WHITE PAPER

NOVEMBER 2021

CHARGING INFRASTRUCTURE TO SUPPORT THE ELECTRIC MOBILITY TRANSITION IN FRANCE

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ACKNOWLEDGMENTS

This study was funded through the generous support of the Children's Investment Fund Foundation. The authors thank Mike Nicholas for his input on analytical steps for calculating vehicle stock turnover, energy allocation, and charger utilization modeling. We especially thank officials from the Ministry of the Ecological Transition and the Ministry of Transport for providing important context and input to help us refine elements of the scope and research questions. We are grateful to Mike Nicholas and Sandra Wappelhorst of the ICCT and Lucien Mathieu from Transport & Environment for their critical reviews of, and constructive inputs to, earlier versions of this report. These reviews and inputs do not imply an endorsement, and any errors are the authors' own.

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EXECUTIVE SUMMARY

This report investigates the amount, type, and distribution of charging infrastructure that will be needed to support the transition of the electric passenger car, taxi, private hire vehicle, and light commercial vehicle fleets through 2035 to put France on a path toward achieving 100% fully electric vehicle sales by 2040. The number of chargers is estimated at the level of French departments, for six charging settings: home, workplace, depot, public normal, fast urban, and fast highway chargers.

The resulting estimates for public normal and fast charging needed in France are shown in Figure ES1. The maps show the normal charging (left) and fast charging (right) in place through 2020, as compared to the levels needed in 2030 to support the projected growth in electric vehicles. Powering 8.5 million battery electric and plug-in hybrid vehicles in 2030 will require 350,000 public chargers, implying an annual growth rate of 28% from 2020. Overall, 8.6% and 12.7% of France's 2030 normal and fast (respectively) public charging needs were in place by 2020. Results varied greatly across France, with regions having between 1% and 25% of their 2030 overall public charging needs met through 2020.

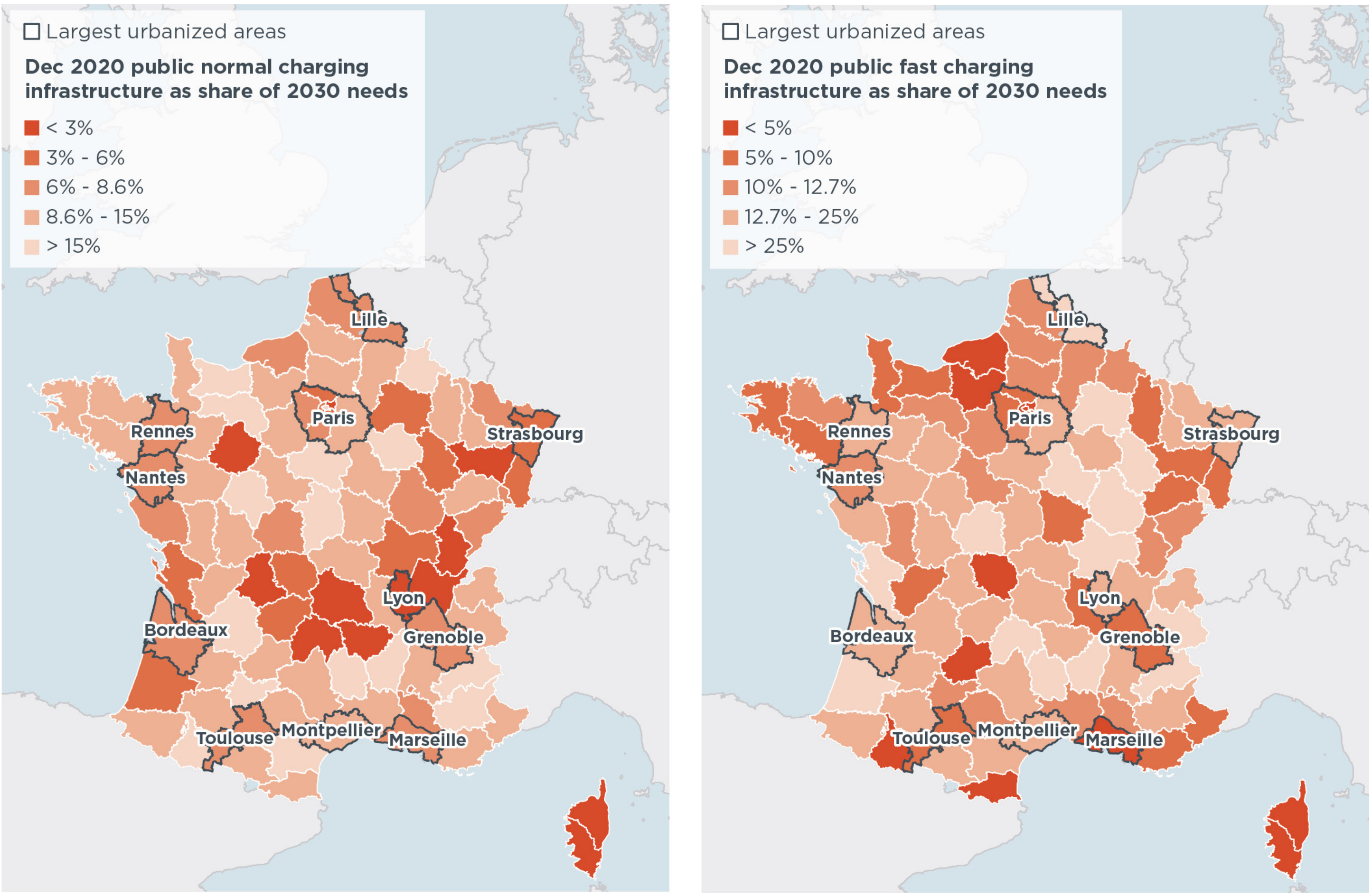

Figure ES1. Percentage of public normal (left) and fast (right) 2030 charging needs in place through 2020.

The results of the analysis lead to four high-level findings:

The growing French electric vehicle market requires a greatly expanded charging infrastructure network. To support growth from 470,000 electric vehicles in 2020 to approximately 8.5 million on French roads in 2030 (including 1.1 million electric light commercial vehicles), public chargers will need to grow from 31,000 to about 350,000. Including public and private infrastructure, 5.7 to 6.0 million chargers are needed by 2030, 15% to 19% less than France's original 2015 goal of 7 million chargers by 2030. However, in an alternative scenario in which full electrification of new sales is reached in 2035, France would need a total of 7.3 million chargers, including 430,000 public chargers, in 2030. Accomplishing the French government's goal of 7 million chargers could thus put the country close to a path towards full electrification of new sales by 2035, 5 years ahead of the current target. Improving home charging access will be key to managing public charging needs, and greater public charger utilization and improved business cases can be expected in the future.

Urban areas, which tend to lead in electric vehicle uptake, show the largest increase in charging needs, but major infrastructure support is also needed across France's rural areas. Denser, affluent urban areas like Paris and Marseille had the highest electric vehicle uptake through 2020. Such urban areas show the greatest need for expanded public charging infrastructure by 2030, in part due to lower home charging availability in their denser urban cores. For France to decarbonize its transport sector and realize electric vehicles' benefits equitably, electric vehicle uptake and overall charging infrastructure will need to increase more quickly in less affluent and more rural areas.

Projected growth in energy demand for electric vehicles is manageable. To support electric vehicle growth, the annual demand for charging energy will grow from 1.0 terawatt-hours (TWh) in 2020 to 16 TWh in 2030, amounting to an average annual increase of 32%. The projected 2035 EV electricity demand amounts to just 7% of France's overall 2020 electricity demand from all sectors, 439 TWh. Electric vehicles' energy demand would be offset, up to 2026, by the annual 7 TWh of electricity savings spurred by the Energy and Climate Law. Any grid impacts from electric vehicles' energy demand are within the scope of utilities' capacity to manage with general grid upgrades.

A new coordinated charging infrastructure framework could galvanize investments. While providing basic charging coverage has been important in building confidence during the early market, further targeted charger implementation is needed to spur charging investments and meet drivers' needs. Based on developments in France and elsewhere, a promising approach would be to implement a coordinated charging installation process based on identified charging demand, clear guidance to ensure equitable access, and streamlined permitting. Doing so could inform, coordinate, and catalyze investments across different stakeholders to enable France's electric mobility transition.

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INTRODUCTION

In December 2019, the French government set 2040 as the target year for ending sales of new fossil fuel-powered passenger car and light commercial vehicles. The Mayor of Paris has set the more ambitious goal of phasing out fossil-fuel powered cars as soon as 2030 (Avere France, 2017). The French president reiterated his government's commitment to electric vehicles (EVs, including battery and plug-in hybrid electric models) through its green recovery plan (Ministry of Economic Affairs and Finance, 2020), a response to the economic impact of the 2020 COVID-19 pandemic. Policies under this plan include electric vehicle purchase subsidies, scrappage schemes, a requirement that the share of electric vehicles in public fleets increase steadily, and targets for expanding charging infrastructure. The French president has also set a target of 1 million battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) to be produced in France by 2025, and one million to be on the roads (600,000 BEVs and 400,000 PHEVs) by 2022 (Ministry of Economic Affairs and Finance, 2020).

As outlined in France's green recovery plan, a reliable and dense charging infrastructure network is key to achieving widespread adoption of electric vehicles. The plan includes a deployment target of 100,000 public chargers by 2021. (France had previously set a 7 million private and public chargers target by 2030.) While most charging among early adopters happens at home or at the workplace, the development of a public charging infrastructure network is particularly important in dense urban areas where off-street parking is not an option for many drivers. As an example, only 27% of people living in the department of Paris have a dedicated parking spot. To reach its ambitious transport electrification goals, France will require a significant expansion of its public and private charging infrastructure network.

This working paper assesses the electric vehicle charging infrastructure required in Metropolitan France by 2035, compared to what was installed through 2020. Metropolitan France, also called European France, includes mainland France and Corsica, excluding overseas departments, and has 96 departments, which are administrative divisions of the French territory. The paper quantifies the country's charging needs consistent with a 2040 target of 100% BEV sales (the target of 0 fossil fuel powered vehicles sold after 2040 is assumed to be equivalent to 100% BEV sales). The focus is on the charging needs of passenger cars, taxis, private-hire vehicles (PHVs), and light commercial vehicles (LCVs), and the analysis incorporates vehicle purchase trends and charging behavior through 2020. The charging results are provided at the departmental level for six charging categories: private home, depot (for light commercial vehicles), private workplace, public normal (including residential and destination), public fast urban, and fast highway corridor. Equity considerations are also analyzed, incorporating departments' varying financial resources to provide further guidance for governments on future charging infrastructure needs.

MARKET CHARACTERIZATION OF VEHICLES AND CHARGING

The development of the electric passenger and light commercial vehicle market in France started relatively slowly in the 2010's but received a significant boost in 2020 as shown in Figure 1 below. Throughout the report, we analyze electric vehicles (EVs), including both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), as each impacts our charging infrastructure modeling differently. This figure displays the passenger (including taxis and PHVs) and light commercial EV stock in light blue for BEVs and dark blue for PHEVs (left axis) and the combined share of passenger EV sales in red (right axis) from 2012 to 2020. The plain bars correspond to electric passenger cars and the hashed ones to light commercial EVs. Based on electric vehicle sales through 2020, there were approximately 330,000 BEVs and 140,000 PHEVs in France in December 2020.

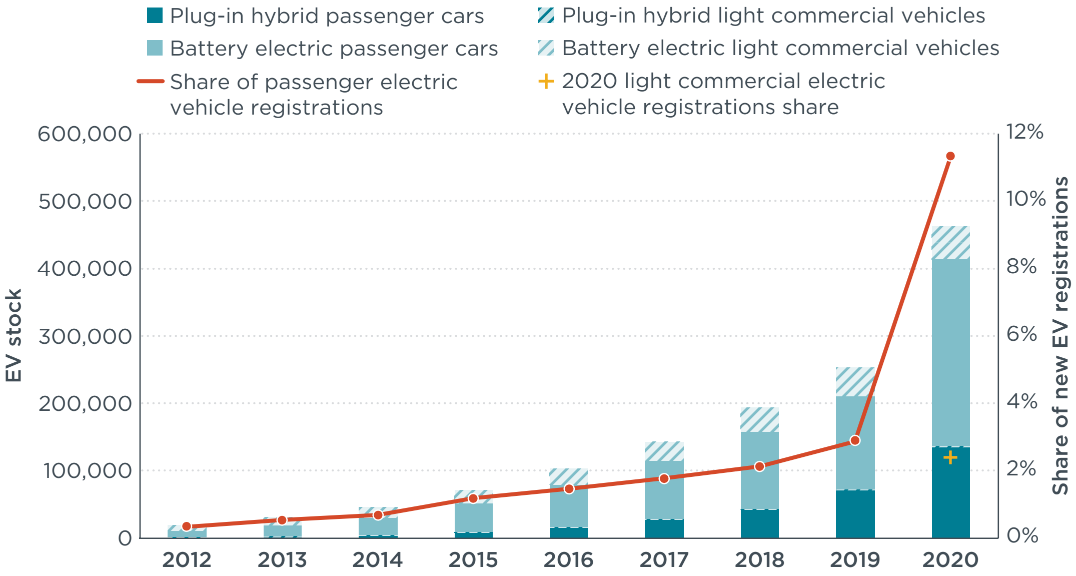

Figure 1. Passenger electric vehicle uptake in France between 2012 and 2020.

Figure 1 shows an unprecedented growth in new passenger electric vehicle registrations' share (red line) in 2020, a period of major disruption in the overall vehicle market due to COVID-19. New registrations are considered a proxy for new car sales. Overall growth was largely fueled by manufacturers increasing their electric vehicle volume and model availability across markets to comply with stringent European Union CO_2 standards initially set in 2009, reviewed in 2014, and reinforced in 2019.

In 2020, passenger EVs accounted for 11.3% of new passenger vehicle sales (including taxis and PHVs but excluding light commercial vehicles, LCVs), a 180% growth compared to 2019. Light commercial EVs constituted a lower sales share, 2.4%. Together, passenger and light commercial electric vehicle sales amounted to slightly less than 10% of all new sales in 2020. On the other hand, EVs represent only slightly more than 1% of the total light-duty passenger vehicle stock with about 470,000 EVs on the roads as of December 31st, 2020.

This electric vehicle stock was supported by about 31,000 public chargers at the end of 2020. The 31,000 public chargers include 90% normal chargers that typically have a power rating between 3 and 22 kilowatts (kW) from alternating current (AC) and 10% fast chargers, defined as 43 kW or greater (Avere-France, 2021). Fast chargers can be AC but are more typically direct current (DC).

Figure 2 shows passenger EV uptake across the 96 departments of Metropolitan France (Rajon Bernard & Hall, 2021). The maps depict passenger electric vehicle market development by department, showing the 2020 electric vehicle sales share and the per-capita deployment of the approximately 410,000 passenger EVs and 31,000 public chargers located across France as of the end of 2020. The map on the left displays the share of 2020 EV sales and the one on the right the number of EVs (in red shades) and chargers (in blue circles) per million population. The 11 largest urbanized areas—urbanized areas of more than 700,000 inhabitants (as defined by the Insee)—are labeled and outlined in black (Insee, 2020). Every large urbanized area is composed of one department except Paris which encompasses the entire île-de-France region composed of 2 sub-areas: Metropole du Grand Paris (comprising 4 departments including Paris) and the rest of the region (comprising the remaining 4 departments). The left map is based on new passenger EV registrations which is considered nearly synonymous with new passenger EV sales.

