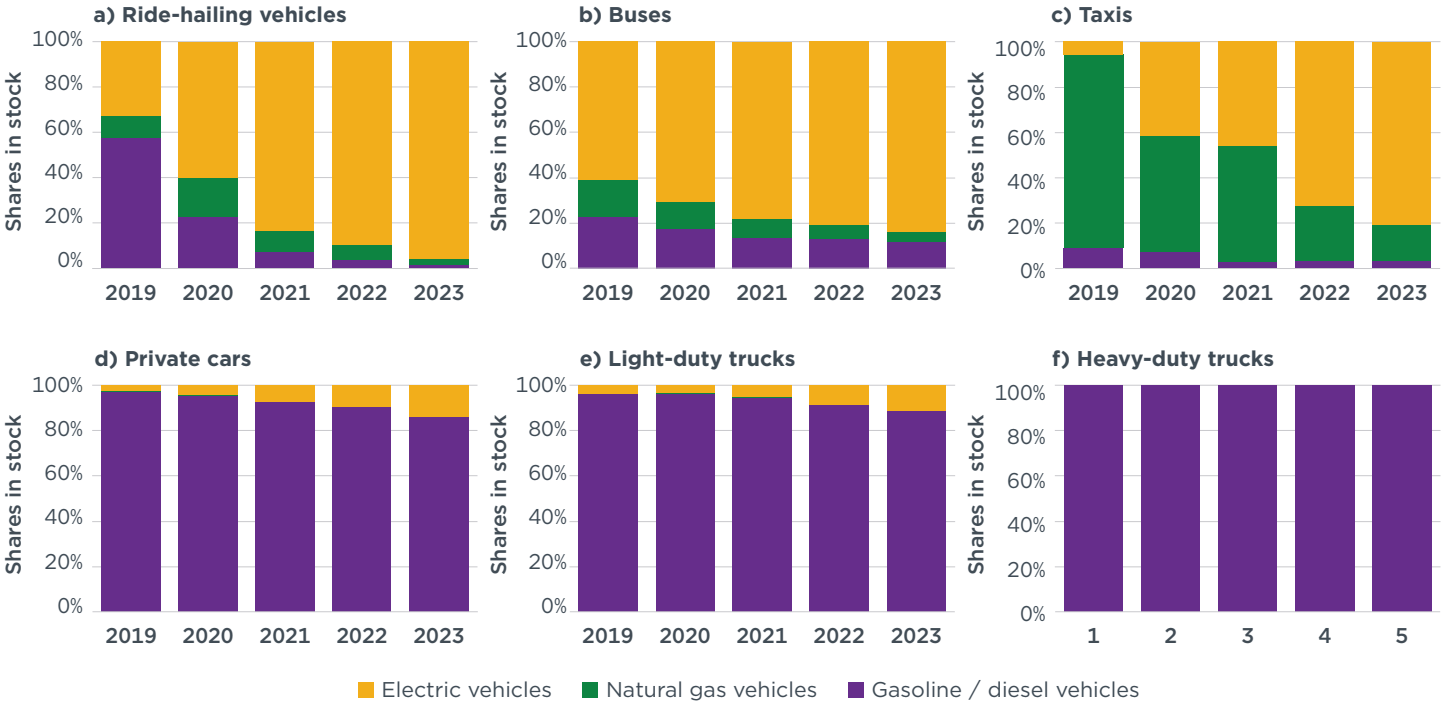

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Figure 6 and Figure 7 show the average daily VKT of EVs and average electricity efficiency of BEVs in Hainan by vehicle category based on 2023 real-world usage data (Hainan New Energy Vehicle Promotion Center, 2024). In general, EVs used for commercial purposes had higher daily VKT. Taxis and ride-hailing vehicles traveled the longest distance per day, with an average daily VKT of 261 km, followed by intercity coaches (213 km), buses (179 km), and tour coaches (172 km). Private cars, which represented the majority of Hainan's EV fleet, traveled 50 km per day on average. Battery electric passenger cars had the lowest real-world energy consumption among all vehicle groups, at 16 kWh/100km, followed by light-duty trucks (32 kWh/100km), buses and coaches (58 kWh/100km), and heavy-duty trucks (120 kWh/100km).

Figure 6
Average daily vehicle kilometers traveled of different types of electric vehicles in Hainan

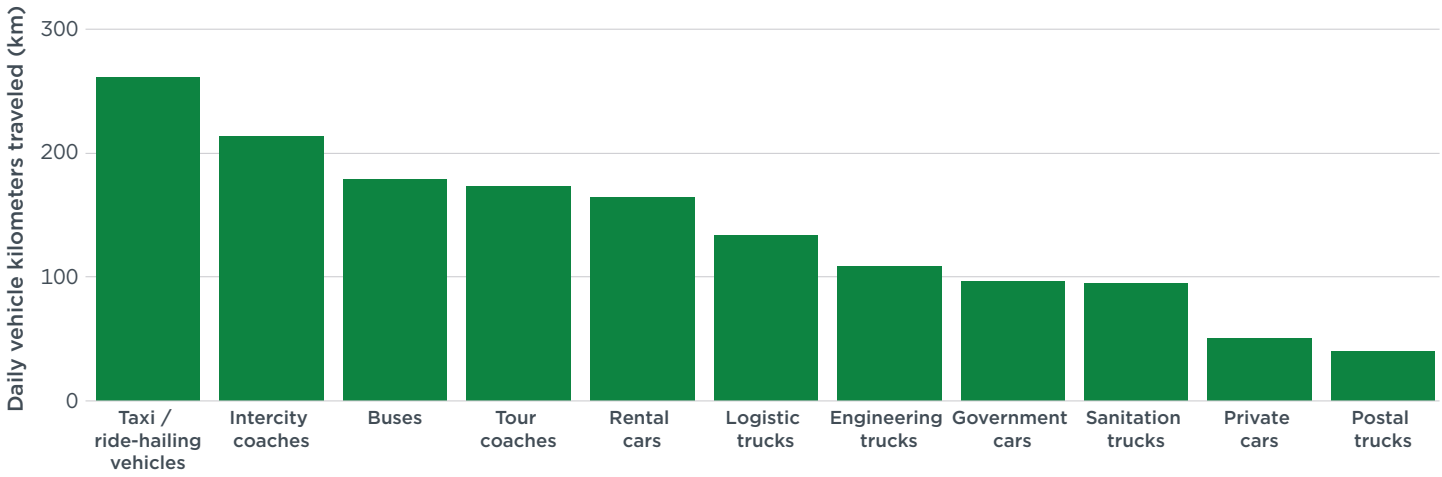

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Figure 7
Average electricity efficiency of different types of battery electric vehicles in Hainan

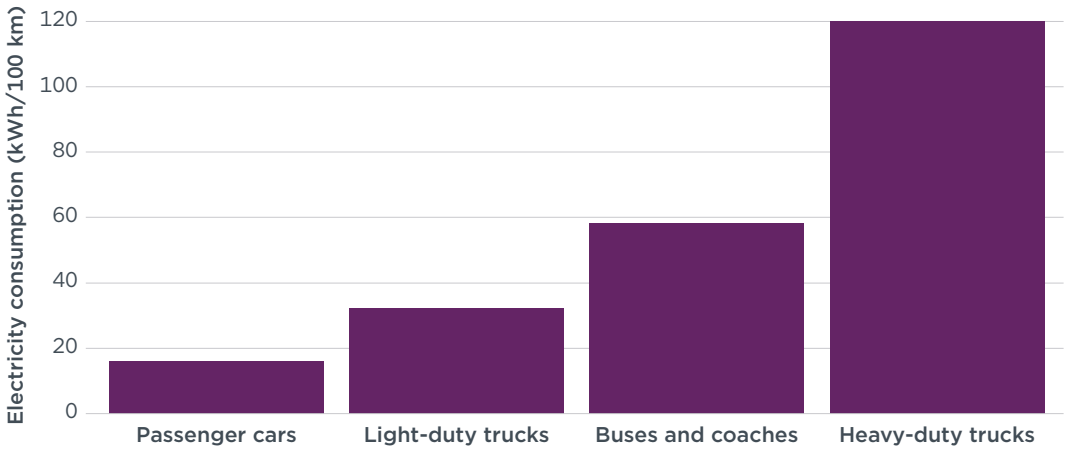

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Figure 8 and Figure 9 illustrate the charging patterns of Hainan's EVs using data on real-world charging events in September 2023 from 5% of EVs registered in Hainan (Hainan New Energy Vehicle Promotion Center, 2024). As shown in Figure 8, the start time of EV charging events was concentrated between 12:00 a.m. and 1:00 a.m. This was largely a result of Hainan's time-of-use electricity rate mechanism, whereby the transition from peak period to valley period—when residential and commercial electricity rates fall by over 70%—occurred at 12:00 a.m. Figure 9 analyzes the start and end state-of-charge (SOC) distribution of Hainan's EV charging events. Over 90%

of charging events began with an SOC of less than 50%, while almost half began with less than 20%. Approximately 91% of charging events ended with an SOC of 90%–100%.