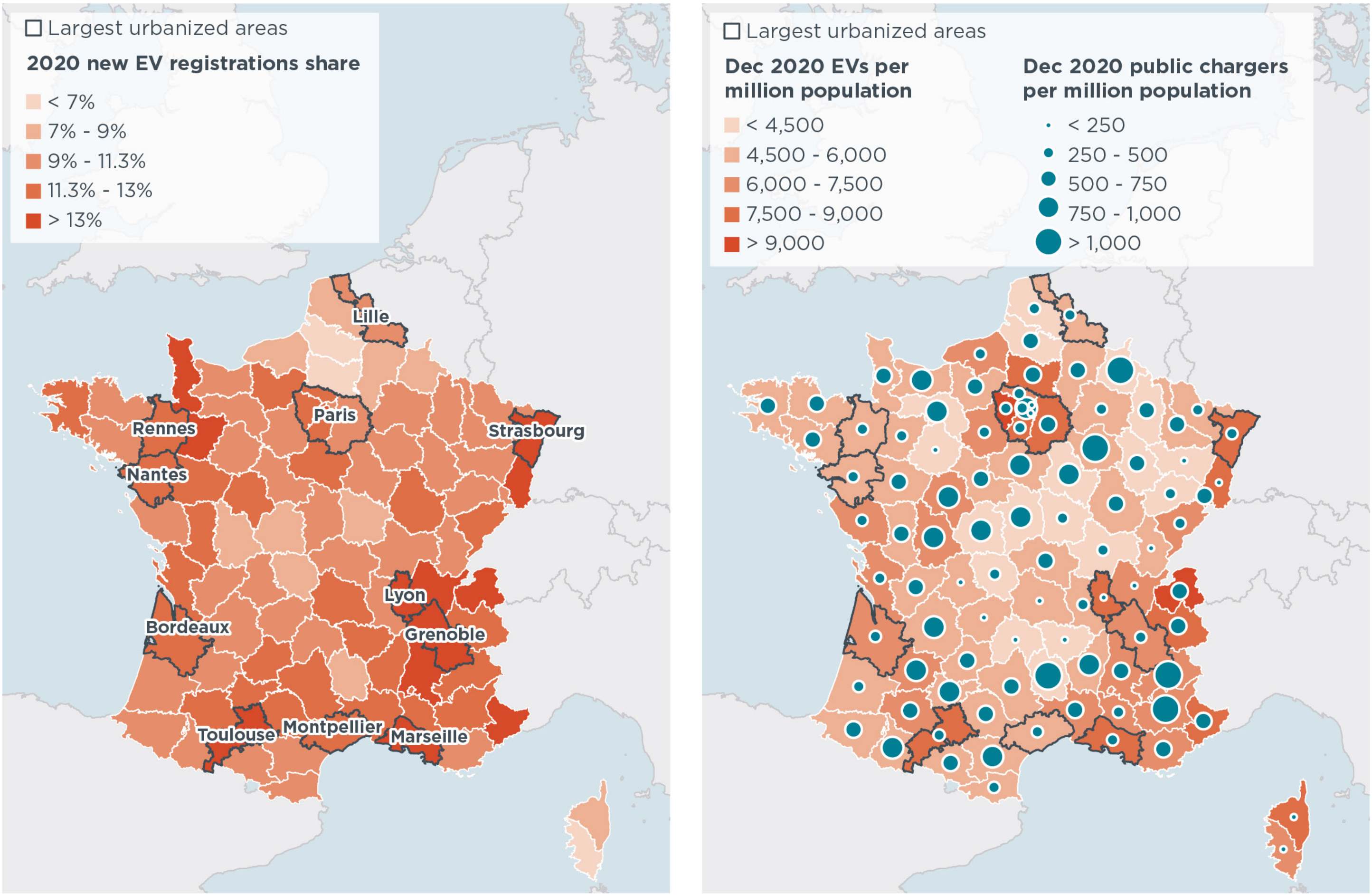

Figure 2. Electric vehicle share of new passenger cars in 2020 (left) and electric passenger car stock per million inhabitants overlaid with the number of public chargers per million population (right).

The left map of Figure 2 shows that the highest rates of electric vehicle uptake are found in large urban areas. The two highest 2020 EV adoption rates were in Paris' department and Bouches-du-Rhône (Marseille) with 18.2% and 16.5% respectively. In contrast, areas like Somme and Oise had 4.6% and 5.2% passenger electric shares, respectively. Again, these figures compare to a national average of 11.3% passenger EV sales share in 2020 for France as a whole.

On the right map of Figure 2, we see that areas with a high number of EVs per million population (dark red shade) tend to have relatively few public chargers per million population (small blue circles). For example, Île-de-France (Paris region) and Marseille have approximately 410 and 350 public chargers per million population while less dense areas like Lozère and Hautes-Alpes have 1,200 and 1,460 public chargers per million population. These compare with the national average of 480 public chargers per million population. Even though the number of total chargers—public and private—is highest in areas with high EV uptake, these areas still have a low number of public chargers per million population which suggests both a more efficient use of public chargers and a need for more chargers. In terms of the absolute number of public chargers (both AC normal and fast), the department with the highest number is Paris with more than 1,900.

VEHICLE CHARGING INFRASTRUCTURE SCENARIOS

This analysis calculates the amount of charging infrastructure required to support a level of electric vehicle adoption through 2035 that will put France on a path to all electric vehicle sales by 2040. This section provides the key modeling steps and data inputs to identify how many and what type of chargers will be needed in each of the 96 Metropolitan departments of France through 2035. Overseas departments were not included in the analysis due to a lack of data. The modeling incorporates charging trends and data through 2020 and accounts for expected changes in vehicle range, home charging availability, charging speed, share of BEVs and PHEVs among EVs, and kilometers traveled. The estimates for private home, depot, workplace, public AC normal, fast urban, and fast highway charging requirements for each department are based on characteristics such as population density, number of driving commuters, access to workplace charging, accessibility of dedicated parking spots, and housing type. The charging needs are analyzed across the vehicle types of passenger car, taxi, private hire vehicle (collectively known as passenger vehicles), and light commercial vehicles.

OVERVIEW OF METHODOLOGY

The methodology used to assess charging needs in Metropolitan France through 2035 is similar to the one employed in a recent study focused on Spain, which is developed in more detail in this paper (Nicholas & Wappelhorst, 2021). An overview of the modeling approach is provided in Figure 3 below. The blue rectangles represent the model steps and begin at the top left. The yellow trapezoids indicate the data inputs and assumptions between the model steps, while the grey ovals explain what occurs at each step in a more readable form. The top left rectangle shows that the model starts with a projection of vehicle sales, which, in turn, allows the stock of vehicles to be tracked over time. The next step allocates this stock to drivers' groups depending on the type of car (BEV vs. PHEV), home charging availability, and commuting status (car commuter vs. non-car commuter). After this, the daily energy required is forecasted for each charging group. Finally, this electricity demand is calculated for each charging setting and translated into the number of chargers required based on estimated daily utilization.

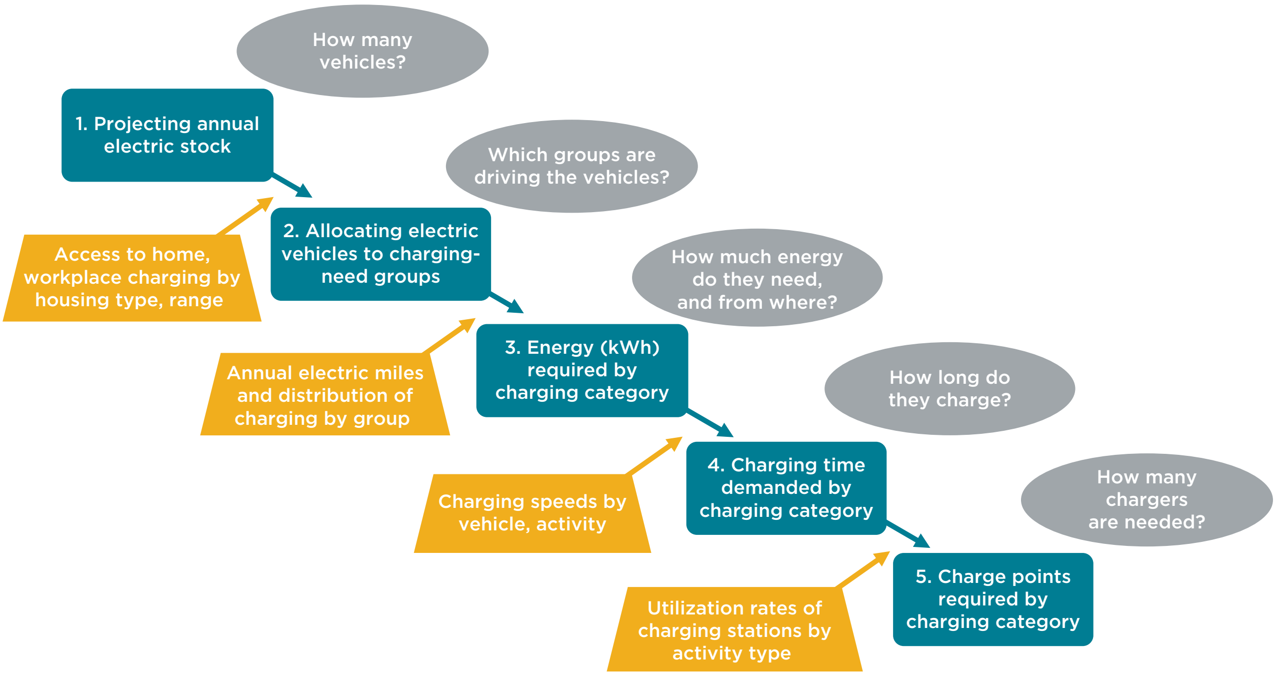

Figure 3. Key modeling steps to assess charging needs based on electric vehicle uptake.

All results in this paper are presented according to charging categories: private home, depot (for light commercial vehicles), private workplace, public AC normal, public fast urban, and public fast highway charging. The home category refers to private chargers in a home or apartment complex. Work and public charging are often interchangeable. We assume that a third of workplace chargers are public AC normal and the remaining ones are private.

The yellow trapezoids of Figure 3 represent data inputs, which are drawn from many sources and other analytical research. The main sources for these data areas, and the variables that depend on the data, are shown in Table 1 below.

Table 1. Main data sources for key variables.

Data area	Variable	Source
Population	Population by department and municipality	Insee, 2017
Housing	Number of houses and apartments in the department and accessibility to a dedicated parking spot	Insee, 2017
Passenger car, taxi, PHV, and LCV sales and stock	Registrations of new and stock of electric vehicles, including battery electric vehicle (BEVs) and plug-in hybrid electric vehicles (PHEVs).	SDES 2019; SDES 2020 January 30; SDES 2020 October 12
Existing charging infrastructure	Counts of AC normal and fast chargers per department	Eco-movement, 2021
Charging behavior	Observed share of charging at different settings and public chargers' usage	Nicholas & Wappelhorst, 2021; Enedis, 2021; Avere/Ipsos 2020
Annual kilometers driven	Based on the share of the population living in the 5 different urban areas and the commuting status	Insee, 2020
Vehicle information	Battery energy, charging acceptance rate	Based on most common BEVs and PHEVs model in France; Nicholas & Wappelhorst, 2021

PROJECTING ANNUAL ELECTRIC STOCK

The first modeling step is to forecast electric vehicle sales as a percentage of annual passenger car sales. This modeling is in line with the target to achieve 100% zero-emission vehicle sales in 2040, as defined by the French government in its December 2019 "Loi orientation des Mobilités" (Mobility guidance law). The 100% BEV sales and stock target is reached earlier than 2040 in Île-de-France to account for the "Metropole du grand Paris" phase-out of internal combustion engines from its roads in 2030 and in 2035 for the entire Île-de-France department. Figure 4 shows the year-by-year passenger electric vehicle stock estimates on the left axis (in light blue for BEVs and dark blue for PHEVs) and the share of new EV sales (in red) and of EV stock (in green) on the right axis. The purple cross shows the government's 2022 goal of 1 million EVs on the road.

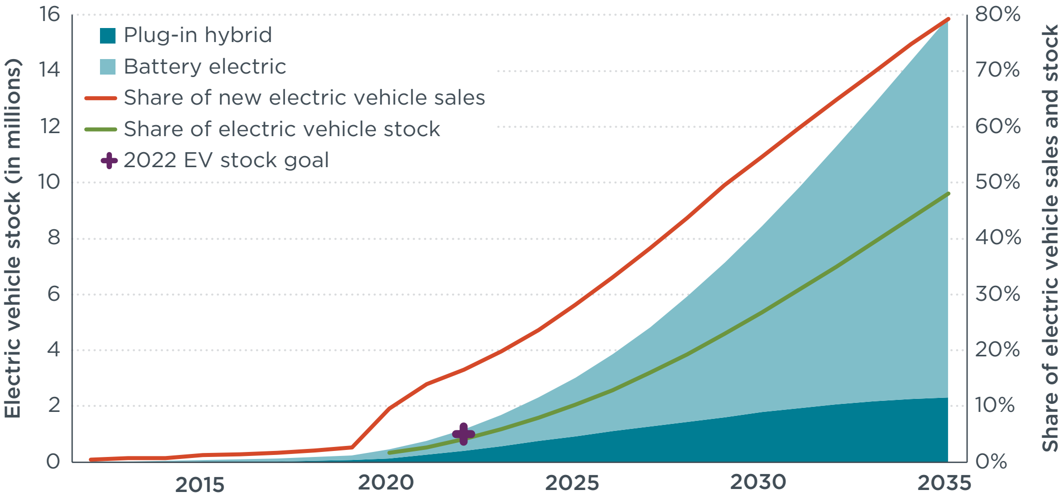

Figure 4. Electric vehicle stock in millions (left axis) and new sales share and electric share of stock (right axis), 2012–2035.

Figure 4 shows the growth in new electric vehicle sales share (red line) in 2020, followed by projections to put the market on a path toward France's national goal of 100% BEV sales by 2040. From 2019 to 2020, although overall vehicle sales fell by more than 20%, electric passenger cars grew by 180%, such that the electric passenger car share reached 11% of new passenger car vehicle sales in 2020. This growth was largely spurred by manufacturers' deployment of more EV models, to comply with stringent European Union CO_2 standards.

The national trajectory for the new passenger electric vehicle share follows an S-shaped curve starting at 11% of new passenger EV sales in 2020; it is projected to reach 31% in 2025, 56% in 2030, and 79% in 2035. Concerning light commercial EVs, we model a slight lag in the near-term compared to passenger vehicles based on data through 2020, resulting in 17% EV sales in 2025, and 48% in 2030. To incorporate a growing market preference for BEVs over PHEVs, the national BEV share is projected to increase from 60% of EVs in 2020 to 75% in 2025, 86% in 2030, and 92% in 2035 for passenger cars. Values for various departments are adjusted according to having lower or higher initial EV shares in 2020, and stronger targets. To take two examples, based on these targets, assumptions, and market developments through 2020, we expect EV sales share to reach 20% in 2025 and 43% in 2030 in Lille department (Nord, 59) and 44% in 2025 and 86% in 2030 for Val d'Oise (95) in Île-de-France.

New car registrations per year dropped in 2020 due to the global pandemic. The study assumes that registrations will rebound to 2019 levels by 2023 and then remain constant for rural areas and decrease slightly in dense urban areas through 2035 for passenger cars, based on data for Île-de-France and due to a general desire to encourage alternative transportation modes across France (Apur, 2019). While light commercial vehicle (as opposed to passenger car) sales also rebound to 2019 levels by 2023, they increase by 2% per year until 2028 to take into account both recent trends and increased urban freight delivery from e-commerce in the years to come (SDES, 2020). Finally, to reflect the redistribution of vehicles after the conclusion of a lease and to account for used vehicle sales, conventional and electric passenger vehicle registrations per capita were compared to passenger vehicle stock per capita and redistributed proportionally after a period of three years (the normal duration of a lease). Cases of areas with more registrations than vehicle stock suggest that vehicles were redistributed to areas that had lower sales compared to stock.

The methodology outlined above is applied for passenger cars and light commercial vehicles. A different methodology is used for taxis and PHVs. These two categories have had different market developments up to 2020 and their definitions differ slightly. Unlike taxis, which can be both hailed and pre-booked, private hire drivers are only allowed to pick up pre-arranged bookings made via mobile apps or websites. The stock of these taxis and PHVs fleets follows an S-shaped curve reaching 100% BEVs in 2030 aligning with operators' commitments, local governments' objectives, and higher vehicle turnover rate. Finally, these fleets are assumed to grow by 1% and 3% per year, respectively, and by 6.5% for the Île-de-France PHV fleet until 2025, and then remain constant. These growth rates are based on market development up to 2020 (SDES, 2020).

ALLOCATING ELECTRIC VEHICLES TO CHARGING NEED GROUPS

The second modeling step is the allocation of the electric vehicle stock into groups based on charging needs, each with distinct charging behavior. For private passenger cars, three factors are taken into consideration: vehicle type (BEV or PHEV), commuting status, and home charging access. Vehicle type influences the number of electric kilometers driven per day, the efficiency of the car (kilometers per kilowatt-hour [kWh]), and typical charging power for AC normal and fast chargers (power in kilowatt [kW]). Commuting status is important for determining the number of kilometers driven and the accessibility to workplace chargers. Home charging access influences the magnitude of workplace and public charging needed. Taken together, these variables result in 8 charging needs groups.

The Enedis and Avere/Ipsos surveys mentioned earlier are used to estimate national home charging availability in 2020. The variation among departments in 2020 is based on the housing stock (apartments vs. houses). Data from the Insee—obtained through the 2017 country-wide census (Insee, 2017)—on dedicated parking spot availability is used to assess home charging availability in 2035 for every department. Based on the Avere/Ipsos survey, it is assumed that 82% of EV owners with a dedicated parking spot have access to overnight home charging.

The map below displays the estimated 2020 (left) and the forecasted 2030 (right) home charging availability of EV owners for every department. Some 76% of all EV owners nationally were estimated to have access to home charging in 2020; this share is projected to decrease to 60% by 2035. The decreased home charging availability through 2035 is based on the shift from early EV adopters (who generally have dedicated private parking) to mainstream purchasers whose acces to a dedicated parking spot eventually approaches the (lower) national average.