Figure 8

Distribution of start time and end time of EV charging events in Hainan in September 2023

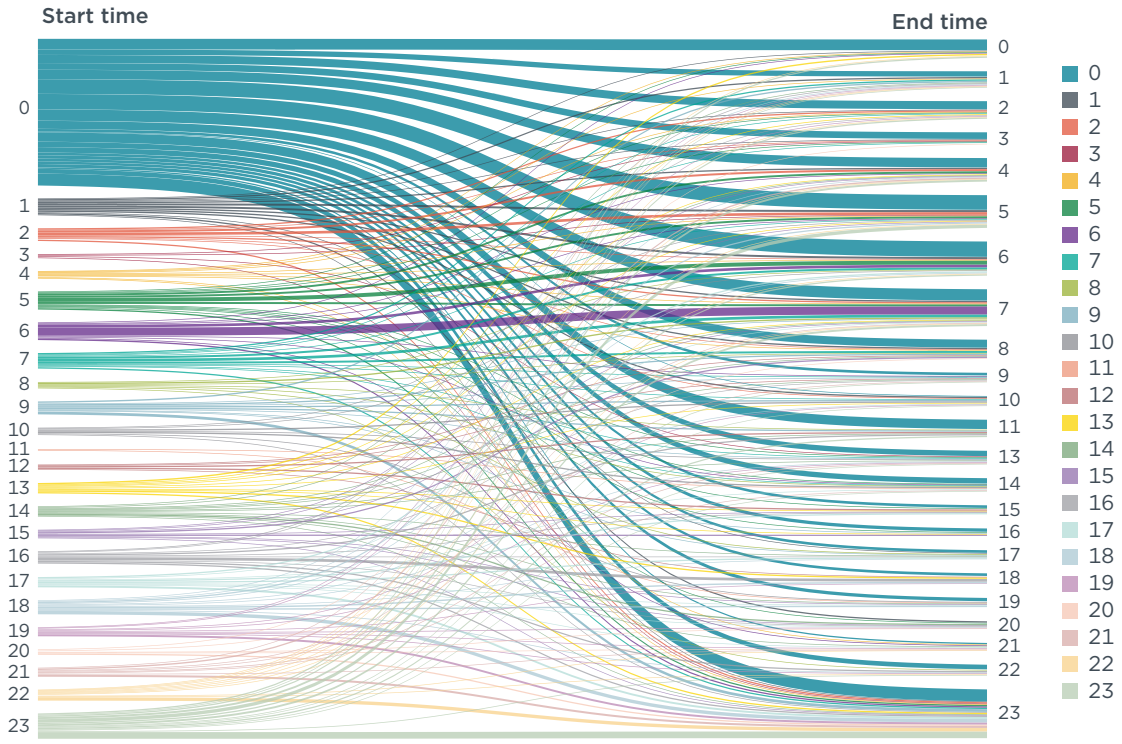

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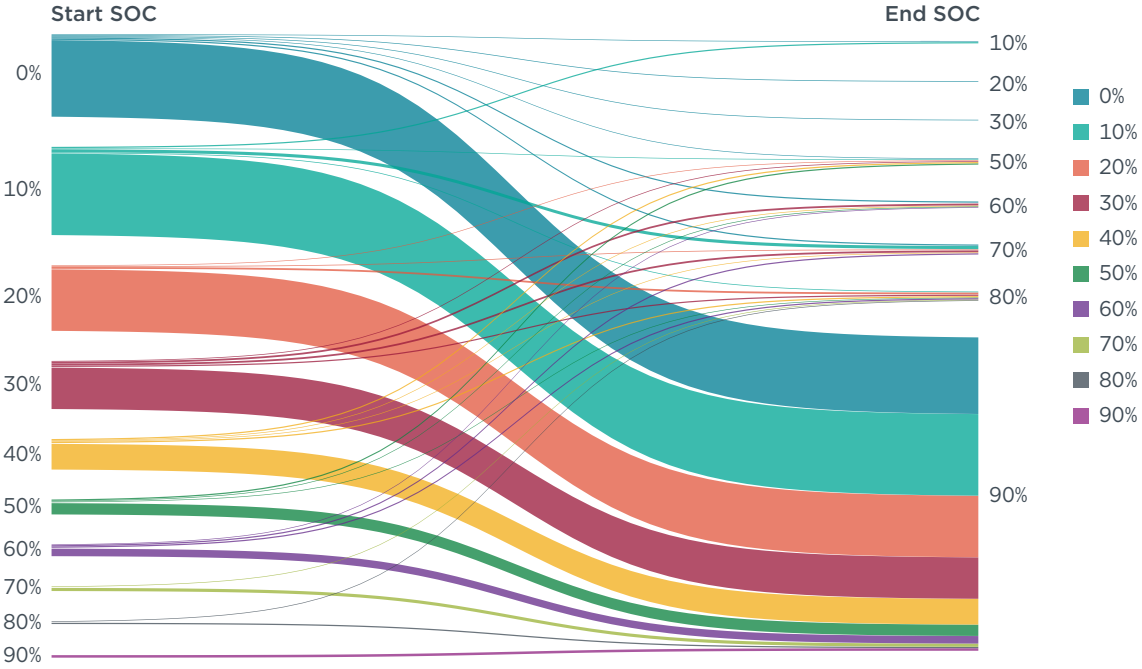
Figure 9

Distribution of start and end state-of-charge of EV charging events in Hainan in September 2023



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CHARGING INFRASTRUCTURE DEPLOYMENT

Hainan's EV charging infrastructure deployment has progressed alongside the accelerating adoption of EVs over the past 5 years. As shown in Figure 10, Hainan's charger stock rapidly increased from 16,000 at the end of 2019 to 110,000 at the end of 2023, which included 72,000 home chargers and 38,000 public chargers. Based on this home charger stock and the electric private car stock discussed above, we can estimate that around 30% of electric private car owners in Hainan had access to home chargers as of 2023.

Hainan's 38,000 public chargers as of 2023 were distributed in 3,200 public charging pools consisting of one or more chargers, up from 625 in 2019. Also known as electric vehicle supply equipment, charging points, or charging ports, chargers in this report refer to devices through which electricity is transferred from the grid to the EV. In China, the number of chargers is equal to the number of connectors, although this is not the case in markets where multiple charging standards coexist such as Europe and the United States (Cui et al., 2024). In addition to wired stationary charging, Hainan has also been actively promoting alternative charging solutions, such as battery swapping. By the end of 2023, Hainan had deployed 63 battery swapping stations used by either electric private cars, taxis, or heavy-duty trucks, up from 6 in 2019.

Figure 10

Hainan's charger stock (left), public charging pool stock (middle), and battery swapping station stock (right) from 2019 to 2023

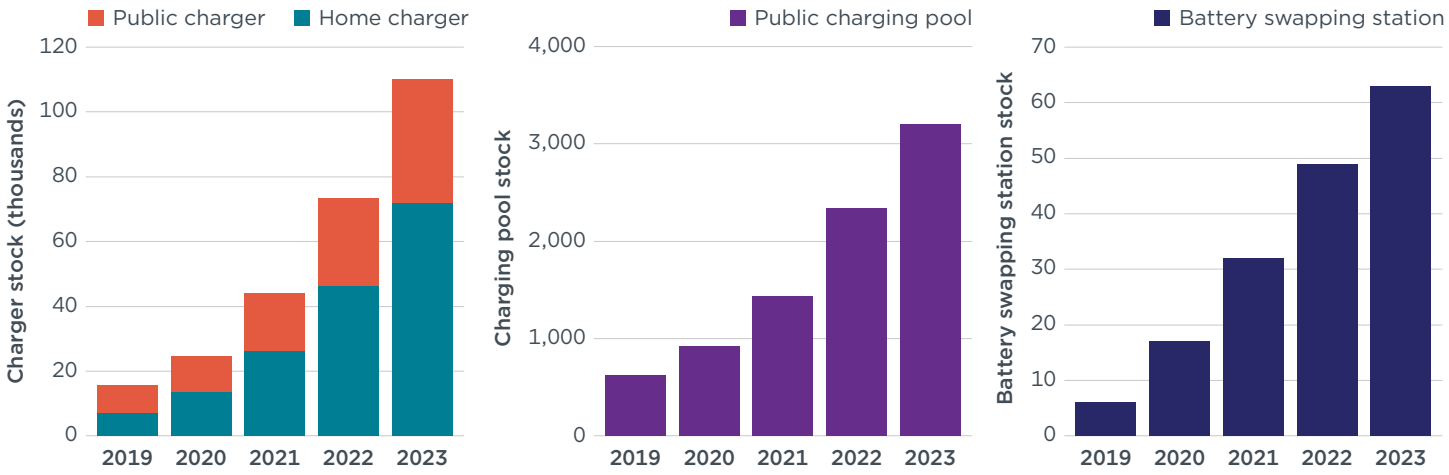

Figure 11 illustrates the public charging pool stock (left) and public charger stock (right) in different cities in Hainan as of 2023. Whether measured by the number of charging pools or number of chargers, public charging infrastructure in Hainan was primarily concentrated in two leading cities, Haikou and Sanya. Of all 3,200 public charging pools in Hainan as of 2023, 33% were in Haikou and 13% were in Sanya. Meanwhile, of the 26,000 public chargers installed as of 2023, 16,000 were in Haikou and 7,000 were in Sanya, representing 43% and 19%, respectively, of Hainan's total. Public charger deployment was comparatively much more limited in other cities in Hainan.

Figure 11

Public charging pool stock (left) and public charger stock (right) by city in Hainan as of 2023

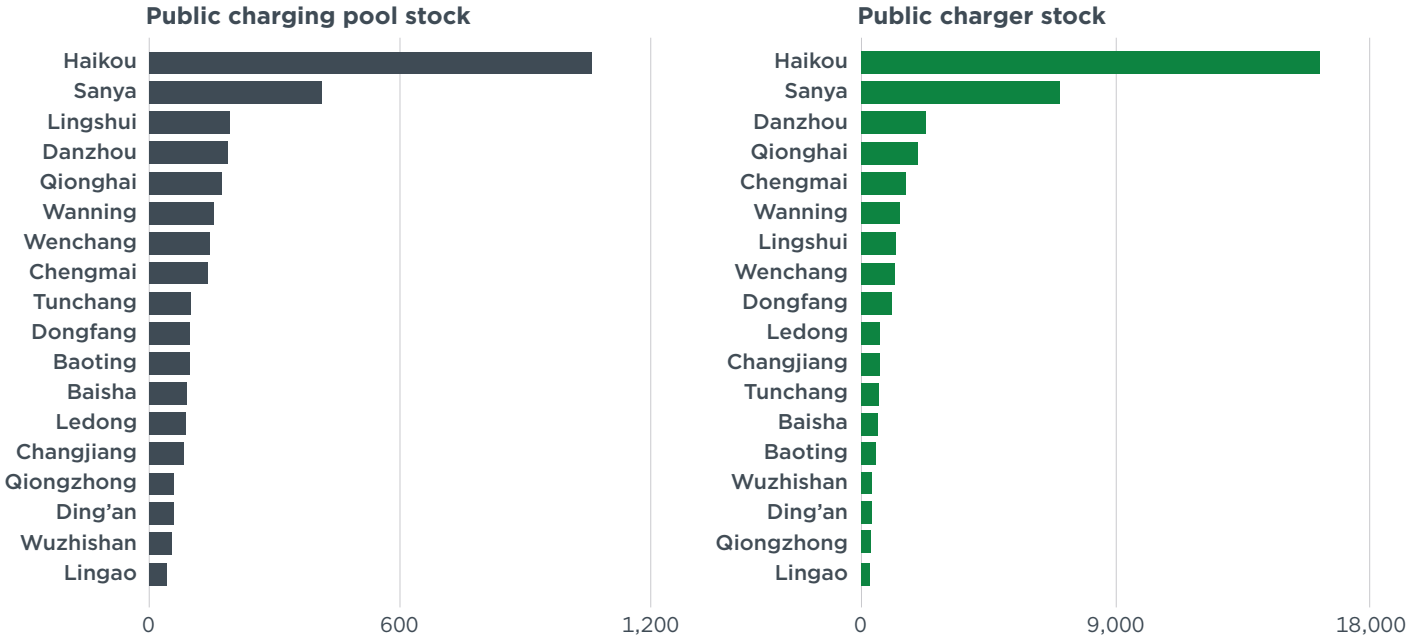

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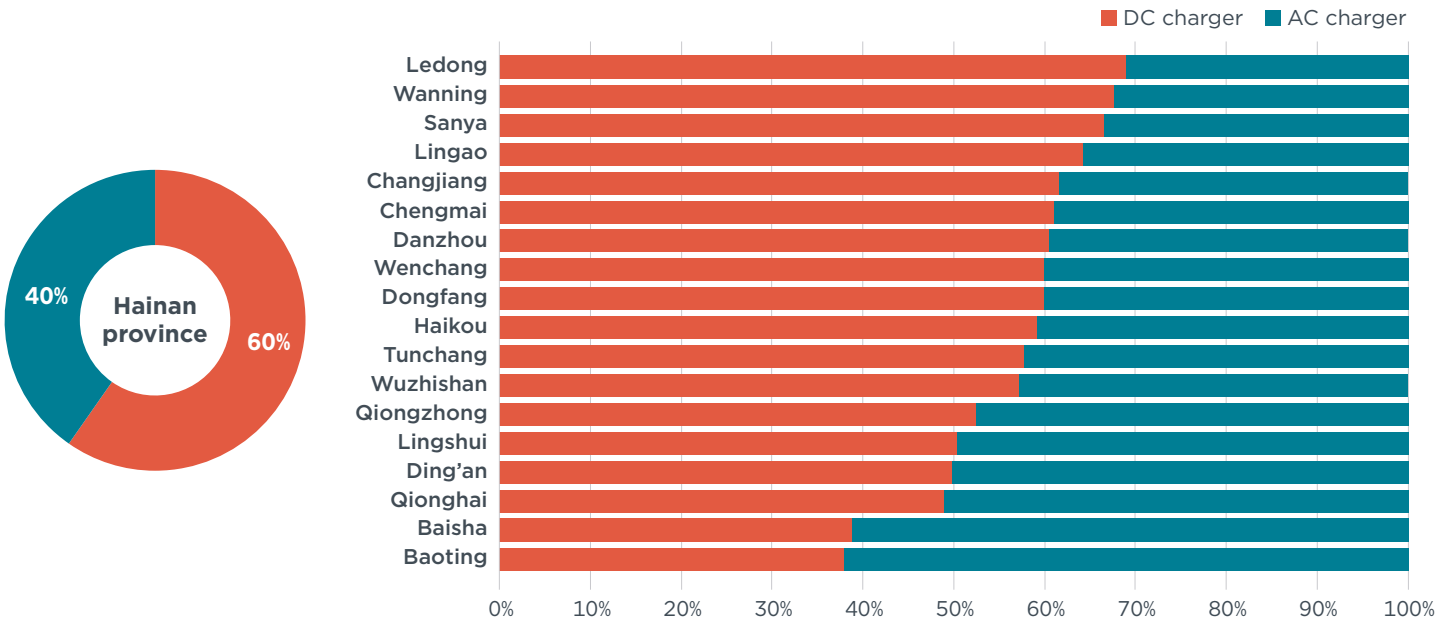
Figure 12 further investigates the technology mix of Hainan's public charger stock—that is, the relative shares of alternating current (AC) and direct current (DC) chargers—at the provincial and city levels. DC chargers usually have a higher installed power output (i.e., maximum power that they can deliver to an EV) and are thus capable of recharging a vehicle faster than AC chargers. As shown, DC chargers made up the majority of Hainan's public charger stock, with a share of 60% as of 2023. At the city level, the DC share of public charger stock ranged from 38% (Baoting) to 69% (Ledong). The two leading cities for charger deployment in Hainan, Haikou and Sanya, had DC charger shares of 59% and 67%, respectively.

Figure 12

Technology mix of public charger stock in cities of Hainan



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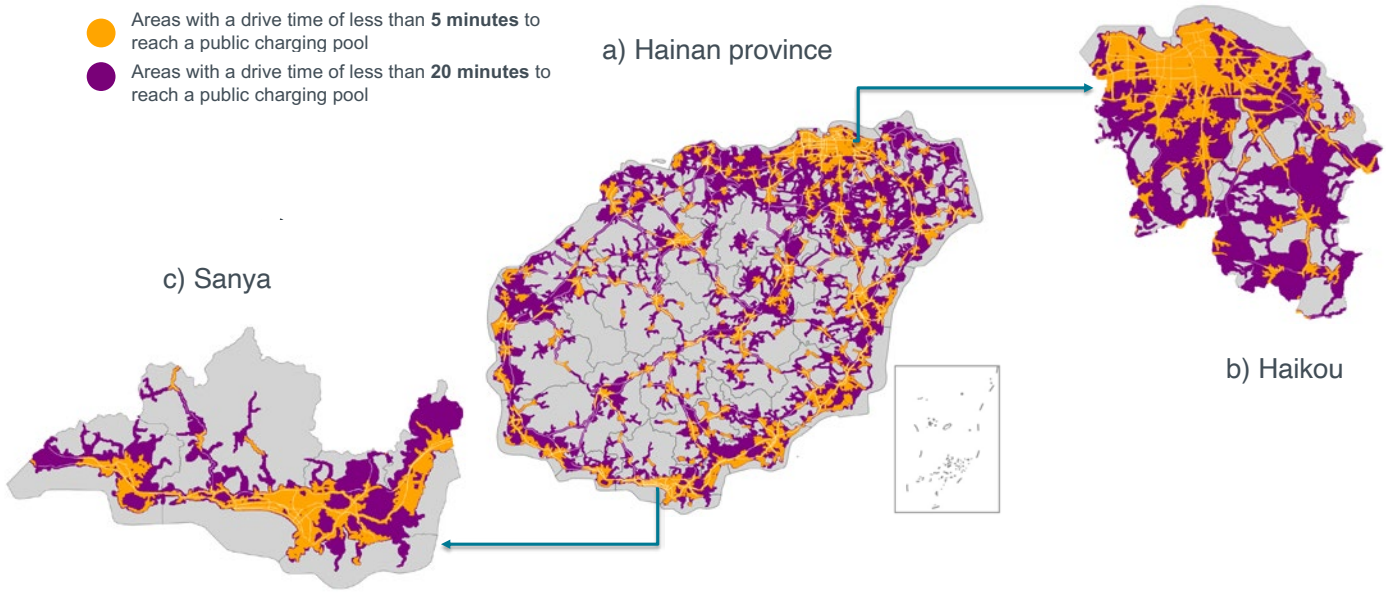
When measuring public charger availability, it is also important to examine the coverage of public chargers, or how public chargers are geographically distributed within a given area. In this study, we leveraged a novel metric proposed in a recent ICCT report (Cui et al., 2024)—the minimum drive time needed to reach a public charging pool—to measure Hainan's public charger coverage. Figure 13 depicts the minimum drive time required to reach public charging pools in Hainan generally and in Haikou and Sanya. Orange and purple regions represent areas where EV drivers could find a public charger within 5 minutes and 20 minutes of drive time, respectively, as of 2023.

As shown in Figure 13, 7.4% of the area of Hainan fell within a 5-minute drive from a public charging pool while 34% was within a 20-minute drive. In Haikou and Sanya, 21% and 12% of city areas, respectively, fell within a 5-minute drive of the nearest public charging pool, while 67% and 35% of city areas, respectively, were within a 20-minute drive. The geographical coverage of public chargers in Haikou is comparable with leading cities in China such as Shanghai, Beijing, and Chengdu (Cui et al., 2024). Nonetheless, Figure 13 implies that public charging pools were concentrated in urban areas. Public charger coverage in suburban and rural areas was much lower by comparison.

Figure 13
Minimum drive time needed to reach a public charging pool in Hainan province, Haikou, and Sanya as of 2023



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The capacity of public chargers, measured in power output, is another critical factor to consider when assessing public charging infrastructure networks, as it has significant impacts on charging speed and user convenience. By the end of 2023, the total rated power of Hainan's public charging infrastructure reached 1.4 gigawatts (GW), of which 41% and 21% was concentrated in Haikou and Sanya, respectively. Public charging power installed per EV in Hainan was 4.9 kilowatts (kW), on average. Figure 14 depicts the rated power distribution of all public chargers (top), public AC chargers (middle), and public DC chargers (bottom) in Hainan as of 2023. Hainan's public chargers were dominated by AC chargers with a rated power of 7 kW, which accounted for 39% of the province's total public charger stock in 2023, followed by DC chargers with a rated power of 60 kW (24%). Among Hainan's public AC chargers, 97% were 7 kW; among public DC chargers, 41% were 60 kW, 7.8% were 80 kW, and 2.5% were 40 kW.