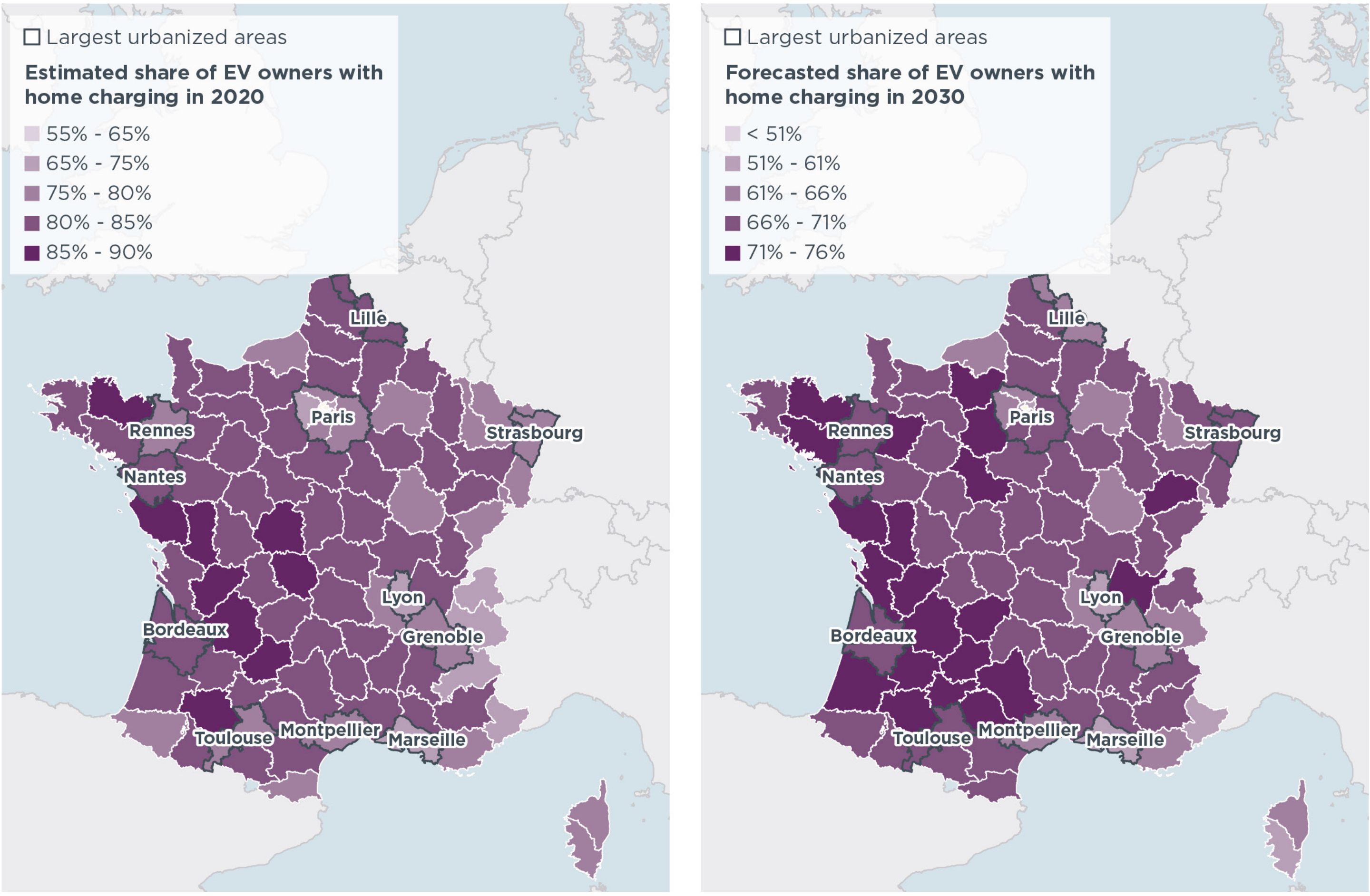

Figure 5. Estimated home charging availability of EV owners in 2020 (left) and 2030 (right).

Many of the largest urbanized areas are projected to have a lower level of home charging availability than the national average through 2035. When comparing the two maps, we can see that the estimated share of EV owners with home charging is considerably higher in 2020. The relative differences in home charging availability are maintained in future years. To take two examples from the figure, home access in the Lyon area (Rhône, 69) is assumed to decrease from 70% in 2020 to 59% in 2030, while in Vendée (85) it decreases from 86% to 76% in the same period. In this analysis, we model a linear decrease in home charging availability between 2020 and 2035.

The assumption for home charging is handled differently for the other vehicle types. We assume that, depending on kilometers driven per day, between 75% and 90% of professional light commercial vehicle energy comes from overnight charging at a business depot center. This is further detailed in Table A2 in the Appendix. As for taxis and PHVs, only a third of drivers has access to home charging (Migette J.C., Petcu M., Delahaie H., Debbah F, 2019).

ENERGY REQUIRED BY CHARGING CATEGORY

For the third modelling step, the total energy required for each driver group is calculated and allocated to the different charging locations: private home, private depot, workplace, public AC normal, and fast chargers. Assumptions related to the energy needs of each driver group are outlined in Table 2 for passenger cars, including inputs for BEV and PHEV drivers, and whether they commute with their EVs. Commuting vehicles are assumed to have traveled 43 km in 2020, compared to 26 km for non-commuting EVs. The table provides the inputs that further clarify the breakdown of that driving based on the charging location, as well as how each vehicle group changes over 2020-2035. Table A2 and Table A3 in the Appendix provide similar information and assumptions related to light commercial vehicles, and taxis and PHVs. The three first columns display the charging group, the next four the share of energy drawn from each location, then information related to electric vehicle kilometer travel (VKT), and finally the share of vehicles at the national level that belong to each category in 2020, 2030, and 2035.

Table 2. Allocation of energy needs per driver category for private passenger cars.

Vehicle	Commuting	Home charging	Home	Work	Public Normal	Public Fast	Vehicle kilometers traveled (VKT) per day in 2020	Share of electric VKT	Share of vehicle stock in 2020	Share of vehicle stock in 2030	Share of vehicle stock in 2035
BEV	Commuter	Yes	75%	15%	5%	5%	43	100%	30%	28%	29%
		No	0%	55%	20%	25%		100%	8.4%	14%	18%
	Non-Commuter	Yes	85%	0%	5%	10%	26	100%	21%	22%	22%
		No	0%	0%	45%	55%		100%	7.3%	14%	16%
PHEV	Commuter	Yes	75%	20%	5%	0%	43	70%	14%	8.5%	5.4%
		No	0%	65%	35%	0%		40%	4.0%	4.1%	3.3%
	Non-Commuter	Yes	90%	0%	10%	0%	26	50%	11%	6.1%	3.8%
		No	0%	0%	100%	0%		10%	3.9%	3.2%	2.5%

*BEV= battery electric vehicle, PHEV= plug-in hybrid electric vehicle, VKT= vehicle kilometers traveled

The energy need allocation for each driver group is based on similar studies (Nicholas & Wappelhorst, 2021) and the average daily kilometers traveled come from the previously mentioned Enedis EV driver survey. Furthermore, it is assumed that 5% of the VKT is powered by fast highway charging mainly used for long-distance trips. The daily distance traveled varies between and within departments and is based on the 6 different types of areas defined by the Insee—from rural areas to the urban dense Paris area (Insee, 2020). These areas are called "areas of attraction of a city" and are defined as the area of influence of a city on the surrounding ones. This daily VKT also decreases over time, ranging from 0% per year in rural areas to 1.3% in other areas (Hubert J.P., Pistre P., & Madre J.L., 2016). Finally, it is assumed that non-car commuters travel on average 60% of commuters' kilometers based on the 2020 National survey on mobility, which found that on average, 43% of kilometers traveled are related to work (Forum vies mobiles, 2020).

Energy demand is determined based on electric kilometers driven and vehicle efficiency. Passenger BEVs and PHEVs in 2020 have efficiencies of 0.16 and 0.23 kilowatt-hours per kilometer (kWh/km), respectively, and light commercial BEVs and PHEVs have efficiencies of 0.21 and 0.27 kWh/km, respectively. This is based on a weighted average of the most common BEV and PHEV models on French roads for passenger cars and light commercial vehicles, respectively. As technology improves, we estimate that per-km energy needed for each vehicle category declines by roughly 5% through 2030.

The eight groups above are meant to represent averages, although each group is heterogeneous, with greatly varying individual-level vehicle specifications, driving patterns, and charging behavior. For example, not every commuter has access to workplace charging, and not every driver with home charging plugs in at home. Furthermore, some PHEV drivers have access to charging at home or work, but never plug in, preferring instead to drive nearly exclusively using fuel.

Several additional assumptions are made to model the annual driving and energy demand of light commercial vans, taxis, and PHVs. Light commercial vans drive between 28km and 123km per day depending on their use type (personal, professional for goods' transport, professional for services, and other professional uses) and their VKT remains constant through 2035 (El Fadili S., Huitric C., & Moitry J., 2018). The four use types influence not only the daily VKT but also the proportion of energy derived in each charging setting (home, depot, public AC normal, public fast urban, and public fast highway). Finally, taxis and PHVs drive 143km per day on average and their VKT also remains constant through 2035 (SDES, 2020). Table A2 and Table A3 in the Appendices provide further details on assumptions made for these vehicle types.

CHARGING TIME DEMANDED BY CHARGING CATEGORY

In the fourth modeling step, we estimate the average charger power and vehicle power accepted. Indeed, both are important to forecast the power that can be drawn from a charger. For instance, if a PHEV is plugged into a 22 kW charger but can only draw 3.4 kW, the value of 3.4 kW is used in the weighted average to estimate the power available at the charging station. The average rate of power draw is the same for all vehicle categories (passenger and light commercial vehicles) and increases over the years to reflect technology improvements in the vehicles and greater availability of higher-power charging. Table 3 displays the average rate of power draw for different chargers over the years.

Table 3. Average rate of power draw for different chargers and vehicles, selected years.

	BEV – AC normal charger	PHEV – AC normal charger	Urban fast charger	Corridor highway charger
2020	8 kW	3.4 kW	35 kW	60 kW
2030	9.1 kW	4.8 kW	80 kW	120 kW
2035	9.5 kW	5.4 kW	90 kW	150 kW

Even though higher power is possible in 2020, in practice power sharing, battery management over an entire charge cycle, and the lower cost of lower power suggest that, on average, speeds will be lower than the maximum. These charging and vehicle power acceptance assumptions are used for all the vehicle types, assuming technologies will evolve similarly across the various electric vehicle applications.

CHARGERS REQUIRED BY CHARGING CATEGORY

The final step is the calculation of the number of chargers of various types across the regions. To do this, we forecast the hours per day of power drawn from the different stations. We then multiply this by the charger output power in kW determined at the previous step to obtain the daily energy available in kWh. Finally, the energy required for the EVs determined at step 3 is divided by this energy available to arrive at the number of outlets needed.

The model reflects increasing utilization in hours per day with increasing electric vehicle penetration for both public AC normal and fast chargers as shown in other studies. This results in different hours per day of power drawn across departments, with higher usage in mature EV markets. By using benchmarked studies applied in previous ICCT analyses and adapting to the French context, the increasing usage of normal charging as a function of EV share of vehicle stock can be represented by the following equation:

$$\textit{Average daily hours of normal chargers' usage} = 0.71 \times \ln(\textit{EV stock share}) - 4.52$$

Using a natural log (ln) function prevents the number of hours from rising past a practical threshold at high market penetrations, but also allows for a rapid increase in utilization in the nascent stages of an electric vehicle market. The equation stems from an assumed national average daily utilization of 1.6 hours in 2020, reaching 4 hours in 2035. The daily usage varies in each department based on EV market penetration (represented by EV stock share in the formula above). As a result, utilization is typically higher than the national average in larger urbanized areas where there is a higher concentration of EVs and chargers, allowing for more frequent and convenient matches between EV and charger locations. As an example, daily utilization in Paris department increases from 2 hours in 2020 to 4.5 hours per normal charger in 2030.

A similar model is used to account for increasing usage of fast chargers represented by the following equation:

$$\textit{Average daily hours of fast chargers' usage} = 0.67 \times \ln(\textit{BEV stock share}) - 4.59$$

The equation stems from an assumed national average daily utilization of 1.6 hours in 2020, which is projected to reach 4 hours in 2035. Similar to AC normal chargers, the daily usage varies in each department depending on the market's maturity, represented by the BEV stock share. As an example, daily utilization of fast chargers in Paris department increases from 1.9 hours in 2020 to 4.6 hours in 2030.

The utilization assumptions described above for public chargers are applied for all vehicle types: passenger cars, light commercial vans, taxis, and PHVs. However, private charging assumptions differ across the four vehicle categories.

Workplace charging for passenger cars is modeled differently than public charging and is assumed to remain constant at 5 hours per workday throughout the study period as it is tied to routine usage and can expand in a more predictable way. Since workplace chargers are rarely used on weekends, the average daily hours of use over a seven-day week is 3.6 hours.

Home chargers used by passenger car drivers are calculated in another manner, without using the utilization parameters described above. Instead, home charger count is based on the number of EV drivers with access to home charging, as defined in the housing section above. The methodology assumes one home charger per BEV and takes into account that some houses may share one charger among multiple PHEVs (except for taxis and PHVs).

We assume a more coordinated strategy for depot charging of professional LCVs such that one charger can share power between two BEVs or among three PHEVs. This can be done through entire-site power-sharing among multiple charging ports, power sharing through multiple charging ports on one charger, or physically moving a port from one car to another. Overnight charging allows these vehicles to receive the majority of their daily charging needs.

Finally, while the methodology presented in Figure 3 above is applied at the departmental level for workplace, public AC normal and fast urban chargers, it is applied at the national level for fast corridor highway chargers. The number of highway corridor chargers is calculated at the country level and then split per highway based on its average daily passenger car traffic. It is further split per department, based on the average daily passenger car traffic of the highway in each department. The average daily traffic is obtained by calculating the average over one year of the number of vehicles circulating on a certain section, during one day. Each section belongs to one highway and is attributed to the department where it starts (Data.gouv.fr, 2018).

A summary of data inputs is provided in Table A1 in the Appendix.

RESULTS

The following presents our projections of increased EV energy demand, and the resulting number of public and private chargers needed, along with the evolution in the number of EVs served per charger over time. These results depend on several assumptions and the impact of varying key assumptions is presented in the sensitivity analysis concluding this section.

ELECTRIC VEHICLE ENERGY DEMAND

Figure 6 presents the total energy demand for charging, in terawatt-hours (TWh) per year, for each EV charging setting from 2020 to 2035, including charging at public and private stations. The figure includes charging needs for passenger cars, light commercial vans, taxis, and private-hire vehicles. Energy demand from EV charging grows substantially, from an estimated 1.0 terawatt-hours (TWh) of electricity in 2020 to 5.7 TWh in 2025, and 16 TWh in 2030. As indicated, by 2030, 10TWh, or 64% of the overall EV charging energy is from private charging. For context, the total electricity used by all applications in France in 2019 was 439TWh, so our results for 2030 would amount to 4% of that total (SDES, 2020).

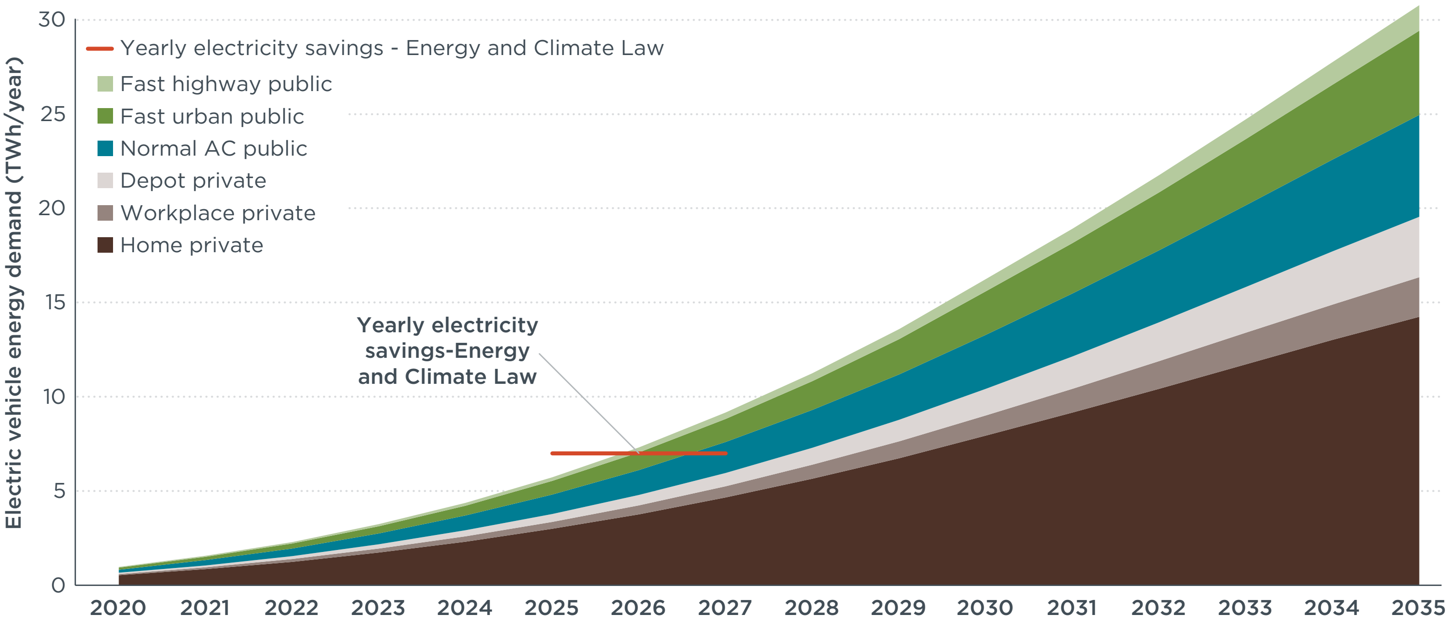

Figure 6. Energy demand (TWh) from electric vehicle charging per charging setting.