Figure 14

Rated power distribution of public chargers installed in Hainan as of 2023

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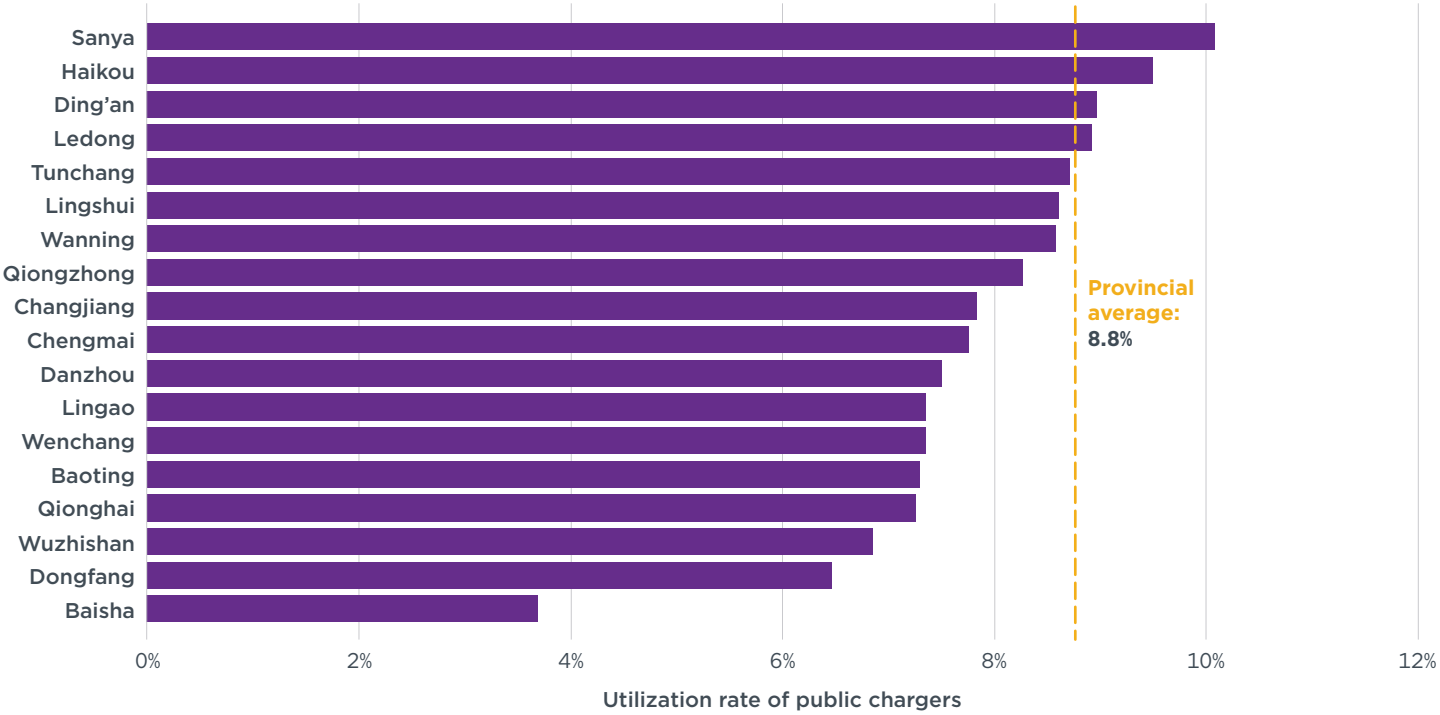
The charger utilization rate is defined in this report as the percentage of time that a charger is plugged into an EV. As is shown in Figure 15, the average utilization rate of public chargers in Hainan was 8.8% in 2023. At the city level, Sanya ranked first with an average public charger utilization rate of 10%, followed by Haikou (9.5%), Ding'an (9.0%), and Ledong (8.9%). Researchers estimate that an average utilization rate of 15% is necessary to ensure the economic viability of public charging pools (Sperka, 2022). This indicates that there is significant potential for Hainan to further increase public charger utilization through data-driven planning and deployment of public chargers to more accurately match public charger locations with EV drivers' charging needs.

Figure 15

Average utilization rate of public chargers in cities of Hainan in 2023



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FUTURE DEMAND ASSESSMENT

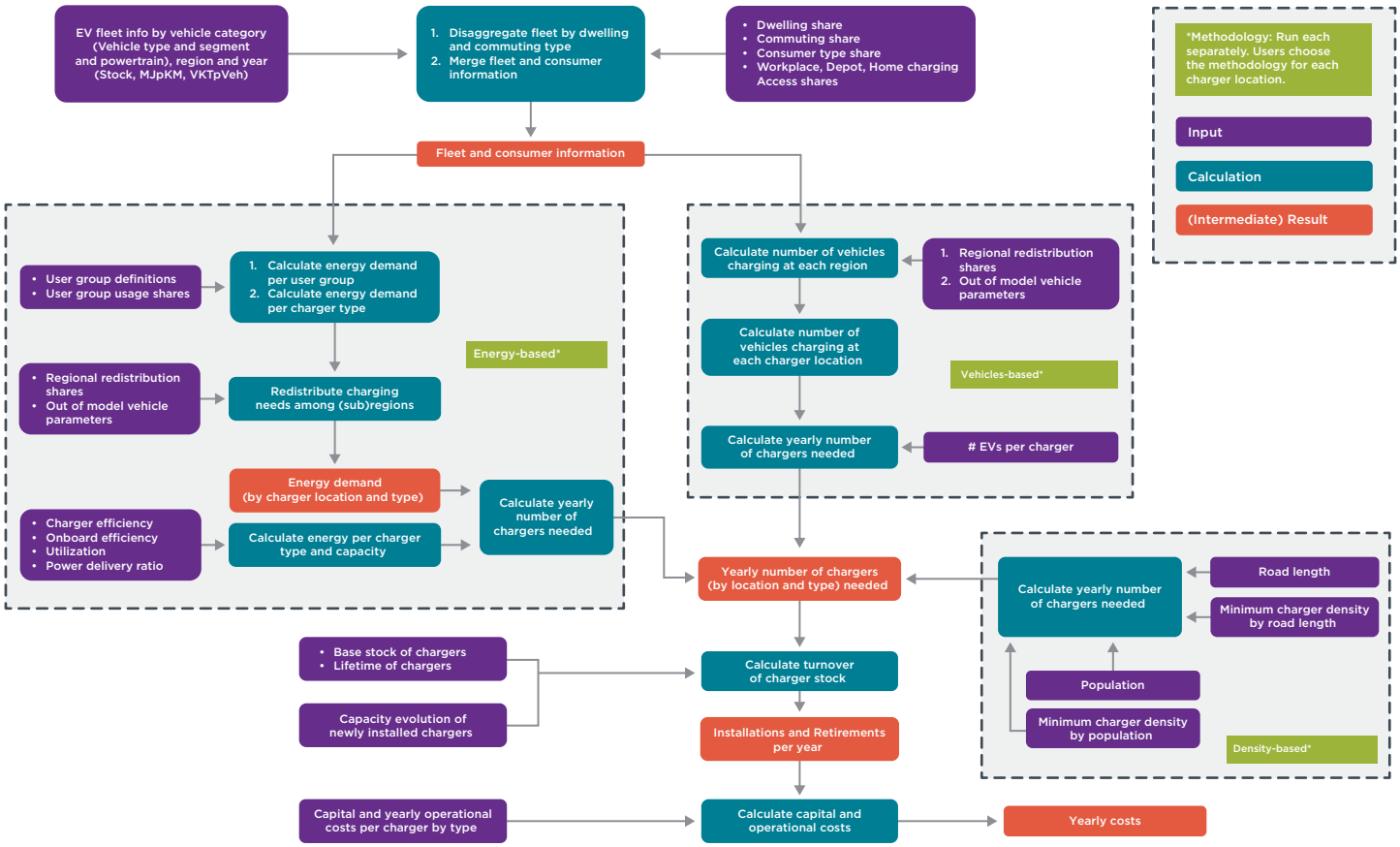
In this section, we project the charging infrastructure needed in Hainan to support the province's envisioned transition to EVs by 2030. We first describe the methodology used to quantify the number and type of chargers needed in each city of Hainan. We then discuss the results of the charging infrastructure needs assessment and examine the gap between the expected demand and the status quo in the province.

METHODOLOGY

We used the ICCT's EV CHARGE model to estimate Hainan's charging infrastructure needs (ICCT, n.d.). Figure 17 illustrates the methods and steps that this model uses to project EV charging infrastructure needs in a given region. It employs three types of modeling methods—based on energy needs, the number of vehicles to be charged, and the population or road infrastructure density—to examine the demand for different types of chargers used for different vehicle categories. The energy-based approach calculates the number of chargers needed based on the electricity demand of EVs, which is determined by parameters that include EV stock, daily electric VKT, and vehicle energy efficiency. The vehicles-based approach projects the number of chargers needed based on EV stock and assumed EV-per-charger ratios (e.g., one home charger per electric private car that has access to home chargers). The density-based approach estimates charger numbers either by multiplying the population by an assumed minimum charger density per person (e.g., 15 public DC chargers per 1,000 people) or by multiplying the road length by a minimum charger density per kilometer (e.g., one charging pool consisting of 5 DC chargers for every 60 km of highways).

Figure 16

Electric vehicle charging infrastructure needs assessment methods used in the EV CHARGE model



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The baseline year of our modeling exercise is 2023, while the target years are 2025 and 2030. The charger technology types considered are AC chargers and DC chargers, and location types considered are home chargers and public chargers. Public chargers are further classified in the EV CHARGE model into depot chargers, workplace chargers, overnight chargers, destination chargers, and en-route chargers (ICCT, n.d.). Depot chargers are typically used by commercial fleets and are located at the fleet operator's private hub or depot locations. Workplace chargers are located at workplaces and are intended for employees who commute to work. Public overnight chargers are located at the roadside near residential areas and are used to serve EV drivers without home charging. En-route chargers are located alongside highways and are used to support long-distance trips. Destination chargers are located in public locations other than residential areas and highways (e.g., in parking lots of shopping malls, parks, hospitals, and stadiums). All AC chargers in this analysis are assumed to be 7 kW chargers, while we consider seven different power ratings for DC chargers, depending on the use case: 30 kW, 60 kW, 120 kW, 150 kW, 240 kW, 360 kW, and 480 kW. Battery swapping is not considered in our modeling because it is not widely available in Hainan.