One broad trend evident in the figure is the increasing share of energy allocated to depot charging (light brown). As shown in Table A2, it is assumed that 75% to 90% of company light commercial vehicles' charging happens at the depot. This effect is magnified as light commercial vehicles account for a higher share of the total electric fleet over time. The other broad trend is the increase in public charging. While private home electricity needs increase over the years, its share among all electricity needed decreases due to a forecast decrease in the share of EV owners with home charging availability as EVs reach mass adoption.

Although not shown in the total EV energy demand across vehicle types in Figure 6 examining private passenger cars in particular, the majority of energy demand continues to result from home-based charging. Energy for private passenger car charging in 2030 amounts to 12 TWh, including 54% home charging, 6.6% private workplace, 21% public normal,14% DC fast, and 4.4% DC fast highway corridor charging. It is interesting to note that while in Île-de-France 47% of the total energy comes from home charging, in the rest of France this percentage goes up to around 56%. This 9-point difference is explained by the relatively high share of apartments in Île-de-France (and especially in Paris) where it is harder to rely on overnight home charging. The projection suggests that as the market evolves to include more EV drivers in multi-unit dwellings, ensuring growth in the availability of home charging will be important as it is typically the most convenient and low-cost charging option for EV drivers.

At a more granular level, departments with the highest energy need to 2030 are the largest urbanized areas. These 11 areas account for approximately 44% and 51% of the total and public (respectively) energy needed in 2030. This is due to early mass electrification in large urban areas partly triggered by policies such as low emission zones, to a large population concentrated in these areas, and to fewer people having access to private home charging in mostly dense urbanized areas. For broader context, these 11 areas are home to 43% of the French population.

In terms of public energy per vehicle type, private passenger cars account for the greatest energy demand (67% in 2025) for every region. Île-de-France has some peculiarities with 63% of energy emanating from passenger cars and 21% from private hire vehicles in 2025 (compared to 10% for this vehicle type at the national level). This is due to the Paris region hosting a large number of private hire vehicles and taxis and having fewer car commuters (compared to other regions), especially in Metropole du Grand Paris, which result in a small amount of workplace charging. There is a shift towards more energy demand coming from passenger and light commercial vehicles in later years due to mass electrification of these fleets occurring later than the electrification of taxis and PHVs.

Finally, for broader context, in 2019, France passed an Energy and Climate Law to achieve its climate and environmental ambitions (LOI N° 2019-1147 Du 8 Novembre 2019 Relative à l'énergie et Au Climat (1), 2019). A key measure seeks to increase the energy efficiency of all buildings with an energy efficiency class of F or G. As a result of this law, the Pluriannual Energy Program forecasts a decrease in building-sector energy consumption of 76 TWh between 2023 and 2028 (Ministry of the Ecological Transition, 2020). Since about 45% of this energy comes from electricity, this results in a five-year savings of about 35 TWh, or about 6.9 TWh in electricity savings annually over the 2023–2028 period. Another study forecasts a yearly electricity saving of 7.1 TWh starting in 2026 thanks to this energy efficiency law (Sia Partners 2017). As shown in Figure 6, the approximately 7 TWh of yearly savings offsets the projected increase in electric vehicle electricity consumption through 2026.

Figure A2 in the Appendix provides a detailed breakdown of the energy demand for all charging segments and every region of Metropolitan France in 2025, 2030, and 2035.

EVOLUTION OF ELECTRIC VEHICLES SERVED PER CHARGER

Based on an increase in usage of public AC normal and fast chargers as well as the greater concentration of EVs and chargers in the same regions, the number of EVs per charger increases through 2035 even though the share of EV owners with home charging availability decreases over the years. Figure 7 shows the growth in EVs per public chargers (left axis and brown) and BEV per fast charger (right axis and blue) over time.

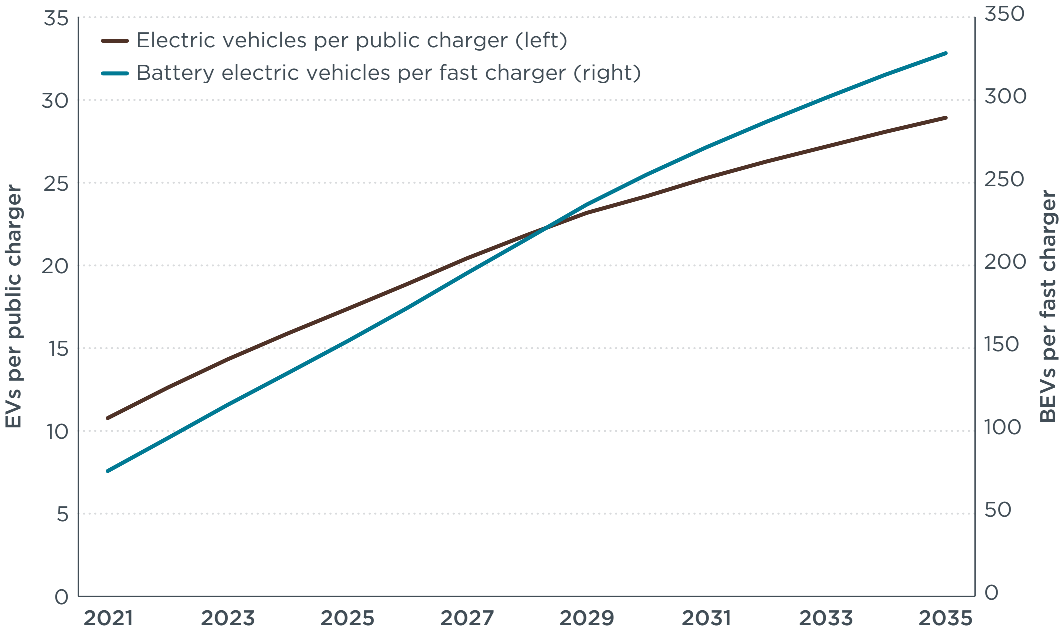

Figure 7. Number of EVs per public charger (brown and left axis) and BEVs per fast charger (blue and right axis).

The number of EVs per public charger at the national level increases from 17 in 2025 to 24 in 2030, and continues upward through 2035. However, it is worth noting that when the ratio includes private workplace chargers as well (so EVs per public plus private workplace chargers) this ratio is lower, at 13, 17, and 19 EVs per charger in 2025, 2030, and 2035 respectively. At the same time, the number of BEVs per fast charger increases over the years and reaches 254 in 2030. These figures show that in early market phases there is a need for even geographic coverage to ensure a minimum level of access to all. However, even geographic coverage invariably means low utilization in some areas. After reaching this even coverage, chargers can be added where there is more demand. As the market develops, utilization increases, resulting in more EVs per public chargers and BEVs per fast chargers. These ratios vary by department; as an example, the number of EVs per public charger in 2030 in Paris is around 27 while this ratio goes down to 15 in the less densely populated department of Vendée (85). The graphs above represent the average at the France level.

NUMBER OF CHARGERS

Public chargers. Figure 8 displays the number of public normal (left) and public fast (right) chargers needed in Metropolitan France by 2030. The darker the blue shade, the greater the number of chargers needed. Detailed maps with the number of public chargers are provided in the Appendix in Figure A3, while Figure A4 presents the split of different public segments in 2025, 2030, and 2035. As indicated in these maps, departments with the highest projected number of both normal and fast chargers in 2030 are in the Paris region.

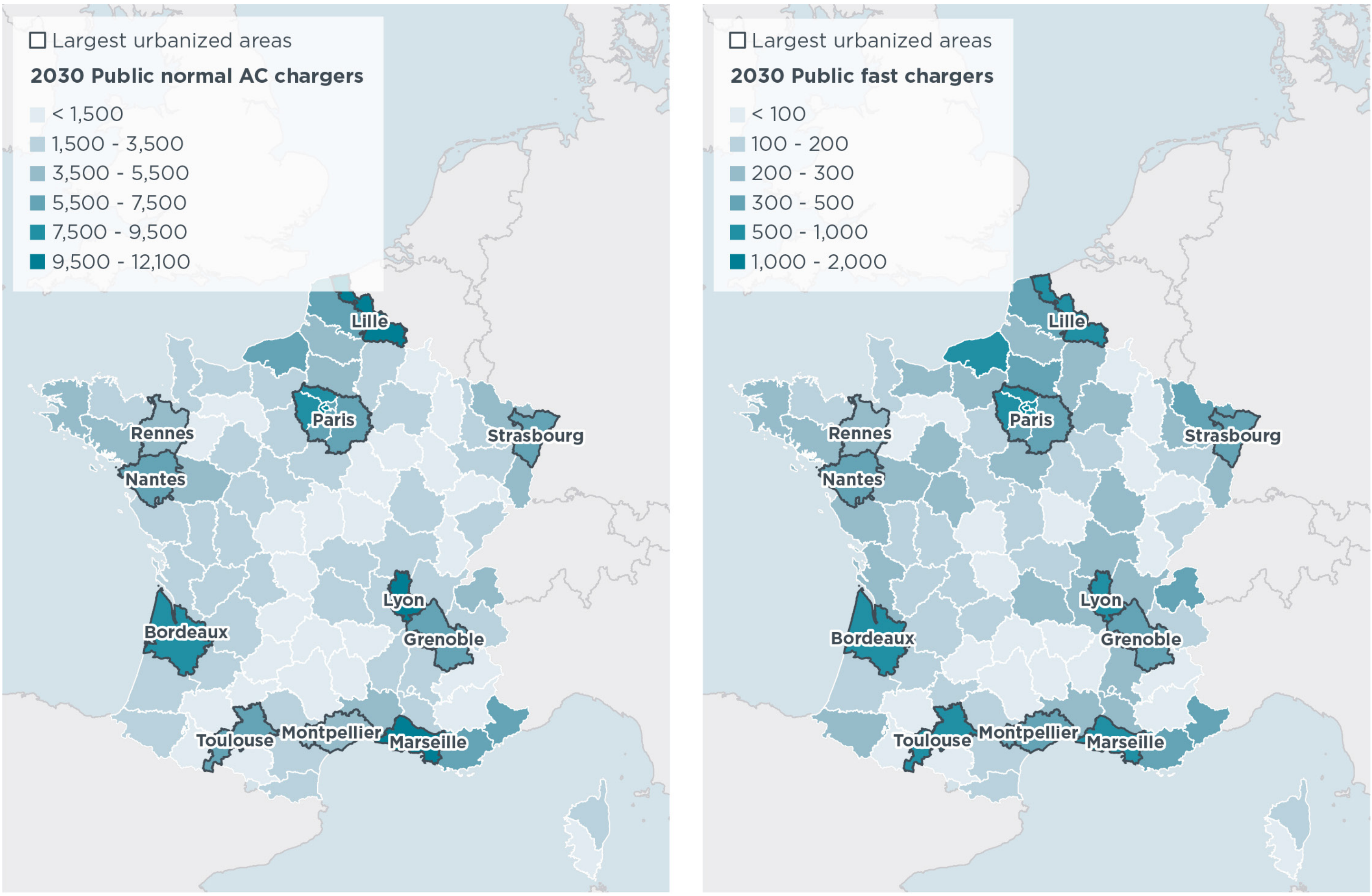

Figure 8. Number of public normal (left) and public fast (right) chargers needed by 2030, by department.

The maps in Figure 8 clearly show that normal and fast chargers will be needed above all in the 11 largest urban areas. This is explained by at least two factors. First, these areas have a high concentration of EVs on their roads (due to a high population and an early level of EV adoption), but a low share of home charging compared to the national average due to a higher proportion of the population living in multi-unit dwellings. Second, these areas are home to a high number of taxis and PHVs, which have a particular need for fast charging during the day.

Although not evident in the maps, Paris department will need a large stock of public normal chargers by 2030, totaling 11,600 normal chargers and 1,900 fast chargers. As for Île-de-France (Paris region) its public charging needs will reach 66,200 normal and 6,640 fast chargers. This is due to the bold ambition of allowing only BEVs on the roads of Metropole du Grand Paris by 2030 and for all of the Île-de-France region by 2035.

Figure 9 displays the results in another way by providing the share of 2025 (left) and 2030 (right) public charging infrastructure already in place at the end of 2020. Departments in light red are closer to meeting their 2030 public charging infrastructure target and those in dark red are further away and below the national average. At the national level, 17.8% of 2025 charging infrastructure is already in place; this share is 8.9% for 2030. Various departments range from meeting 3% to 59% of their 2025 overall public charging needs, and 1% to 25% of their 2030 needs.

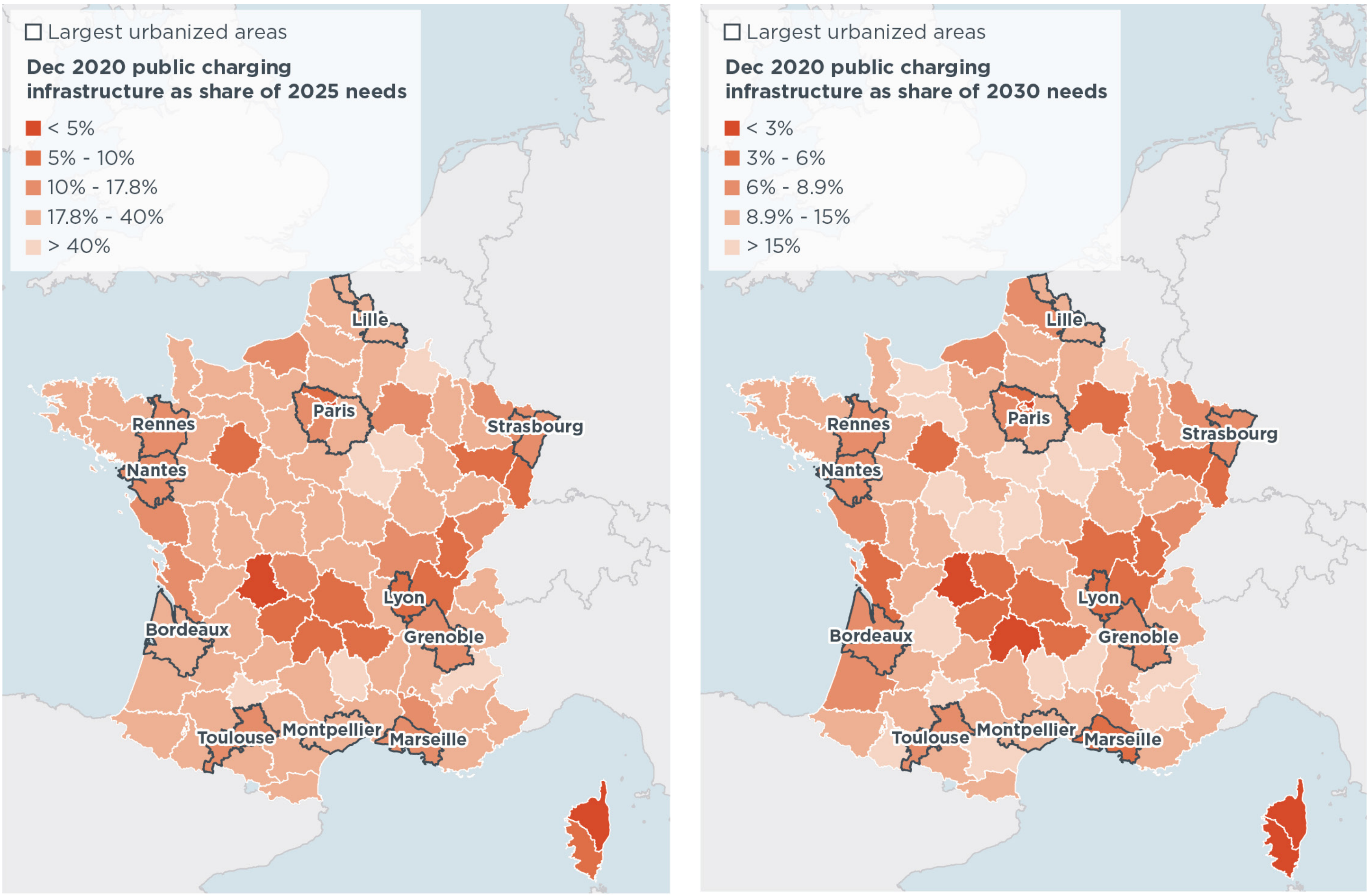

Figure 9. Share of 2025 (left) and 2030 (right) public charging infrastructure already in place at the end of 2020.