All ten vehicle categories with 100% NEV sales targets (Table 1) are considered in this assessment of Hainan's EV charging infrastructure needs. These include five types of passenger cars (private cars, government vehicles, taxis, ride-hailing vehicles, and rental cars), light-duty trucks, buses, tour coaches, intercity coaches, and sanitation trucks. Heavy-duty trucks were not considered because Hainan province has not yet set electrification targets for this segment. Table 2 illustrates the modeling methods used to project the number of different types of chargers needed for passenger cars and light-duty trucks. For buses, coaches, and sanitation trucks, the vehicles-based approach was applied.

Table 2

Modeling methods used to assess the number of different types of chargers needed for passenger cars and light-duty trucks in this study

Charger type		Modeling method used		
		Energy-based approach	Vehicles-based approach	Density-based approach
Home charger			●	
Public charger	Depot charger		●	
	Workplace charger	●		
	Overnight charger	●		
	Destination charger	●		
	En-route charger			●

We took a six-step approach to combine the three modeling methods to estimate the number of different types of chargers needed for passenger cars and light-duty trucks. Below, we use private cars, the vehicle category with the largest EV stock, as an example to illustrate these six steps; more details on the assumptions used in this study are provided in the subsequent paragraphs.

- First, we projected Hainan's electric private car stock by city through 2030 to align with the province's official NEV sales share targets shown in Table 1.
- Second, we classified each city's electric private cars into different user groups based on factors that include powertrain type, home charging access, whether the EVs are used to commute, and whether there is access to workplace chargers, as shown in Table 3.
- Third, for each user group, we calculated the annual energy demands based on EV stock, annual VKT, electric share of annual VKT, and vehicle energy efficiency, and split the total energy demands by charger type, including home chargers and the different types of public chargers shown in Table 2. The default data in the EV CHARGE model, which were derived from a series of EV driver surveys globally, were applied to determine the shares of energy coming from each charger type for each user group in this modeling exercise.
- Fourth, we translated the annual energy demands for workplace chargers, overnight chargers, and destination chargers (measured in kWh), into total power demands (measured in kW) based on the annual charger utilization (measured in hours). The annual utilization hours of chargers were determined based on the assumed charger utilization rate.
- Fifth, we calculated the number of each type of charger based on the total power demands and the assumed power rating mix of chargers. For each charger type, the power rating mix was based on our analysis of the 2023 data, as discussed above, and accounted for an assumed increase in the relative shares of higher-power chargers due to technology improvements from 2023 to 2030.
- Last, we calculated the number of home chargers needed for each user group, assuming that each electric private car with access to home charging would need one home charger. We calculated the number of en-route chargers needed for each user group assuming the charger density on Hainan's highways gradually increases to 20 DC chargers per 50 kilometers (in both directions of travel) by 2030. The total number of chargers required for electric private cars in each city through

2030 was calculated by adding up the number of different types of chargers needed. The same approach was applied to the other types of passenger cars and light-duty trucks.

Table 3
User group classification for electric private cars in this study

User group ID	Vehicle powertrain type	Home charging access	EVs used for commuting	Workplace charging access
PC_BEV_home_commuter_work	BEV	Yes	Yes	Yes
PC_BEV_home_commuter_nowork	BEV	Yes	Yes	No
PC_BEV_home_nocommuter	BEV	Yes	No	
PC_BEV_nohome_commuter_work	BEV	No	Yes	Yes
PC_BEV_nohome_commuter_nowork	BEV	No	Yes	No
PC_BEV_nohome_nocommuter_work	BEV	No	No	
PC_PHEV_home_commuter_work	PHEV	Yes	Yes	Yes
PC_PHEV_home_commuter_nowork	PHEV	Yes	Yes	No
PC_PHEV_home_nocommuter	PHEV	Yes	No	
PC_PHEV_nohome_commuter_work	PHEV	No	Yes	Yes
PC_PHEV_nohome_commuter_nowork	PHEV	No	Yes	No
PC_PHEV_nohome_nocommuter_work	PHEV	No	No	

For the four types of heavy-duty commercial vehicles considered (buses, tour coaches, intercity coaches, and sanitation trucks), we applied the vehicles-based approach to calculate the number of chargers needed through 2030. To do so, we multiplied the EV stock of each vehicle category with the associated EV per normalized charger ratio. A normalized charger here refers to a DC charger with a rated power of 60 kW; the EV per normalized charger ratios applied in this analysis (of 4 for buses, 3 for coaches, and 1 for sanitation trucks) were derived from field surveys and interviews with bus, coach, and sanitation truck fleet owners in Hainan.

To accommodate Hainan's targeted increase in EV stock from 293,000 in 2023 to 1.55 million by 2030, the EV charger stock would need to expand rapidly over the next several years. Based on our field surveys and interviews with policymakers and other stakeholders in Hainan, we gathered that it would be challenging for Hainan, particularly its capital city of Haikou, to substantially increase the number of non-workplace public chargers due to a lack of available land for charger placement. However, there are four alternate approaches that could enable sufficient chargers to be deployed in Hainan to accommodate its vehicle electrification targets while minimizing the number of overnight and destination public chargers needed: maximizing home charging access, maximizing workplace charger access, prioritizing DC chargers when adding new public chargers, and increasing public charger utilization.

These four strategies are reflected in the assumptions of our EV charging infrastructure needs modeling exercise. Specifically, we assumed that home charging access for electric private cars in Hainan would increase from 30% in 2023 to 50% in 2030. We considered this to be achievable given that only 2.5% of the 1.7 million private parking spaces in Hainan's existing residential areas have been equipped with EV chargers to date, according to Hainan New Energy Vehicle Promotion Center surveys; in addition, 100% of parking spaces in new residential buildings in Hainan are now required to be

equipped with EV chargers. Workplace charging access was assumed to increase from 30% in 2023 to 50% in 2030. All home chargers were assumed to be 7 kW AC chargers. For workplace chargers, overnight chargers, destination chargers, and en-route chargers, the DC share was assumed to be 20%, 60%, 60%, and 100%, respectively, through 2030 (China EV100, 2024). The average utilization rate of public chargers was assumed to increase from 8.8% in 2023 to 15% in 2030.

MODELING RESULTS DISCUSSION

Figure 17 shows the projected growth of EV stock and EV share of total vehicle stock in Hainan through 2030 to align with the province's official NEV sales share targets. As noted above, this includes all vehicle categories except heavy-duty trucks. Hainan's EV stock was projected to follow a similar trajectory as in the past 5 years to increase from 293,000 in 2023 to 500,000 by 2025 and 1.55 million by 2030. This would result in a rise of the EV stock share from 15% in 2023 to 21% in 2025 and 45% in 2030.

Figure 17

Hainan's EV stock and EV share of total vehicle stock in 2019–2023 and projections for 2024–2030

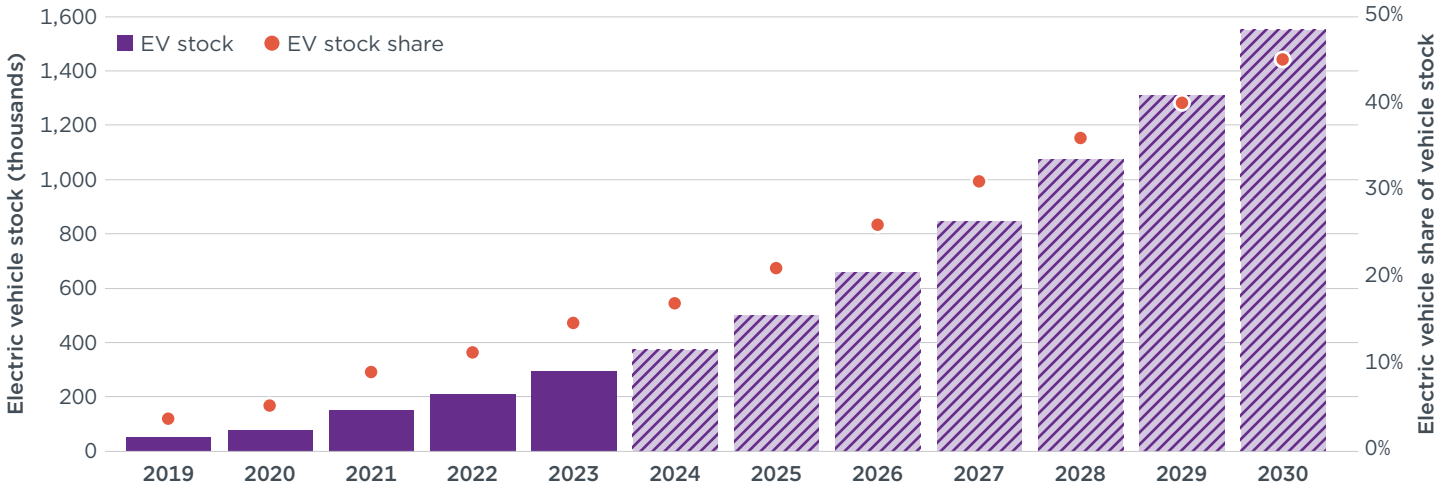

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Figure 18 and Figure 19 break down Hainan's projected EV stock through 2030 by city and vehicle category. As the province's two top cities for EV deployment to date, Haikou and Sanya were projected to continue playing a leading role in Hainan's transition to EVs through 2030. The EV stock in Haikou was projected to increase from 180,000 by 2023 to 310,000 in 2025 and 930,000 by 2030, when it would account for 60% of Hainan's overall EV stock. Sanya's EV stock would rise from 57,000 in 2023 to 100,000 in 2025 and 290,000 in 2030, when it would represent 19% of the provincial total. Private cars and light-duty trucks were estimated to account for a large share of Hainan's new EV sales in the coming years. According to our modeling exercise, the electric private car stock in Hainan would increase from 234,000 in 2023 to 350,000 in 2025 and 1.25 million by 2030, when it would represent an 81% share of Hainan's total EV stock. The stock of electric light-duty trucks would also rise, from 21,000 in 2023 to 40,000 by 2025 and 150,000 by 2030, representing 10% of the total stock. Comparatively, the growth potential of taxis, buses, coaches, and sanitation trucks was limited.