These maps show that many of the largest urbanized areas are in dark red, meaning that they have further to go to reach the level of charging infrastructure needed in 2030. For nine of the 11 largest urbanized areas, the share of 2030 public charging infrastructure in place is lower than the national average of 8.9%. The remaining two are only slightly above this country-wide average. For example, as of end of 2020, Marseille has 12% and 6% of the public charging needed by 2025 and 2030, respectively, while Lille has 20% and 9%, respectively. Interestingly, in Île-de-France, Paris department has the highest share of 2030 infrastructure already in place (14%) even though Île-de-France as a whole is below the national average and has only 7% of the charging infrastructure required in 2030 already in place.

These estimates of the number of public chargers are provided for all vehicle types. Figure A5 in the Appendix presents an estimate of the number of normal AC and fast urban chargers for taxis and PHVs in 2025 and 2030, in the largest urban areas. This can help national, regional, and local governments in planning their charging infrastructure roll outs since fast urban chargers are primarily located at train stations, airports, or other tourist-heavy places, while normal AC chargers are for drivers' overnight charging and thus are located close to their homes i.e., in less dense areas further away from the city center.

Highway corridor chargers. With the development of a reliable public charging network and an increase in EVs' range, people will feel more comfortable using their EVs for long distance trips for which the deployment of public fast highway chargers will be especially important. Our modeling forecasts an increase in fast highway chargers through 2035, reaching 2,200 in 2025, 4,400 in 2030, and 6,800 in 2035. Table A5 in the Appendix provides a detailed breakdown per highway.

Total chargers. The estimated charger stock in every region, including private (brown) and public (blue and green) is provided below. The hashed brown segments indicate the estimate of home chargers at the end of 2020, and hashed blue, the number of public chargers at the same point. As indicated, Île-de-France requires a total of 1,364,000 chargers in 2030, the highest need of all 13 regions. It is followed by Auvergne Rhône Alpes with 672,000 chargers in 2030. Most of these chargers are private home chargers.

Table A4 in the Appendix provides the forecast number of chargers per region and per category for 2025, 2030, and 2035.

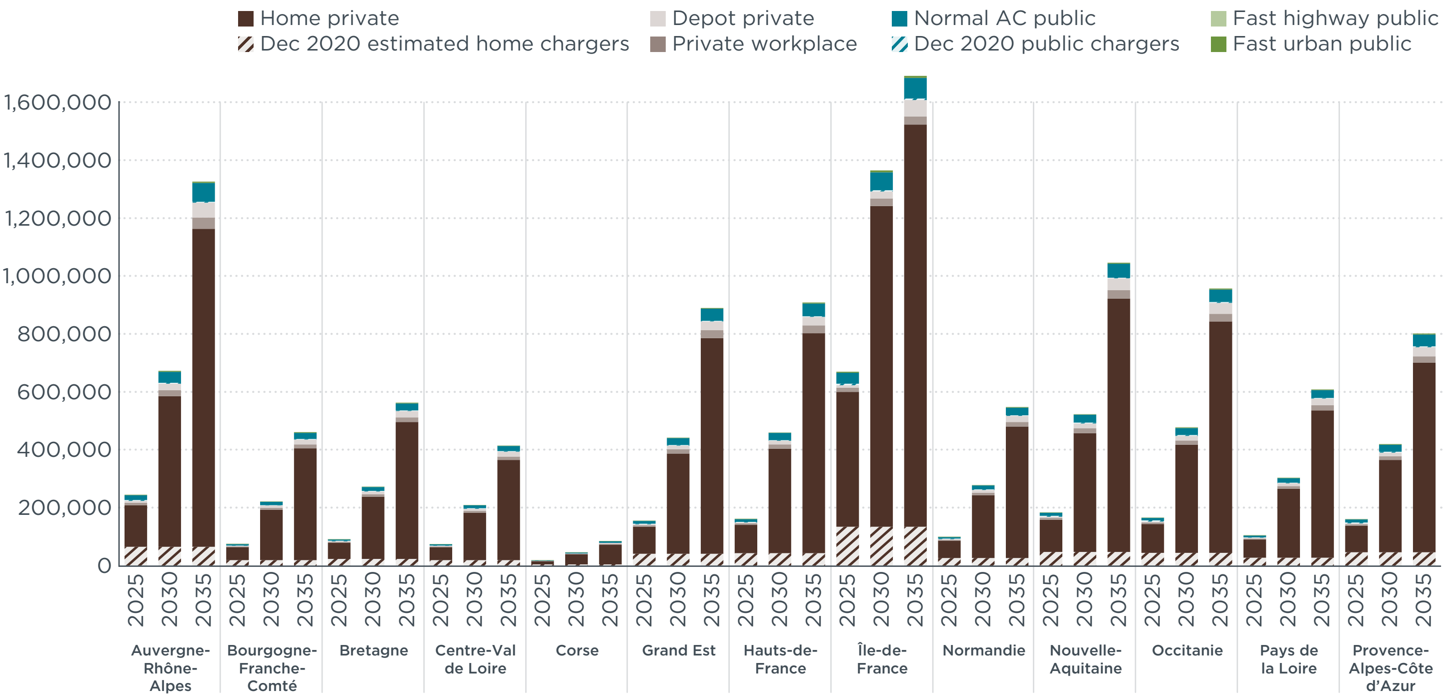

Figure 10. Estimated total number of chargers private (brown) and public (blue and green) for 2025, 2030, and 2035.

An estimated 2.2 million chargers (private and public) will be needed by 2025, 5.7 million by 2030, and 10.3 million by 2035. Although expanding this infrastructure will require greatly increased efforts by governments and private industry, our projected 5.7 million 2030 need represents approximately 81% of France's announced goal of 7 million public and private chargers by 2030 (LOI N° 2015-992 Du 17 Août 2015 Relative à La Transition Énergétique Pour La Croissance Verte, 2015). This difference is explained by market developments up to 2020, a lower number of chargers per electric vehicle as the market matures, less accessibility to home charging in later years, and a better case for fast charging.

As shown in Figure 10 the region with the highest number of chargers needed in all years is Île-de-France, the most populated region and home of the French capital. Among the 1,364,000 2030 chargers, about 90% are home chargers. Even though Île-de-France has a low share of home charging availability compared to the national average, its share of EV stock is high due to its high level of BEV adoption, which results in efficient use of public chargers and decreases the number of public chargers needed. The region with the second highest number of chargers needed, which is also the second most densely populated French region, is Auvergne-Rhône-Alpes, home to 2 of the 11 largest urbanized areas, Lyon and Grenoble.

Finally, Table 4 summarizes the overall charging infrastructure needs in France for 2025, 2030, and 2035, including overall results for the 11 largest urbanized areas and other parts of France, and comparisons with chargers installed through 2020. This analysis indicates that the total number of public normal and fast chargers across France will need to increase from 31,000 at the end of 2020 to 174,000 by 2025. To meet the electric vehicle goals through 2030, approximately 350,000 chargers will be needed. This infrastructure amounts to about 7.9 times more public chargers in 2025 and about 14 times more in 2030 than in 2020 for the largest urbanized areas. These ratios are lower for the other parts of France, showing a greater need in terms of charging infrastructure in dense urbanized zones. To put this in perspective, these results suggest that a 41% annual growth in the number of chargers is needed from 2020 to 2025, and 27% per year from 2020 to 2030, to support the electric vehicle growth targets. As indicated, the annual increase of chargers is higher for the larger urbanized areas.

Table 4. Summary of charging infrastructure needs.

	Year	Largest urbanized areas*	Other parts of France	Country-wide
Total public chargers (public normal, fast)	through 2020	10,809	20,277	31,086
	2025	84,950	89,260	174,211
	2030	153,497	196,252	349,750
	2035	217,996	331,605	549,600
Electric vehicle stock	through 2020	233,958	236,337	470,295
	2025	1,673,673	1,348,973	3,022,646
	2030	4,140,654	4,313,934	8,454,588
	2035	6,647,251	9,247,630	15,894,881
Projected multiple of future public charging needs compared to 2020	2025	7.9	4.4	5.6
	2030	14.2	9.7	11.3
	2035	20.2	16.4	17.7
2020 public charging as a percentage of future chargers needed	2025	13%	23%	18%
	2030	7%	10%	9%
	2035	5%	6%	6%
Annual increase in chargers from 2020 to 2025, 2030 and 2035	2025	51%	35%	41%
	2030	30%	25%	27%
	2035	22%	20%	21%

*The 11 largest urbanized areas are home to 43% of the French population.

SENSITIVITY ANALYSIS

The assumptions and results presented in the previous section represent our base scenario. However, the number of chargers is sensitive to key assumptions and variables. In order to show the effect of changing these assumptions and variables, a sensitivity analysis for three important variables is presented.

Three additional scenarios were analyzed for their impact on charging infrastructure needed in 2030, as compared to the results presented above. The first scenario assesses the impact of moving forward, to 2035, the 2040 sales phase-out of internal combustion engines. The second assesses a decrease in car dependency over time, reflecting fewer cars purchased and a decrease in annual kilometers traveled per vehicle (reflecting, for example, more success in local policies and more teleworking). The third scenario analyzes the impact of increased access to home charging, with 69% of EV owners having access to home charging in 2030, as compared with 64.5% in the base scenario.

The effects of these cases, as a percentage change in the 2030 number of chargers relative to the base scenario, are substantial. For the accelerated 2035 combustion vehicle phase-out scenario, the need for private, public AC normal, urban fast, and highway fast chargers increases by 28%, 22%, 28%, and 35% respectively, resulting in a 23% increase in the number of total public chargers. The second alternative case, decreasing car dependency, results in a 9% reduction in private charging needs and a 14% reduction in public charging needs. For this accelerated electrification path, France would need a total of 7.3 million chargers, including 430,000 public chargers, in 2030. Accomplishing the French government's goal of 7 million chargers could thus put the country close to a path towards full electrification of new sales by 2035, 5 years ahead of the current target. These two scenarios demonstrate that different charging infrastructure outcomes are possible by 2035 depending on national priorities and technology developments.

The third scenario—increased access to home charging—has a proportional effect on the need for public chargers. The 4.5 percentage point increase (from 64.5% to 69%) in home charging access decreases the need for public urban chargers (normal AC and fast urban) by approximately 5%. This reflects the importance of increasing access to overnight charging, for example for residents in apartments. In 2030, about half of electric vehicle owners will be apartment dwellers and an estimated 35% of France's passenger electric vehicle stock will be owned by households without access to home charging. Independent of these national, local, and businesses decisions, efficient strategies along with strong policies should be implemented to ensure an efficient development of the charging network (Rajon Bernard & Hall, 2021).

COMPARISON OF RESULTS

This section compares the results with data from three publications that also estimated future electric vehicle uptake and charging infrastructure needs in France: a 2019 report commissioned by the French Ministry of the Ecological Transition and conducted by Coda Stratégies (hereafter, the "Coda" study, Migette J.C., et al., 2019); the 2020 Pluriannual Energy Planification (PEP) study (Ministry of the Ecological Ecological Transition, 2020), and the 2020 Transport & Environment (T&E) study (Transport & Environment, 2020).

Table 5 compares our results with those of the optimized scenario of the "Coda" study, the dynamic scenario of the PEP study, and the Road2Zero scenario of the T&E study. The comparison is done in terms of estimated number of electric vehicles (excluding light commercial vehicles since all studies assume that they mostly or entirely rely on private depot charging) and estimated public charging infrastructure to support the growing electric vehicle population for 2025, 2030, and 2035, and compares to the numbers through the end of 2020. Data in the middle columns suggest that the four studies find that at least 12 times more public chargers are needed by 2030 compared to 2020. However, the values for 2030 public chargers needed range from 12 (PEP and ICCT) to 29 times (Coda) the 2020 charging in place. The table also details the number of passenger EVs, to offer a partial explantion for the difference in absolute charger numbers across the four studies. This ICCT analysis projects 7.4 million passenger EVs in 2030, compared to 5.3 million in Coda, 6.2 million in PEP, and 6.3 million in the Transport and Environment studies. The following describes some of the major underlying differences across the four studies that result in more and fewer chargers of various types.

Table 5. Passenger electric vehicles and supporting chargers needed through 2035, comparing this analysis with three others.

		2020 reference	2025				2030				2035	
			ICCT	Coda[a]	PEP[b]	T&E[c]	ICCT	Coda[a]	PEP[b]	T&E[c]	ICCT	PEP[b]
Electric vehicles (excluding LCV, in thousands)	BEVs	277	1,870	1,500	2,650	2,069	5,808	3,100	6,200	6,341	11,458	
	PHEVs	135	854	1,000			1,593	2,200			1,984	
Estimated number of public chargers (thousands)		30	174	394	203	214	350	884	361	467	550	436
Electric vehicles (excluding LCV) per public charger		13.72	15.6	6.35	13.1	9.67	21.2	6.00	17.2	13.6	24.5	

[a] optimized scenario, [b] dynamic scenario, [c] Road2Zero scenario

Overall, we forecast a higher number of EVs in 2025 and 2030 than the other studies based on market developments up to December 2020 and on French commitments related to BEV sales share and BEVs on the roads. We also forecast a growing daily utilization of public chargers, which reduces the stock of public chargers needed and increases the ratio of electric vehicles per charger. We project the highest passenger EV-per-charger ratio of all four studies, at 21.2 in 2030, in part because of increased EV market penetration. In addition, our higher ratios result from an expectation that more fast chargers will be found in urban hubs as the business case for charging hubs becomes stronger. This confidence should come from a more predictable energy load, a higher utilization rate, and a reduced grid connection cost, with the costs being spread to more chargers per site. Finally, we also assume that private workplace charging will play an important role, which also helps explain our higher ratios.

There are important discrepancies in charging infrastructure estimates between the July 2019 Coda consultant report and our study. These differences come mainly from assumptions related to PHEVs. The Coda study first models a higher PHEV uptake compared to this ICCT one, and, more importantly, they assume that each PHEV without home charging had at least one public normal charging session each day to maximize its share of electric kilometers. This Coda assumption increases the number of public normal stations for PHEV drivers. As for the total number of chargers, while the Coda studies forecasts the need for 6 million, our study results in 5.7 million private and public chargers in 2030. Both Coda and our estimates are lower than the French goal of 7 million private and public chargers in 2030.

Relative to the Pluriannual Energy Planification (PEP), our EV per public charger results are higher due to our forecasted higher EV uptake and higher home charging availability in light of new laws that increase home charging access in multi-unit dwellings. Finally, in comparison with the Transport & Environment study, we project both a higher number of EVs and a higher EV-per-charger ratio. A key reason is that we forecast more efficient usage of public chargers through 2035, resulting from higher power capacity of chargers and vehicles, and less downtime due to increasing EV penetration.

CHARGING NEEDS BASED ON ECONOMIC SITUATION

The results of the analysis depict differences in future EV uptake and charging infrastructure needs across departments, which in turn are a function of other variables such as wealth. The gross domestic product (GDP) per capita of a department give an indication of the investment or financial support potentially available to close the projected gap in charging infrastructure. To better understand the impact of departmental disparities, we use a per capita GDP (Eurostat, 2021) lens to look at the relative increase in number of EVs on the roads between 2020 and 2030 (Figure 11) and the share of 2030 infrastructure in place in 2020 (Figure 12).

Figure 11 displays the targeted increase in EVs on the roads between the end of 2020 and 2030 in relation to GDP per capita. It covers all metropolitan departments and highlights the 11 largest urban areas, each home to more than 700,000 inhabitants as defined by the Insee (Insee, 2020). (Note that the number of EVs on the roads—the metric displayed on the y-axis—differs from the number of EVs registered in each department because many new EVs—41% in 2020—are registered by companies in their home department but are used in the department where employees live.) National averages of wealth and EV growth are shown in the dashed red vertical line (national average GDP per capita) and the dashed red horizontal line (national average increase in EVs).

The Figure shows that the 11 largest urban areas, which are the wealthiest, typically have the smallest relative EV increase by 2030 because EV ownership levels are already relatively high. By contrast, the department with the lowest GDP per capita, La Creuse, has a relatively low number of EVs, requiring a greater increase to meet the national goal of 100% BEV sales by 2040. Its EV stock is forecast to increase 27 times in ten years. The figure suggests that national financial support could be needed in less affluent areas over the next ten years to ensure an equitable electric vehicle transition.