Figure 18

Hainan's electric vehicle stock in 2019–2023 and projected stock in 2024–2030 by city

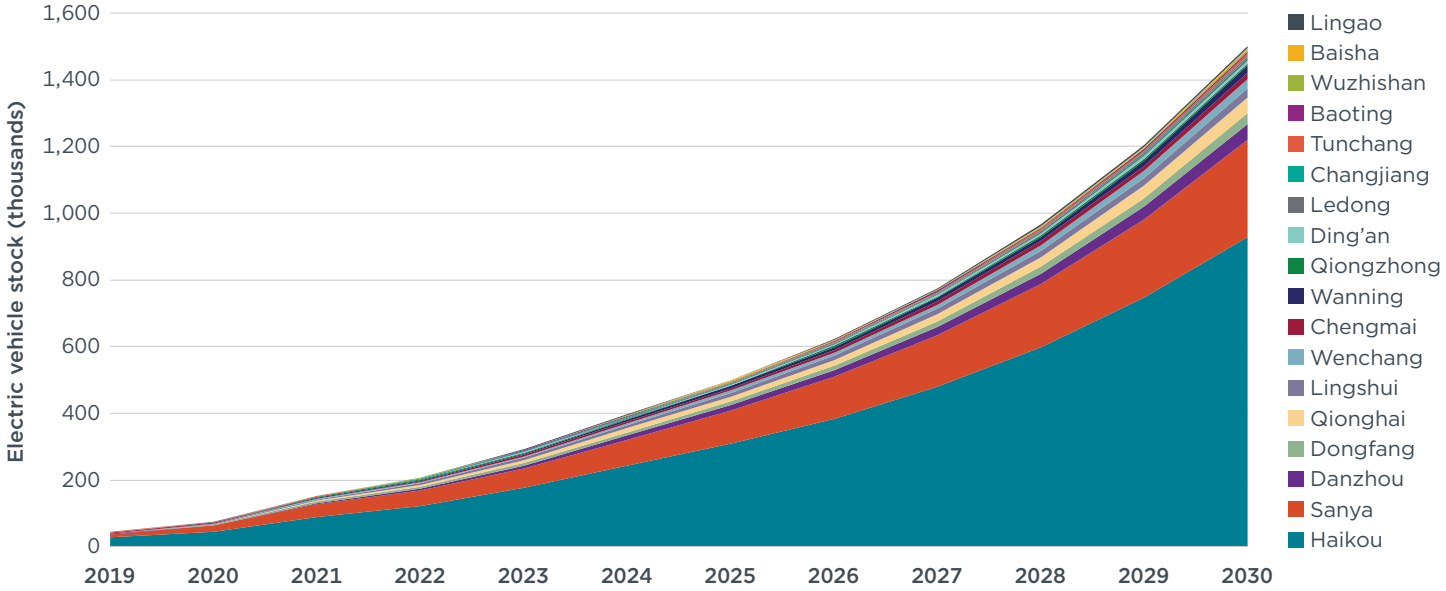

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Figure 19

Hainan's electric vehicle stock in 2019–2023 and projected stock in 2024–2030 by vehicle category

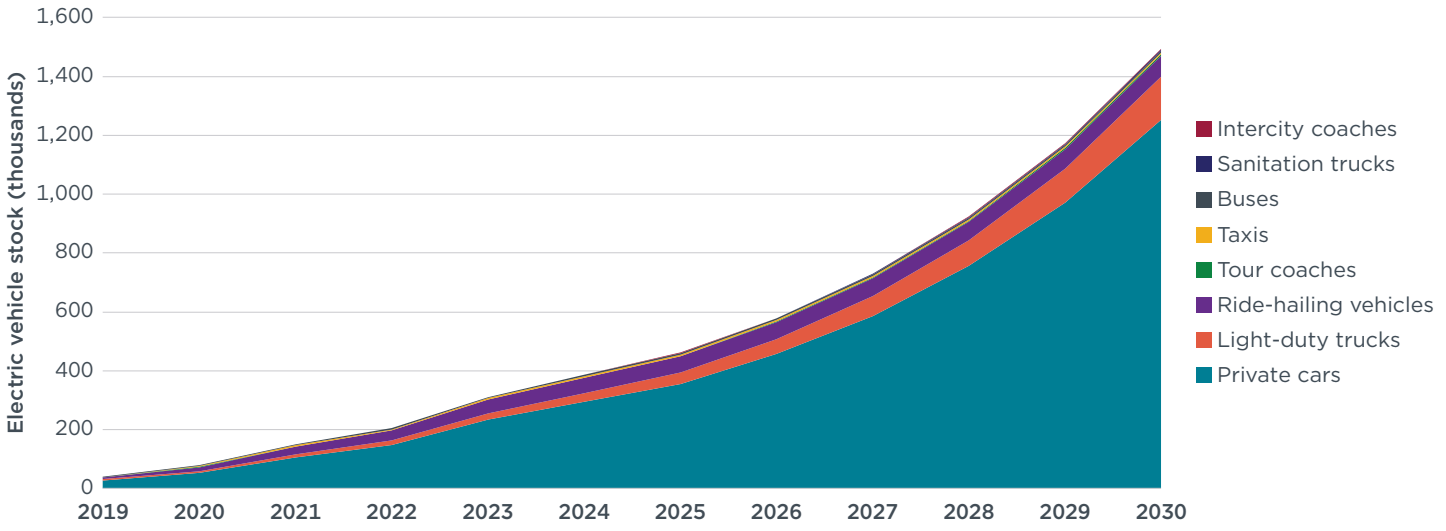

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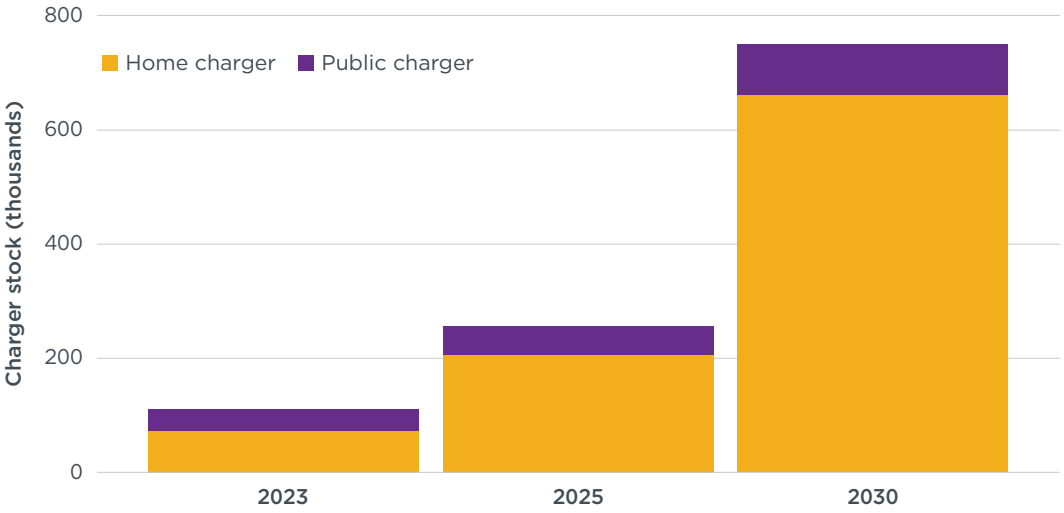
Figure 20 shows the estimated number of home and public EV chargers needed in Hainan in the two target years of this modeling exercise, 2025 and 2030. In total, Hainan's EV charger stock was projected to increase from 110,000 in 2023 to 256,000 in 2025 and 750,000 in 2030. Specifically, the stock of home chargers was estimated to increase from 72,000 in 2023 to 206,000 in 2025 and 662,000 in 2030. As noted above, this analysis considered four strategies for increasing EV charging access, including increasing home charging access. Correspondingly, the share of home chargers in Hainan's EV charger stock was projected to increase from 65% in 2023 to 80% in 2025 and 88% in 2030. This home charger-focused approach would not only help to reduce the need for public chargers and corresponding land requirements, but would also match the preferences of EV drivers, as home charging is typically more convenient and affordable than public charging (China Consumers Association, 2023).

Figure 20

Projected charger stock by charger type in Hainan in 2025 and 2030



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The stock of public chargers, which include workplace, depot, overnight, destination, and en-route chargers, was estimated to increase from 38,000 in 2023 to 51,000 in 2025 and 89,000 in 2030. This increase reflects a 13% compounded annual growth rate in public charging infrastructure from 2023 to 2030, which is much less than the 46% compound annual growth rate in public charging infrastructure between 2019 and 2023. Figure 21 breaks down the projected public charger stock by charger technology. DC chargers were projected to continue playing a leading role in Hainan's public charger deployment, which aligns with the DC charger-focused principle introduced in the methodology section. The number of public DC chargers was projected to increase from 23,000 in 2023 to 32,000 in 2025 and 57,000 in 2030, when it would represent 64% of Hainan's total public chargers. For public AC chargers, the stock was estimated to increase from 15,000 in 2023 to 19,000 in 2025 and 32,000 in 2030.

Figure 21

Projected public charger stock by AC charger and DC charger in Hainan in 2025 and 2030

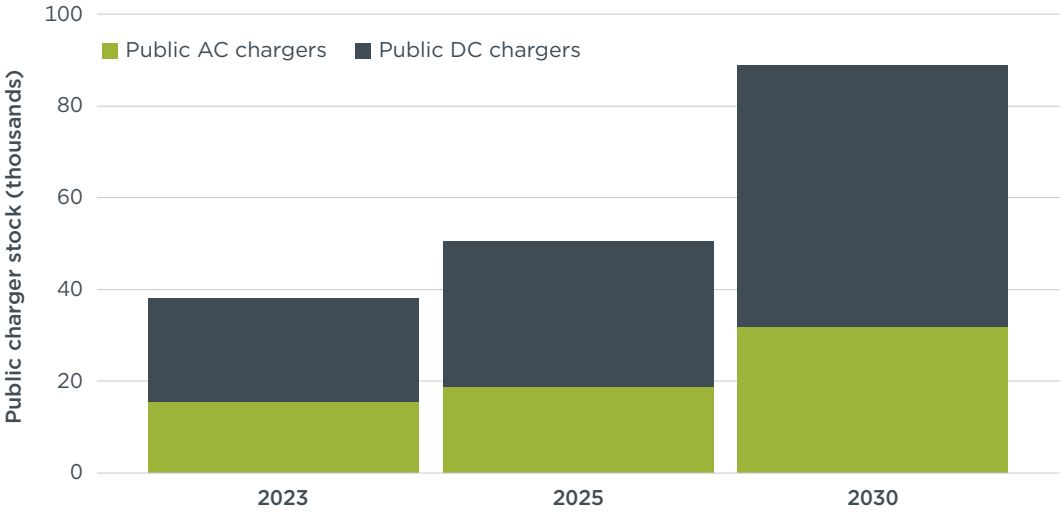

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Figure 22 shows the city-level charging infrastructure needs assessment results for 2030 and identifies the gap between the 2030 needs and 2023 stock. All cities in Hainan will need to substantially increase their EV charger stock to accommodate the province's vehicle electrification targets. The largest gaps between projected needs and the status quo were in Haikou and Sanya, which would need to add 407,000 and 107,000 chargers, respectively, to their existing charging infrastructure networks by 2030. This represents a 794% increase in Haikou and 773% increase in Sanya from 2023 levels.