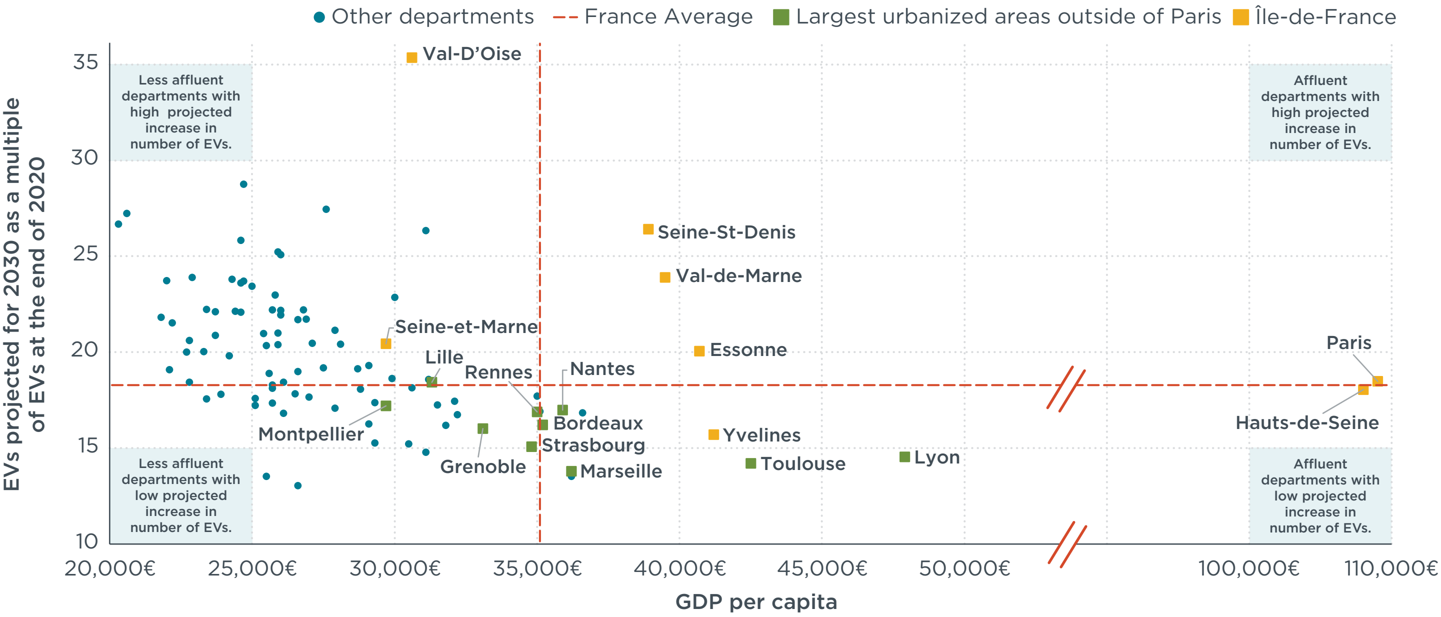

Figure 11. Projected increase in EVs by department, compared with GDP per capita. Green squares indicate the 11 largest urban areas outside the Paris region. Yellow squares indicate communities around Paris, including the entire Île-de-France region. Other departments are shown in blue circles.

Figure 12 maps electric vehicle charging infrastructure already in place in 2020 against wealth across departments. The vertical axis shows the share of required 2030 infrastructure that was in place at the end of 2020. The horizontal axis shows GDP per capita. The dashed red lines reflect the national averages, such that each quadrant reflects the relative charging challenge and relative affluence. For example, Lyon, in the bottom right quadrant, is in a more affluent department, but has only 3% of its projected 2030 charging needs in place through 2020, suggesting a large supply challenge, but also the financial capacity to meet it. Departments in the lower left have lower financial resources and the largest projected increase in charging needs, indicating a larger charging infrastructure challenge.

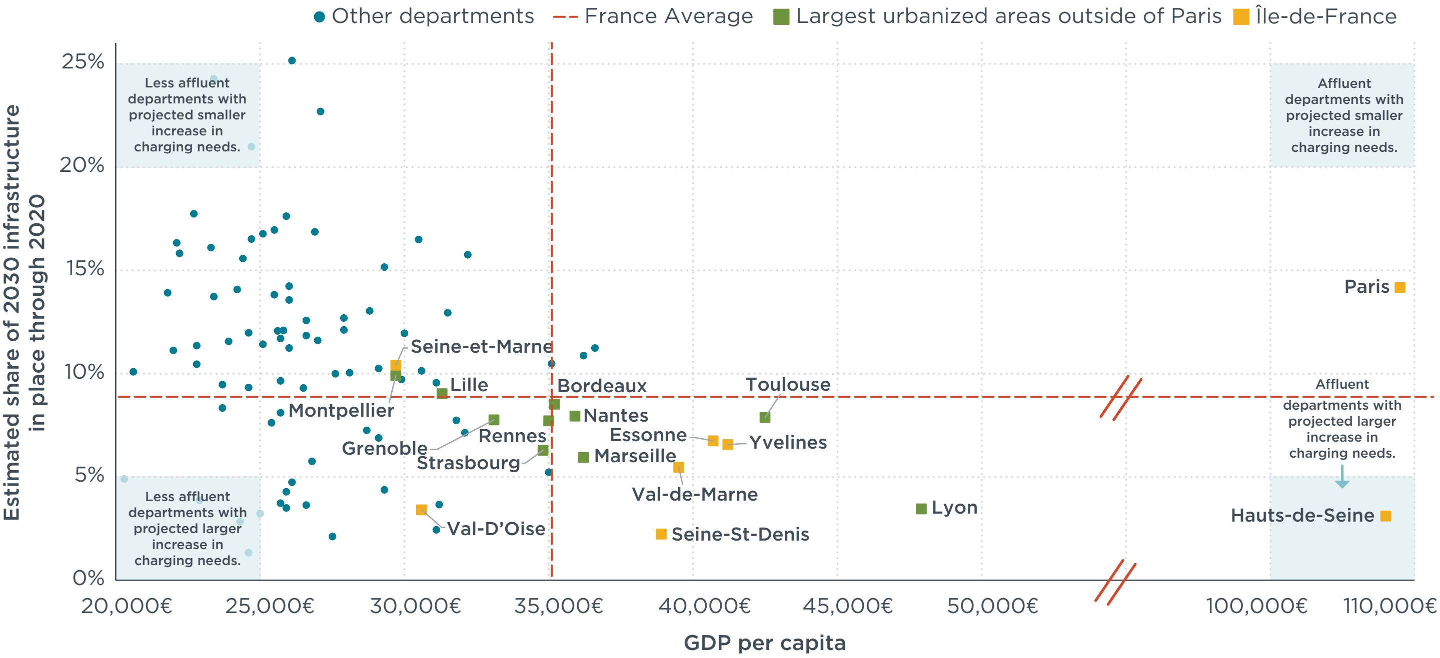

Figure 12. Required charging infrastructure, compared with GDP per capita.

Quantifying the relative EV and charging growth as related to the relative prosperity of departments can help identify potential investment gaps for future charging infrastructure needs at the local level. It is clear from this report that a high level of charging infrastructure deployment is needed in every department to support national, regional, and city EV goals, and it is important that less-affluent departments are not left behind. Indeed, in order to significantly increase EV uptake in less mature markets, the development of a visible public charging network is key to building confidence. We also note that overseas departments were not included in this study because of a lack of data. However, it is important from an equity perspective not to leave them behind, since they have among the lowest wealth of all departments. Continuing to refine and track such variables may help to optimize the deployment of additional charging infrastructure over time.

POLICY RECOMMENDATIONS

Based on the estimate given earlier of the amount, location, and type of chargers required, numerous policy actions will be required to meet the growing need for charging infrastructure. This section provides several high-level policy recommendations to support the efficient development of France's charging network, focusing on actions that can be taken by the national government. Other reports have already provided recommendations and best practices for local authorities' role in facilitating charging infrastructure deployment (Rajon Bernard & Hall, 2021; Hall & Lutsey, 2020). Policies related to the importance of an interoperable and well-maintained network with clear pricing structures are not discussed in detail here, but such recommendations have already been made by Afirev (Afirev, 2018) and could be reinforced by the European Union when it revises the Alternative Fuels Infrastructure Directive (AFID) in July 2021.

Table 6 summarizes policy recommendations designed to enable increased charger deployment in support of an accelerated pace of EV uptake in France. For policies aimed at local governments, the national government can issue guidance to local authorities similar to that given after the publication of the Mobility Orientation Law in 2019 (Ministry of the Ecological Transition, 2019). The national government also plays a critical role in providing fiscal support to help fill charging infrastructure gaps. In addition, national guidance can support activities that aim to improve electric vehicle owners' charging experience.

Table 6. Summary of policy recommendations.

Category	Policy/Action type	Stakeholder(s)	Description
Guidance and support to local authorities	Provide targets for adoption of chargers	Departments and regions	Provide departmental and/or regional level targets in terms of number of public chargers for different time horizons.
	Create streamlined charger permitting and implementation processes	Municipalities, EV owners, distribution network operators, charge point operators	Unlock mass EV adoption and encourage private sector to take over charger delivery by implementing a streamlined, coordinated charging installation process based on drivers' demand, with additional direction to ensure equitable charging access.
	Develop an electric vehicle charging infrastructure knowledge platform	Local and national policy makers, EV knowledge institutes, charge point and grid operators	Developing a platform aimed at informing and connecting charging infrastructure stakeholders. Objective is to help stakeholders learn from one another and to develop innovative cross-industry partnerships.
	Develop charging stations in public parking garages	Parking owners and managers, and safety experts	Update safety guidelines related to charging stations in parking garages, or clearly regulate and subsidize parking garages safety upgrades.
Fiscal support	Direct funding, cost sharing, tax credits for deployment	Municipalities, charging providers, property owners	Based on input from local authorities regarding gaps in charging, national support can help to share costs for charging infrastructure and building upgrades; tax credits can partially defray upfront costs and promote equitable long-term electric vehicle access.
Improve EV owner charging experience	Adopt standardized labels on vehicles and chargers	Electric vehicle sellers (automakers and dealers)	Most EV owners do not know the charging speed of their car and the chargers they use. A car sticker displaying compatible chargers and giving charging guidance when buying an EV could solve several issues.
	Develop an "EV welcome" national label	Private businesses	Similar to the "Cyclists welcome" national label, an "EV welcome" label would allow EV drivers to find a secure place to charge when going on holiday.

GUIDANCE AND SUPPORT TO LOCAL AUTHORITIES

Since January 1, 2021, every grouping of local authorities has had a team in charge of local mobility. While local authorities are well-positioned to adapt strategies to fit the local context, detailed national guidance can help to share best practices, avoid duplication of efforts, and encourage standardization and compatibility of programs across the country. A direct dialogue between the national government and local ones—without going through intermediate parties such as Avere—has also been cited by local policy makers as key to efficient coordination.

Provide charger adoption targets. The national government could enlarge its goal of 100,000 public chargers by the end of 2021 by providing a target per department or region, at different time horizons. This could include separate targets for fast and normal chargers along with an approximate substitution ratio between normal and fast charger (e.g., in 2025, one fast urban charger can substitute for 8 normal chargers; this ratio goes up to 10 in 2030). Figure A3 in the Appendix displays the estimated number of public normal and fast chargers per department that would put France on a path to 100% BEV sales by 2040. A per-region breakdown of the same results is given in Figure A4. Providing departmental and regional level targets would help local authorities plan efficiently.

At a higher level, France could support the implementation of binding national targets for urban and highway chargers from the European Union. As mentioned above, the European Union will revise the Alternative Fuels Infrastructure Directive in July 2021. Issuing binding national-level targets for chargers will help government and industry to plan effectively for charging deployment so that chargers are not a barrier to electric vehicle uptake.

Create streamlined charger permitting and implementation processes. While providing even coverage of charging is important in building confidence during early stages of EV market development, it is not enough to meet drivers' needs, nor to unlock investments by charger providers, as the market grows. Additional supportive actions could include implementing a streamlined, coordinated charger installation process in areas of high driver demand, while ensuring equitable access to charging (Rajon Bernard & Hall, 2021). In order to balance high demand, which is of interest to private charging operators, and equitable access, authorities can use risk balancing. This involves pairing, in tender processes, vendor commitments to supply low- and high-utilization locations, with the government providing subsidies for chargers installed in areas of low demand to offset their lower profitability and to ensure network integrity, charger accessibility and affordability for residents. In this approach, cities could also help to find sites that encourage a variety of uses from different fleets, resulting in high utilization.

A combination of these two approaches has been successful in Saint Etienne for 22-kW and 50-kW chargers (Saint Etienne Métropole, 2020). This program could be expanded by allowing only EV drivers who lack access to home or workplace charging to request a 7.4-kW charger near their home. This is key to spurring equitable EV uptake for the mainstream market, given that about 35% of EV owners will most likely not have access to private home charging in 2030. While local authorities will ultimately develop local charging strategies, the national government could provide guidelines, recommendations, and a template to follow.

Develop an EV charging infrastructure knowledge platform. France could follow the lead of the Netherlands in developing a "Knowledge Platform for Charging Infrastructure" (NKL, 2014). This platform is aimed at informing and connecting charging infrastructure stakeholders for the rapid expansion of a cost effective and future-proof charging network for electric vehicles. Every stakeholder—local and national policy makers, knowledge institutes, and grid and charge point operators—could share innovative charging infrastructure projects and lessons learned. This would accelerate interest in EVs by allowing users to learn from one another and by connecting stakeholders to develop innovative cross-industry partnerships. Local and national governments could also list, on this platform, all tenders and charging infrastructure incentive programs and provide a streamlined way to apply to these.

Since the field is rapidly evolving with new laws, requirements, guidelines, and decrees regularly published, having a one-stop website for all stakeholders to stay up to date would be particularly useful.

The platform could also include a regularly updated, searchable list of all available subsidies, and a time and cost estimator. Such a tool could reduce uncertainties or confusion by EV drivers and building managers about costs they might face (after deducting subsidies), time required to permit and install chargers, relevant regulations, and streamlining processes already in place.

Develop charging stations in parking garages. Public parking garages are an important potential location for chargers that could meet overnight charging needs for residents as well as daytime charging for nearby workplaces and destinations, particularly in dense metropolitan areas. Prioritizing charging in parking garages could also reduce competition with other infrastructure at the curbside and promote cities' objectives of car-free city centers. However, high costs and difficulties with permitting and standards have deterred charging deployments in parking garages in France, and fire safety standards have presented a particular challenge.

Avere-France has found that "an electric vehicle in recharging phase does not present a particularly higher risk of fire" (Avere France, 2017), a finding supported by other studies (Brandt & Glansberg, 2020). However, a 2018 guide from the general directorate for civil security (Direction générale de la sécurité civile et de la gestion des crises, 2018) issued non-binding guidelines that chargers should only be installed on the ground floor or on the levels immediately below and above it, that power should be limited to 150-kVA (kW) per location, and that there should be a maximum of 20 chargers per location. These recommendations do not apply if the garage is equipped with a water sprinkler system and exceptions are made if the garage is highly ventilated. Insurance companies are hesitant to insure facilities that do not follow these recommended guidelines, and installation of water sprinkler systems is an expensive and lengthy process, so most parking companies have installed chargers only on floors near the ground level, limiting the total amount of charging available.

Considering this paper's findings that access to overnight charging is critical for France's electric mobility transition, there is a role for the national government to support charging infrastructure in parking garages. The national government could re-assess the safety of charging in these settings using the latest data and issue clear guidance accordingly to local governments, industry groups, and the insurance industry, including provisions for normal and DC fast chargers and above-ground and below-ground facilities. Depending on the findings and resulting safety recommendations, it may be appropriate to provide financial support to make the necessary modifications, e.g., installing water sprinkler systems.

FISCAL SUPPORT

Fiscal support can be provided in several ways to help meet the most pressing electric vehicle charging infrastructure needs. National funding could be targeted at areas of greatest need based on regular assessments, broken down by region as well as application (e.g., corridor fast chargers, private multi-unit dwellings, workplaces, etc.). This would build on the approach taken in the green recovery plan, which, as an example, provided €100 million for corridor fast charging. The charging need estimates provided in this report offer initial values that can be updated and refined at regular intervals. The equity analysis, in particular, could help direct and refine government funding. The national government can also provide targeted funding for localities to help them develop targets and strategies for the number and types of charging needed to meet near- and long-term electric vehicle goals. Related to the previous sub-section, specific funding could be provided for building upgrades such as parking garages and apartment buildings.

Based on data on charging needs, national funding can be issued with contingencies that reinforce the guidance recommendations from above. For example, public funding can be provided with cost sharing from private industry only in departments where local governments have clear targets and policies to streamline charging deployment. The funding can be provided with provisions that recipients share expected and actual usage charger data and that the chargers meet interoperability and public-access requirements. Fiscal support to business, workplace, and property managers can also include tax credits—as is already the case for homeowners and multi-unit dwellers—which reduce company taxes and partially defray the upfront capital cost of charging infrastructure deployment. Such tax credits are attractive as they rely on forgone taxes rather than public expenditures, and they incentivize investments while ensuring that the charging company and property owners remain vested in the success and high usage of the stations.

IMPROVE ELECTRIC VEHICLE OWNER CHARGING EXPERIENCE

Adopt standardized labels on vehicles and chargers. According to the aforementioned Enedis survey, 26% of EV owners with home charging do not know their charger power wattage and 60% of EV owners do not know the charging speed of their car. Not only can this lead to underutilization of public chargers if, for instance, an EV driver with a car charging at 11kW plugs in at a charger able to deliver 22kW, it can also lead to customer dissatisfaction and lack of understanding about charging time and price. To address this, the government could create a standardized label for each vehicle indicating the maximum acceptable AC and DC charging power along with the battery size (in kWh), and it could support European-wide standardization of the practice. This could be similar to the “Crit’Air” sticker commonly used in France (Ministry of the Ecological Transition, n.d.). A similar standardized sticker indicating the maximum power delivered could be put on each charger. A complementary way of addressing this issue is to create a certification program that educates dealers on best practices and tools for informing EV buyers.

Developing an “EV welcome” national label. Some drivers are reluctant to use an electric vehicle for long trips because they fear not having access to charging during their trip or at their destination. We suggest an “EV welcome” national label and website similar to the “Cyclists welcome” national label (France velo tourisme, n.d.) given to places of lodging, restaurants, tourist offices, tourist destinations, and other establishments across cycle routes that guarantee quality services. The “EV welcome” national label could also provide a map and a list of places previously mentioned providing EV chargers at secured locations. Information such as power of the charger, means of payment, and pricing should be included.

CONCLUSIONS

The French government has implemented numerous policies to grow the electric vehicle market, including an 8 billion euro plan to finance the transition to electric mobility. Local policies favoring electric vehicles have also been put in place, including accessibility advantages in the many cities with low-emission zones, free or discounted parking in many dense urban areas, and priority access to specific lanes to avoid traffic jams.

This analysis shows that France will require much more charging infrastructure to enable a growing electric vehicle market through 2035. Using a detailed bottom-up evaluation, we quantified the charging infrastructure needed to support France's electric vehicle goals through 2035. In contrast to other studies, this analysis details the charging and energy needs for private home, depot, and workplace, and public normal AC, fast urban, and fast highway chargers and for passenger cars, light commercial vehicles, taxis, and PHVs at the departmental level, allowing more targeted policies to ensure public charging needs are met. Based on the analysis we draw the following conclusions:

The growing French electric vehicle market requires a greatly expanded charging infrastructure network. As electric vehicles grow from 470,000 electric vehicles through 2020 to approximately 8.5 million on French roads in 2030 (including 1.1 million electric light commercial vehicles), public chargers will need to increase from 31,000 to 350,000. This represents a 28% annual growth rate. Including public and private infrastructure, 5.7 million chargers are needed by 2030, indicating the chargers needed is 19% less than France's original 2015 goal of 7 million chargers by 2030. However, in an alternative scenario in which full electrification of new sales is reached in 2035, France would need a total of 7.3 million chargers, including 430,000 public chargers, in 2030. Accomplishing the French government's goal of 7 million chargers could thus put the country close to a path towards full electrification of new sales by 2035, 5 years ahead of the current target. Improving access to home charging will be a key to managing public charging needs, and greater public charger utilization, along with improved business cases for fast charging, can be expected in the future. We find that the number of EVs supported by each public charger increases from a target of 10 in 2020 to 24 in 2030 at the national level.

Leading electric vehicle-uptake areas, typically in urban areas, show the largest increase in charging needs, but major infrastructure support is also needed across France's rural areas. Denser, affluent urban areas like Paris and Marseille had the highest electric vehicles uptake through 2020. Such urban areas show the greatest need for expanded public charging infrastructure by 2030, in part due to lower home charging availability in their denser urban cores. For France to decarbonize its transport sector and equitably realize electric vehicles' benefits, electric vehicle uptake and overall charging infrastructure will need to increase more quickly in less affluent and more rural areas.

Growing energy demand for electric vehicles over time is manageable. To support electric vehicle growth, the annual charging energy demand will grow from 1.0 terawatt-hours (TWh) in 2020 to 16 TWh in 2030, amounting to an average annual increase of 32%. The projected 2035 EV electricity demand amounts to just 7% of France's overall 2020 electricity demand of 439 TWh from all sectors. Electric vehicles' energy demand would be offset, up to 2026, by the annual 7 TWh of electricity savings spurred by the Energy and Climate Law. Any grid impacts from electric vehicle's energy demand are within the scope of planned utility upgrades to the general grid.

Different charging infrastructure outcomes are possible by 2035 depending on national priorities and home charging access. According to our sensitivity analysis, the total number of public chargers needed could increase by as much as 23% in 2030 compared to our base scenario if the national target for phasing out sales of internal combustion engines were moved forward to 2035, and could decrease by 14% if national and local policies were to encourage a decrease in car dependency. Additionally, the scenarios are sensitive to policies that encourage one type of charging over another, and an increase in one type of charging will result in a decrease in the need for another. We find that increased home charging has a proportional effect on decreasing the need for public chargers. The 4.5 percentage point increase (i.e., 64.5% to 69%) in home charging access approximately decreases the need for public urban chargers (normal AC and fast urban) by 5%. This reflects the importance of increasing access to overnight charging, for example for residents in apartments.

A new coordinated charging infrastructure framework could galvanize investments. While providing basic charging coverage has been important in building confidence during early market development, further targeted charger implementation is needed to spur charging investments and meet drivers' needs. Based on developments in France and elsewhere, a promising approach would be to implement a coordinated charging installation process based on identified charging demand, clear guidance to ensure equitable access, and streamlined permitting. Doing so could inform, coordinate, and catalyze investments across different stakeholders to enable France's electric mobility transition.

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APPENDIX

This Appendix provides additional details on the data inputs and assumptions for the entire model (Table A1), for light commercial vehicles (Table A2), and for taxis and PHVs (Table A3). In addition:

» Figure A1 is a map of Metropolitan France overlaid with department numbers.

» Figure A2 presents the total energy demand by Metropolitan France regions in 2025, 2030, and 2035. The remaining figures present public charging data in different manners.

» Figure A3 displays the number of public normal and fast chargers per department required in 2030.

» Figure A4 displays the number of public chargers required by settings (normal AC, fast urban, fast highway) for every Metropolitan France region in 2025, 2030, and 2035.

» Figure A5 presents the number of normal and fast chargers for taxis and PHV drivers in the largest urban areas in 2025 and 2030.

» Table A4 presents the total number of chargers per region and per category in 2025, 2030, and 2035.

» Table A5 presents the breakdown of fast highway chargers per highway for 2025, 2030, and 2035.

Table A1. Summary of data inputs and assumptions for the charging infrastructure model (some inputs evolve over time between end of 2020 and 2035 while others remain constant).

		2020	2025	2030	2035
Electric vehicles on the roads*	Passenger cars	388,851	2,663,486	7,273,739	13,315,542
	Light commercial vehicles	50,922	298,599	1,053,703	2,452,193
	Taxis and PHVs	22,632	60,560	127,147	127,147
Market share of electric new vehicle registrations (national average)		10%	28%	55%	79%
Ratio of BEV and PHEV among EVs for new car registrations (national average)	BEV	60%	75%	86%	92%
	PHEV	40%	25%	14%	8%
Share of passenger electric vehicle owners with home charging (national average)		76%	69%	65%	60%
Share of EVs used for commuting (national average)		57%	54%	54%	56%**
BEV and PHEV average charging acceptance rate (kW)	BEV	8.1	8.6	9	9.5
	PHEV	3.4	4.0	4.6	5.3
	Fast charging acceptance rate (kW)	40	60	80	90
New passenger vehicle average efficiency (kWh per km)	BEV	0.160	0.156	0.152	0.149
	PHEV	0.229	0.223	0.218	0.213
Passenger average vehicle kilometers per year (national average)	Commuter	13,691	13,019	12,773	12,569
	Non-commuter	7,829	7,346	7,274	7,282
Charging daily utilization in hours (national average)	Workplace	5 hours per workday			
	Public AC	1.6	2.9	3.6	4.0
	Public fast	1.6	2.8	3.6	4.0

* The 2020 total does not add up to 470,295 because 470,295 is the cumulative EV registrations since 2010 whereas values in this row represent the number of EVs on French roads based on the stock turnover model.

** The share of EVs used for commuting increases again after 2030 even if teleworking keeps increasing due to mass electric vehicle adoption in rural areas where households are less likely to telework and more reliant on their vehicle to go to work.

Table A2. Allocation of energy needs per driver category for light commercial vehicles.

Vehicle type	Type of use	Parking location	Home charging	% electric kilometers	% private home	% private depot	% public normal	% Fast urban	% Fast corridor	Share of BEV and PHEV category	VKT (per working day for company cars)
BEV	Services	Home	Yes	100%	75%	0%	10%	10%	5%	8%	123.0
			No		0%	0%	60%	30%	10%	1%	
		Depot	N/A		0%	75%	10%	10%	5%	10%	
	Goods transport	Home	Yes		85%	0%	5%	5%	5%	13%	80.0
			No		0%	0%	65%	30%	5%	2%	
		Depot	N/A		0%	85%	5%	5%	5%	18%	
	Company cars others	Home	Yes		85%	0%	5%	5%	5%	3%	72.9
			No		0%	0%	65%	30%	5%	0%	
		Depot	N/A		0%	80%	5%	10%	5%	5%	
	Private LCV	Home	Yes		85%	0%	5%	5%	5%	33%	27.4
			No		0%	0%	55%	40%	5%	8%	
PHEV	Services	Home	Yes	50%	85%	0%	15%	0%	0%	8%	123.0
			No		0%	0%	100%	0%	0%	1%	
		Depot	N/A		0%	85%	15%	0%	0%	10%	
	Goods transport	Home	Yes		90%	0%	10%	0%	0%	13%	80.0
			No		0%	0%	100%	0%	0%	2%	
		Depot	N/A		0%	90%	10%	0%	0%	18%	
	Company cars others	Home	Yes		90%	0%	10%	0%	0%	3%	72.9
			No		0%	0%	100%	0%	0%	0%	
		Depot	N/A		0%	90%	10%	0%	0%	5%	
	Private LCV	Home	Yes		90%	0%	10%	0%	0%	33%	27.4
			No		0%	0%	100%	0%	0%	8%	

Table A3. Allocation of energy needs per driver category for taxis and PHVs.

Vehicle type	Off street parking?	% electric km	% private home	% public normal AC	% public fast urban	Share of category	Number of kilometers driven per day in 2018
PHEV	No	50%	0%	95%	5%	67%	143
BEV	No	100%	0%	50%	50%		
PHEV	Yes	50%	95%	0%	5%	33%	
BEV	Yes	100%	80%	0%	20%		

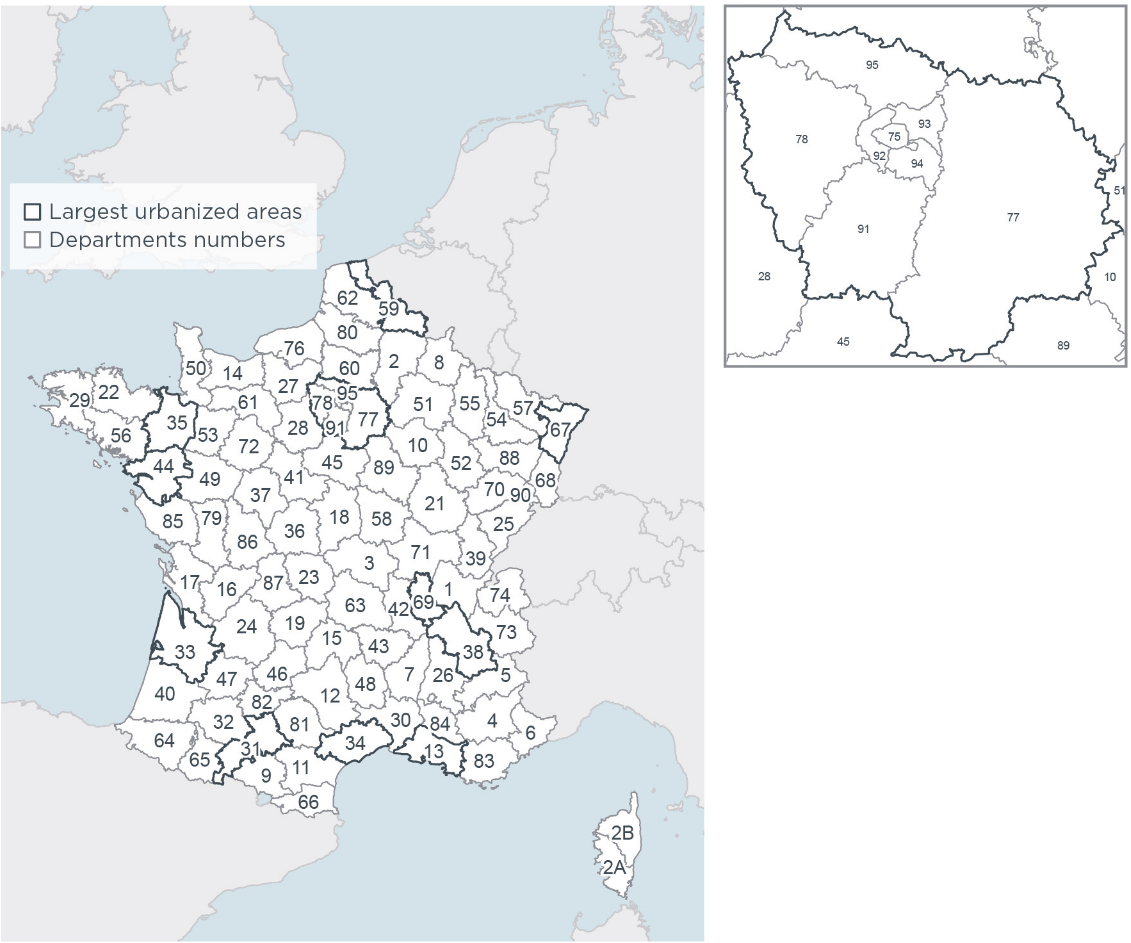

Figure A1. Metropolitan France department numbers. Inset: Île-de-France

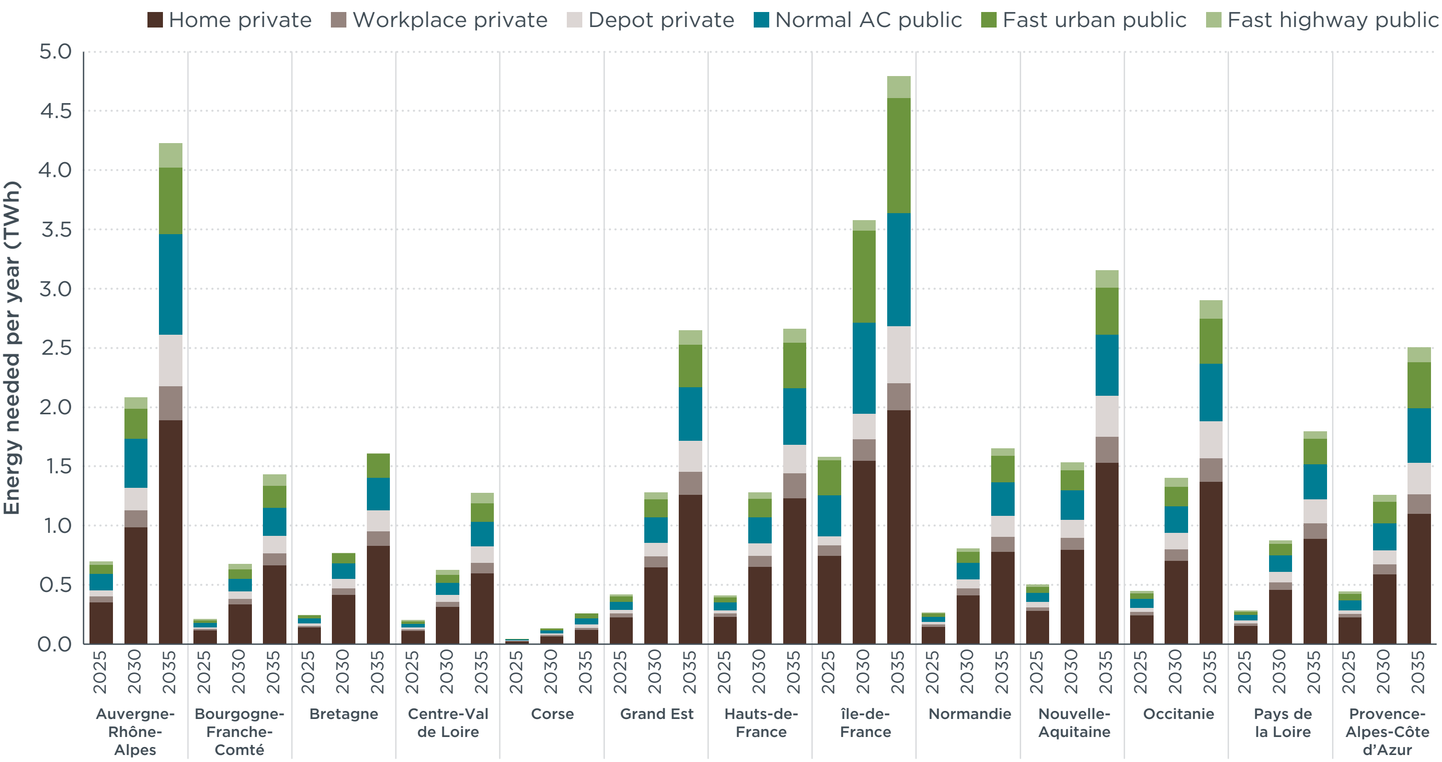

Figure A2. Energy demand by setting (in TWh) for every Metropolitan France region in 2025, 2030, and 2035.