Figure 22

Projected charger stock in Hainan in 2030 by city and gaps with 2023 stock

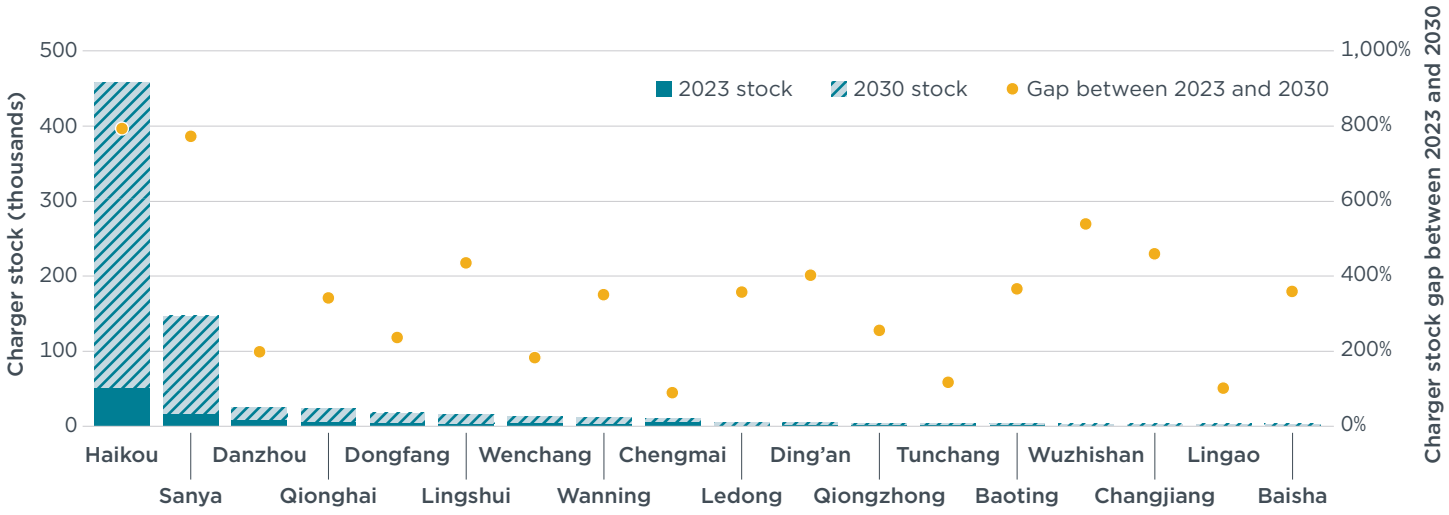

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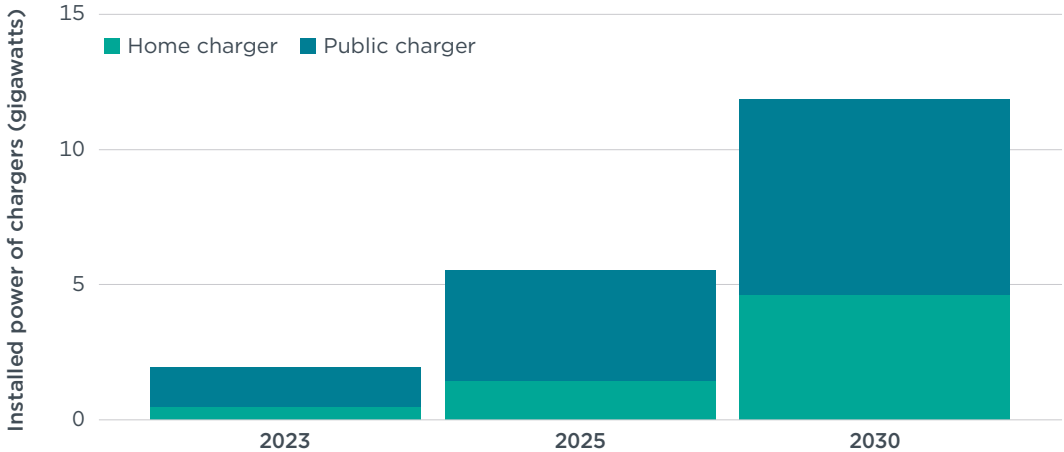
Figure 23 shows the estimated installed power of EV chargers in Hainan in 2025 and 2030, broken down by home charger and public charger. The total installed power of EV chargers was projected to increase from 1.9 GW in 2023 to 5.5 GW in 2025 and 12 GW in 2030. These projections do not imply a need for 12 GW of additional grid capacity in Hainan in 2030, because not all chargers would be used at the rated power at the same time. Although home chargers were projected to represent the majority of Hainan's EV charger stock, their contribution to Hainan's total installed power of chargers is lower than public chargers due to their relatively lower power rating per charger. Of the 12 GW of projected installed power in 2030, home chargers were responsible for 4.6 GW. This represents 39% of all projected installed power of chargers in Hainan in 2030.

Figure 23

Projected installed power of chargers by charger type in Hainan in 2025 and 2030



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The installed power of public chargers in Hainan was projected to increase from 1.4 GW in 2023 to 4.1 GW in 2025 and 7.2 GW in 2030. Figure 24 shows the projected installed power of Hainan's public chargers in 2025 and 2030 by AC chargers and DC chargers. The installed power of public AC chargers was estimated to increase from 107 MW in 2023 to 337 MW in 2025 and 664 MW in 2030. For public DC chargers, the installed power was projected to rise from 1.3 GW in 2023 to 3.8 GW in 2025 and 6.5 GW in 2030. According to our modeling, AC and DC chargers would account for 9% and 91%, respectively, of the total installed power of public chargers in Hainan in 2030.

Figure 24

Projected installed power of public chargers by charger technology in Hainan in 2025 and 2030

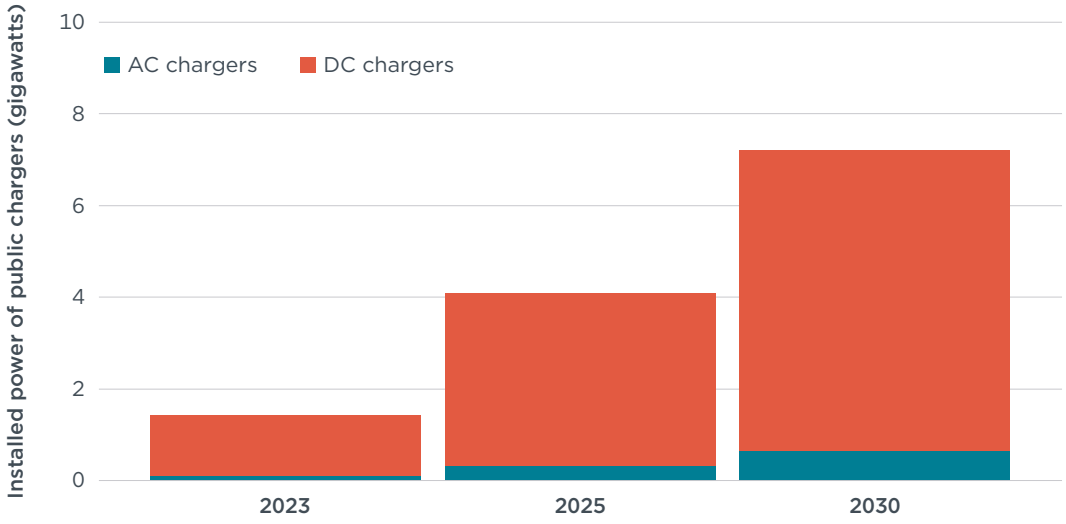

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Figure 25 presents Hainan's 2030 charging infrastructure power needs assessment results at the city level in comparison with the 2023 stock. For all cities in Hainan, there was a large gap between the projected power needs in 2030 and the power installed as of 2023. Haikou and Sanya had the largest gap, and would need to install chargers with a total rated power of 6.5 GW and 1.8 GW, respectively, by 2030. This implies an increase in installed power from 2023 levels of 791% in Haikou and 483% in Sanya.

Figure 25

Projected installed power of chargers in Hainan in 2030 by city and gaps with 2023

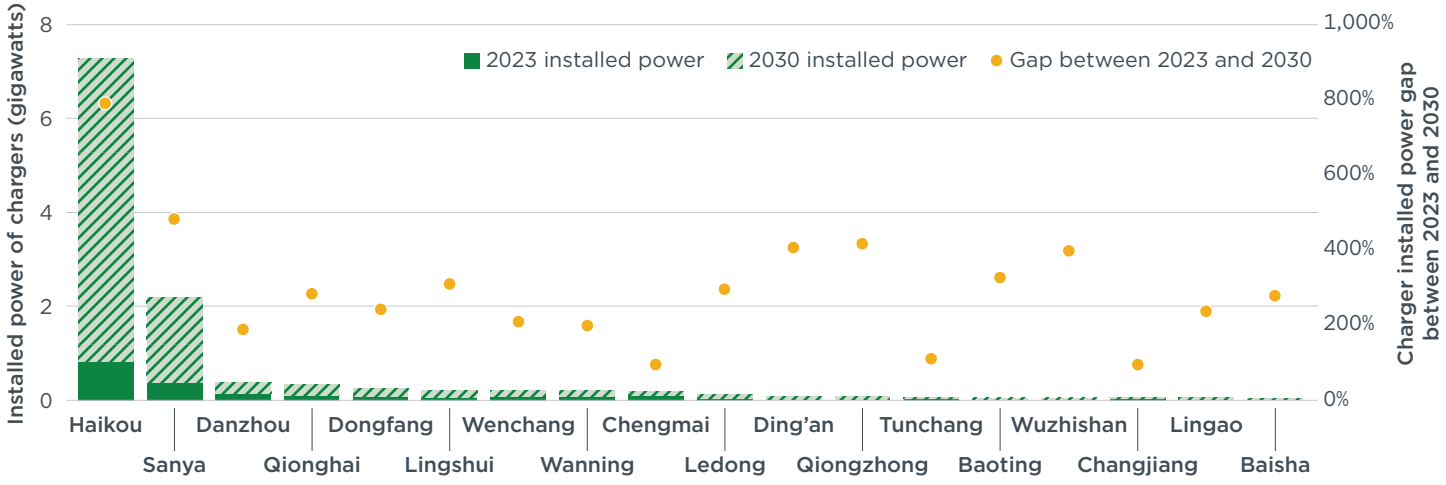

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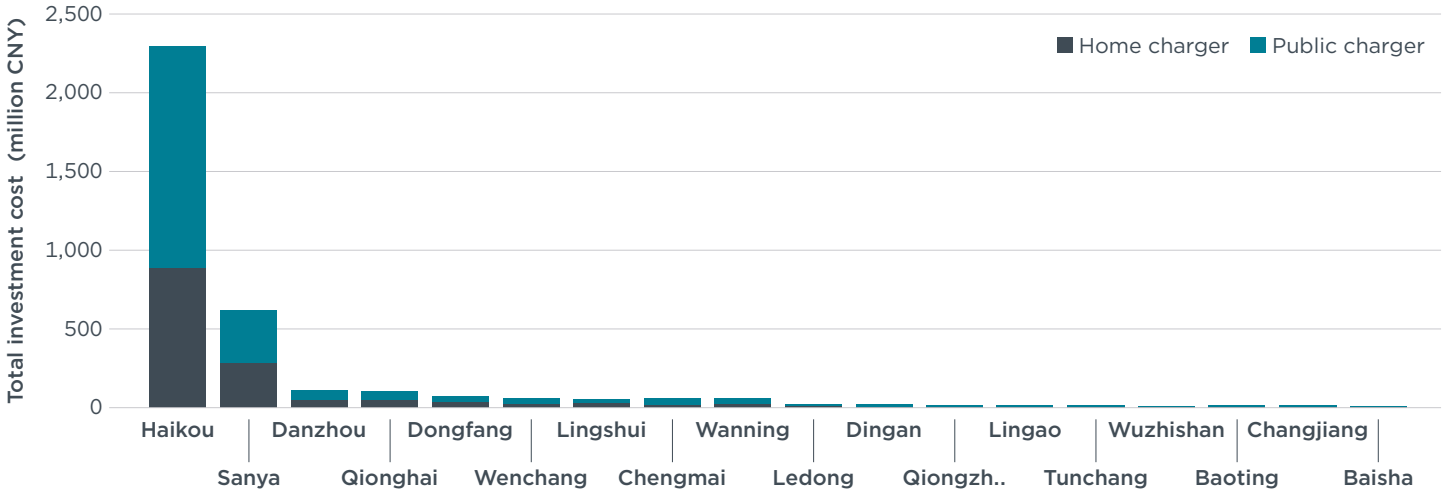
Figure 26 presents the total estimated investment required to meet the projected EV charger needs in each city in 2030, broken down by cost for home chargers and public chargers. This analysis focuses on the upfront costs of chargers and does not consider operation costs. In total, Hainan would need to invest an estimated ¥3.6 billion in EV charging infrastructure development by 2030, including ¥1.6 billion for home chargers and ¥2.1 billion for public chargers. At the city level, the largest investment needed was in Haikou (¥2.3 billion), followed by Sanya (¥619 million). If we only consider public chargers, by 2030, Haikou and Sanya would need to invest ¥1.4 billion and ¥334 million, respectively, potentially drawing on a combination of public and private funding.

Figure 26
Projected total investment cost of chargers by charger type in Hainan in 2030



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We also project the number of chargers needed under three alternative charging scenarios, defined in Table 4. Compared with the central scenario discussed above, the Low Home Charging scenario, Low Workplace Charging scenario, and High Utilization Rate scenario examine the impacts of home charging access, workplace charging access, and utilization rate on the modeling results. The scenario analysis results reveal that high home and workplace charging access is essential to reducing the number of non-workplace public chargers needed in Hainan and thus mitigating the challenge that limited land availability for non-workplace public chargers may pose to expanding Hainan's charging network. When home charging access was assumed to remain at 2023 levels (30%), 17% more non-workplace public chargers were needed in 2030 compared with the central scenario. Similarly, low workplace charging access was projected to result in a 3% increase in the number of non-workplace public chargers needed in 2030. By contrast, assuming Hainan could further increase its average utilization rate from 15% under the central scenario to 20%, non-workplace charger needs in 2030 were estimated to be reduced by 16%.

Table 4

Projected charger needs under different charging scenarios

Scenario	Changes from central scenario	Charger stock in 2030 (thousands)				
		All chargers	Home chargers	Public chargers	Workplace chargers	Non-workplace public chargers
Central scenario	N/A	750	662	81	23	58
		Changes from central scenario				
Low Home Charging scenario	Home charging access in 2030 is 30% instead of 50%.	-34%	-40%	+18%	+20%	+17%
Low Workplace Charging scenario	Workplace charging access in 2030 is 30% instead of 50%.	-1%	0	-10%	-40%	+3%
High Utilization Rate scenario	Average utilization rate of pubic chargers in 2030 is 20% instead of 15%.	-3.5%	0	-19%	-25%	-16%

CONCLUSIONS

This study assessed the deployment of EVs and EV charging infrastructure in Hainan and projected the charging infrastructure needed to accommodate the province's ambitious vehicle electrification targets for 2030. The results of this analysis support the following conclusions.

Hainan stands out as a leader in the transition to EVs in China. By the end of 2023, Hainan's EV stock reached 293,000, almost nine times higher than in 2019. This represented 15% of the province's total vehicle stock, more than twice the national average that year and second only to Shanghai among all provincial-level jurisdictions in China. In 2023, around 189,000 EVs were sold in Hainan, accounting for 49% of new vehicle sales. This EV sales share was almost twice the national average and the highest among all provinces in China. Hainan is the first and only Chinese province to officially announce a full vehicle electrification target, aiming to phase out all new sales of internal combustion engine vehicles (other than heavy-duty trucks) no later than 2030.

Hainan has made solid progress in EV charging infrastructure network development. In the past 5 years, construction of Hainan's EV charging infrastructure network has progressed alongside the province's EV deployment. By the end of 2023, Hainan's charger stock reached 110,000, including 72,000 home chargers and 38,000 public chargers, up from 16,000 by the end of 2019. The total rated power of Hainan's public charging infrastructure reached 1.4 GW, leading to an average public charging power installed per EV of 4.9 kW. Haikou and Sanya, where over 80% of the province's EVs are registered, have established widely distributed public charging networks. As of 2023, EV drivers in Haikou and Sanya could reach a public charging pool with a drive time of less than 20 minutes in 67% and 35% of the city area, respectively.

Hainan's EV stock would increase rapidly under the province's ambitious vehicle electrification targets. Under the targets, Hainan's EV stock would increase from 293,000 in 2023 to 500,000 in 2025 and 1.55 million by 2030, while the EV share of the province's vehicle stock would rise from 15% in 2023 to 21% in 2025 and 45% in 2030. These EVs would be concentrated in the province's two leading cities, Haikou and Sanya, which would account for 60% and 19%, respectively, of Hainan's total EV stock in 2030. The majority of Hainan's EV stock would be private cars and light-duty trucks, which made up a projected 81% and 10%, respectively, of Hainan's total EV stock in 2030.

Charging demands are projected to increase substantially apace with Hainan's continuously expanding EV fleet. Based on the results of our charging infrastructure needs modeling exercise, Hainan's EV charger stock would need to increase from 110,000 in 2023 to 256,000 in 2025 and 750,000 in 2030 to accommodate the targeted increase in EV deployment. The projected 750,000 chargers needed in 2030 included 662,000 home chargers and 89,000 public chargers. Haikou and Sanya were projected to have the largest gap between 2030 EV charger demands and the 2023 status quo and would need to add 407,000 and 107,000 chargers, respectively, to their existing charging infrastructure networks by 2030. This would represent an increase in the EV charger stock of 794% in Haikou and 773% in Sanya from 2023 levels.

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APPENDIX

Table A1

Projected needs for home and public chargers in Hainan by city in 2025 and 2030

City	Projected charger stock in 2025			Projected charger stock in 2030		
	Home chargers	Public chargers	All chargers	Home chargers	Public chargers	All chargers
Haikou	125,476	30,920	156,396	401,806	56,130	457,936
Sanya	42,431	9,389	51,820	131,695	15,769	147,464
Danzhou	6,425	1,665	8,090	21,330	2,720	24,050
Qionghai	6,430	1,379	7,809	21,327	2,348	23,675
Dongfang	4,865	1,004	5,869	16,203	1,626	17,829
Lingshui	4,271	895	5,166	13,912	1,374	15,286
Wenchang	3,472	863	4,335	11,598	1,457	13,055
Wanning	2,913	899	3,812	9,487	1,581	11,068
Chengmai	2,361	793	3,154	8,288	1,419	9,707
Ledong	1,185	498	1,683	4,172	788	4,960
Ding'an	1,002	363	1,365	3,470	617	4,087
Qiongzhong	974	371	1,345	3,431	572	4,003
Tunchang	799	271	1,070	2,807	456	3,263
Baoting	809	227	1,036	2,823	367	3,190
Wuzhishan	729	264	993	2,524	404	2,928
Changjiang	689	255	944	2,342	433	2,775
Lingao	629	284	913	2,167	513	2,680
Baisha	658	170	828	2,296	276	2,572
Hainan province total	**206,118**	**50,510**	**256,628**	**661,678**	**88,850**	**750,528**

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