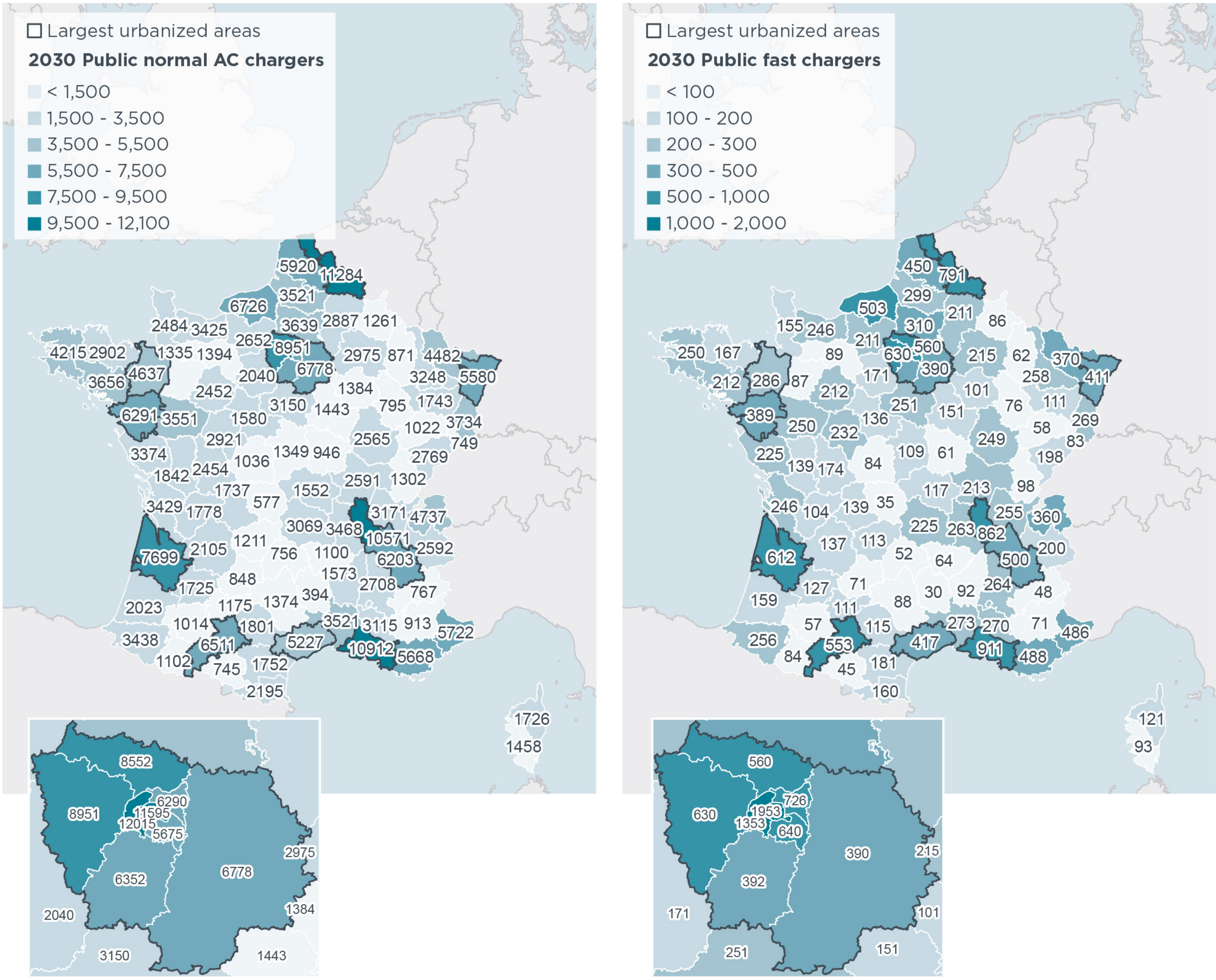

Figure A3. Public normal (left) chargers and fast (right) chargers needed by 2030.

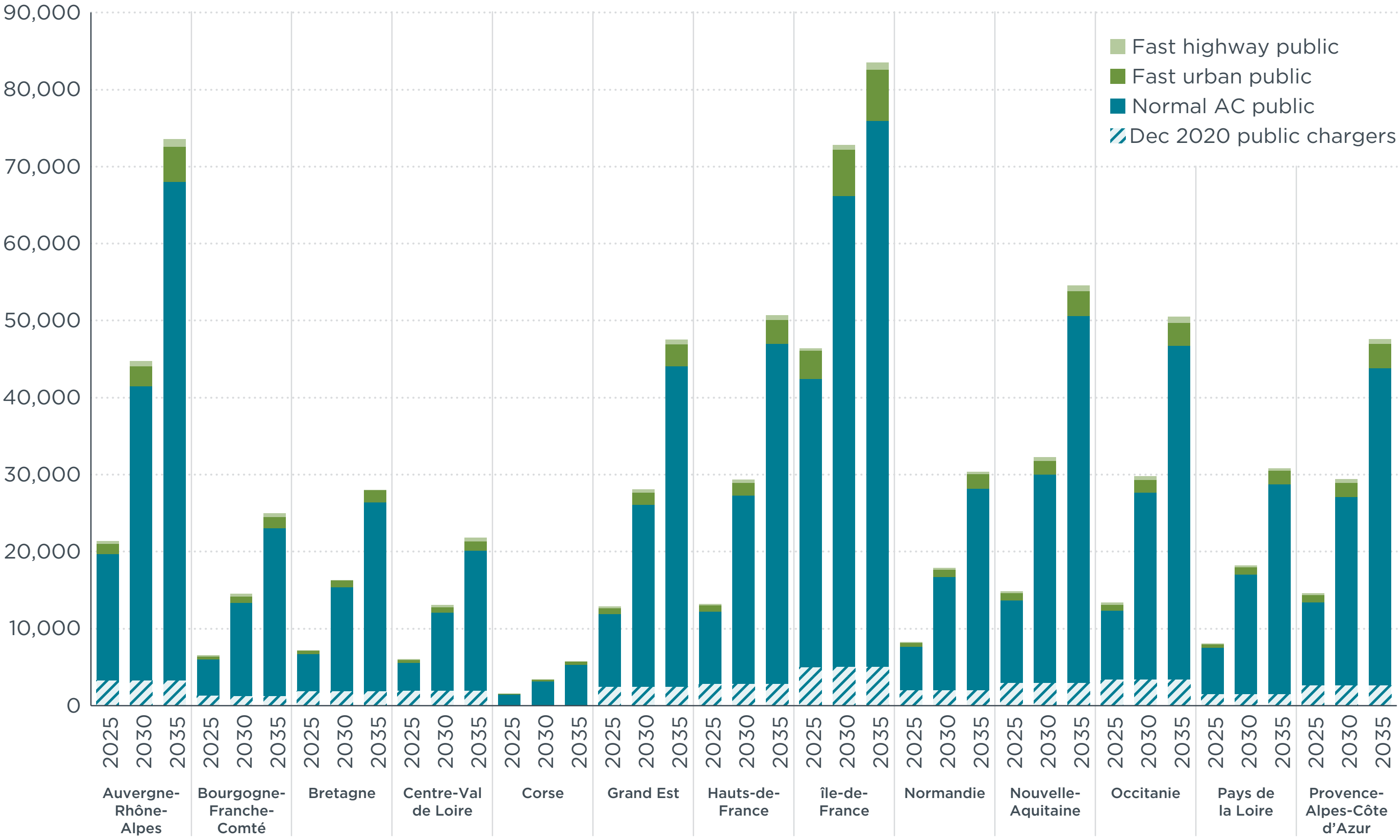

Figure A4. Number of public chargers needed by 2030 for every Metropolitan France region.

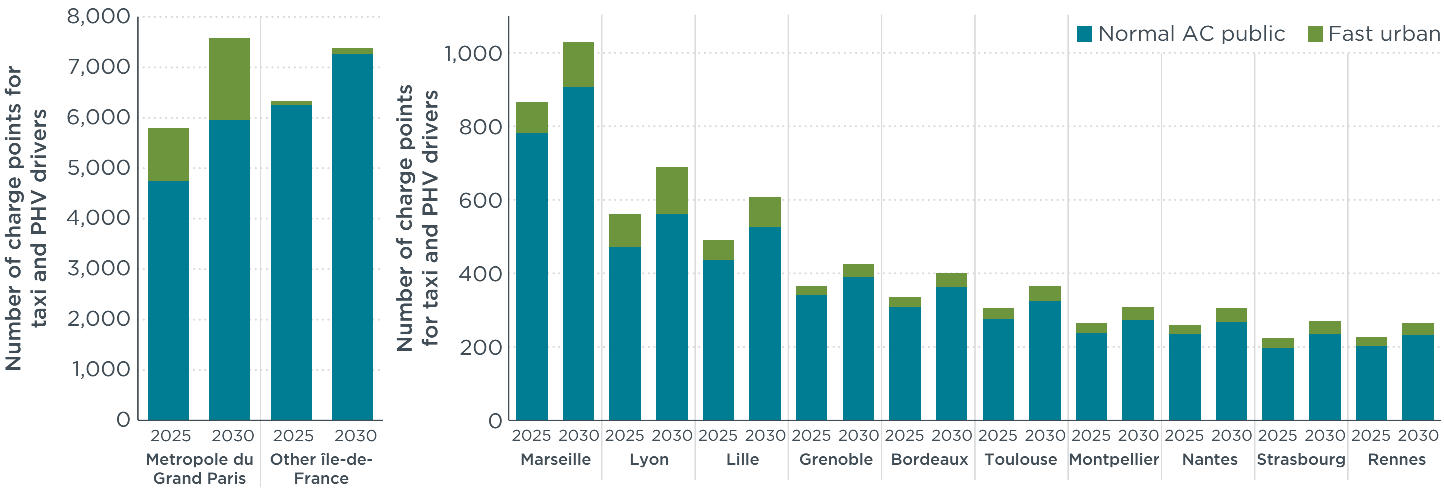

Figure A5. Number of normal AC and fast urban chargers in 2025 and 2030 for taxi and PHV drivers in the departments of the largest urban areas (Île-de-France for the left figure and other large urban areas on the right with a different scale).

Table A4. Total number of chargers per region and per category in 2025, 2030, and 2035.

Region	Year	Normal AC public	Private workplace	Fast urban public	Fast highway public	Home private	Depot private
Auvergne-Rhône-Alpes	2025	19,709	8,636	1,294	333	208,633	5,769
	2030	41,499	21,368	2,583	671	584,529	21,753
	2035	68,072	37,897	4,473	1,033	1,163,391	51,575
Bourgogne-Franche-Comté	2025	6,016	2,641	377	157	63,487	1,881
	2030	13,388	7,065	796	315	192,407	7,459
	2035	23,056	13,433	1,462	485	404,310	17,684
Bretagne	2025	6,730	3,075	422	9	78,310	2,231
	2030	15,409	8,356	896	19	238,063	9,136
	2035	26,402	15,691	1,615	29	496,108	21,660
Centre-Val de Loire	2025	5,555	2,505	346	135	63,015	1,828
	2030	12,075	6,486	712	272	182,473	6,910
	2035	20,113	11,677	1,254	419	364,959	16,383
Corse	2025	1,448	621	109	0	15,036	301
	2030	3,184	1,506	214	0	38,721	1,387
	2035	5,304	2,714	375	0	72,349	3,288
Grand Est	2025	11,912	5,544	759	195	133,508	3,378
	2030	26,072	14,326	1,567	391	386,684	12,874
	2035	44,084	26,273	2,823	603	785,818	30,523
Hauts-de-France	2025	12,232	5,385	798	187	139,810	3,061
	2030	27,251	14,553	1,685	376	403,717	12,114
	2035	46,990	27,673	3,103	578	801,921	28,721
Île-de-France	2025	42,429	14,692	3,681	295	599,927	8,546
	2030	66,208	26,333	6,049	594	1,241,264	23,995
	2035	75,958	28,735	6,651	914	1,522,299	56,890
Normandie	2025	7,631	3,387	494	100	85,375	2,311
	2030	16,681	8,910	1,002	202	242,713	8,813
	2035	28,233	16,363	1,801	311	479,976	20,894
Nouvelle-Aquitaine	2025	13,740	6,109	855	232	157,947	4,757
	2030	30,017	15,988	1,774	466	457,429	17,187
	2035	50,658	29,122	3,189	718	921,638	40,749
Occitanie	2025	12,304	5,483	801	250	142,904	3,789
	2030	27,657	14,315	1,683	502	417,540	15,708
	2035	46,723	26,251	3,015	773	843,483	37,242
Pays de la Loire	2025	7,540	3,662	451	104	89,863	2,576
	2030	17,003	9,625	955	209	264,674	10,059
	2035	28,761	17,501	1,720	321	535,724	23,849
Provence-Alpes-Côte d'Azur	2025	13,400	5,115	980	204	137,054	3,707
	2030	27,098	12,478	1,864	410	364,465	13,161
	2035	43,829	22,035	3,122	631	700,832	31,203

Table A5. Number of fast corridor chargers per highway in 2025, 2030, and 2035.

	2025	2030	2035		2025	2030	2035		2025	2030	2035		2025	2030	2035
A1	16	32	49	**A36**	37	75	115	**A85**	18	36	56	**A411**	1	1	2
A2	4	7	10	**A38**	4	7	11	**A86**	29	58	89	**A430**	2	4	6
A3	16	32	49	**A39**	18	35	54	**A87**	13	25	39	**A432**	5	11	16
A4	107	215	330	**A40**	35	70	108	**A88**	2	4	6	**A450**	3	6	10
A5	25	50	77	**A41**	31	61	94	**A89**	47	94	145	**A466**	1	1	1
A6	131	264	406	**A42**	16	32	50	**A103**	1	2	3	**A500**	1	1	2
A7	119	239	368	**A43**	40	80	124	**A104**	7	14	21	**A501**	1	1	2
A8	91	183	282	**A46**	15	30	46	**A105**	4	7	10	**A520**	1	1	2
A9	82	164	252	**A48**	15	31	47	**A115**	6	11	17	**A620**	16	31	48
A10	145	292	449	**A49**	11	21	33	**A126**	1	3	4	**A621**	3	6	9
A11	67	135	207	**A50**	23	46	71	**A131**	8	16	24	**A623**	1	1	1
A12	7	13	19	**A51**	20	40	61	**A132**	1	1	2	**A624**	4	7	11
A13	82	165	254	**A52**	9	17	26	**A139**	1	2	3	**A630**	23	46	70
A14	5	10	16	**A54**	9	17	26	**A140**	1	2	3	**A645**	1	1	1
A15	21	42	65	**A57**	11	22	33	**A150**	4	7	10	**A660**	2	4	6
A16	44	87	134	**A61**	45	90	138	**A151**	3	5	7	**A714**	1	2	3
A19	9	17	26	**A62**	54	107	165	**A154**	2	3	5	**A719**	1	2	3
A20	59	118	181	**A63**	39	78	119	**A211**	1	2	2	**A811**	2	3	4
A21	9	18	28	**A64**	45	89	137	**A216**	1	1	1	**A813**	1	1	1
A23	13	26	39	**A65**	8	15	23	**A311**	1	2	2	**A837**	3	6	9
A25	6	12	18	**A66**	4	7	10	**A314**	1	1	1				
A26	39	79	121	**A68**	10	21	31	**A315**	1	2	2				
A27	1	2	3	**A71**	50	100	154	**A320**	3	6	9				
A28	25	50	76	**A72**	15	30	46	**A330**	4	7	11				
A29	21	42	65	**A75**	28	55	84	**A344**	3	5	7				
A30	5	9	14	**A77**	10	19	30	**A351**	2	4	6				
A31	70	141	217	**A81**	14	28	42	**A391**	1	1	1				
A33	9	17	27	**A82**	1	1	2	**A404**	2	4	5				
A34	6	12	18	**A83**	22	45	68	**A406**	1	1	2				
A35	25	50	77	**A84**	27	54	82	**A410**	5	9	14				

* When the number of chargers was less than one, it was rounded up to 1.