EV charging in 7 European cities

A comparative analysis of charging infrastructure

April 2022

Summary

Battery electric vehicles (BEVs) are one of the strongest solutions for combating climate change and improving local air quality in urban areas. In Europe, passenger vehicles powered by internal combustion engines (ICE) are responsible for 12% of GHG emissions, for 28% of NOx emissions, for 5% of PM2.5 emissions, accounting for significant portions of nearly all local air pollutants. In cities specifically, passenger vehicles contribute to 47-55% of NOx emissions, and 13-39% of PM2.5 emissions. Thus, residents of European cities are at high risk for transport related air pollution.

Consequently, European cities are moving quickly to confront the pollution problem. A major strategy is stimulating adoption of BEVs, as well as other zero-emission solutions. Some cities have made bold targets to ban ICE vehicle use by 2030, while others have already begun to phase-out ICE vehicle use among private-hire vehicles (PHVs) and taxis. Such steps are encouraging, but they risk being highly problematic if infrastructure is not in place to make the transition to a BEV easy.

To inform a broad community of stakeholders (policy-makers, regulators, PHV and taxi companies, vehicle suppliers, charging equipment suppliers, and infrastructure developers) on the charger infrastructure challenge faced by cities, Transport & Environment collaborated with Guidehouse Insights to analyse the progress of seven European cities.

To do so, Guidehouse Insights evaluated data on public charging deployments, BEV adoption, and the evaluation of government support measures. The seven cities were ranked according to: (a) how well developed the public charging network is relative to the number of BEVs and the overall vehicle fleet of the city, and (b) the scope of actions adopted by city and national governments to support charger deployments and use –both public and private.

The results show that London leads the 7 cities thanks to their greater charging infrastructure roll-out, higher average charger capacity and key policies to support the uptake of BEVs –such as phasing in zero-emissions capability requirements to private hire vehicles (PHVs) and taxi licensing regulations by 2025. Amsterdam –who is targeting the ban of ICE vehicles from city streets by 2030– and Berlin follow London with good charging infrastructure and appropriate policies, but Paris,

Brussels, Madrid and Lisbon fall behind with either charging infrastructure that is lacking, policies that are inadequate to accelerate the transition to BEV fleets, or both.

City	Charger power to BEVs (kW)	Charger power per 100 vehicles (kW)	Government Actions Score (out of 10)
1 London	2.4	5.6	8.0
2 Amsterdam	1.4	6.0	6.5
3 Berlin	1.9	3.3	5.0
4 Paris	0.7	0.7	9.5
5 Brussels	1.4	2.7	6.0
6 Madrid	0.7	0.3	7.5
7 Lisbon	0.8	1.1	3.0

As seen on the ranking, the two cities that rank highest –London and Amsterdam– do so thanks to a high roll-out of public charging infrastructure and bold targets for transitioning away from ICE vehicles as quickly as possible with assertive plans to prohibit their use.

London and Amsterdam are standing well above the rest of the cities in public or semi-public charger numbers, with about 11,000 for the former and close to 8,000 for the latter. With the exception of Paris –standing at around 7,000 chargers– the rest of the cities don't even come close, while at the bottom of the ranking, Madrid and Lisbon really struggle with around 700 chargers only each. Moreover, London stands out as the only city that has over 2 kW of average charger power for existing BEVs, while Amsterdam is the only city with over 6 kW of average charger power per 100 vehicles (which shows the great potential of Amsterdam for converting ICE vehicles fleet to fully electric).

A combination of city fast-charging hubs in key areas of the city and slow on-street chargers where people live has hence proved to be the way forward, as London and Amsterdam clearly show. Furthermore, in addition to banning the sales of ICE vehicles at national or EU level, plans at city level to prohibit the use of ICE vehicles will set the right policy signals for private market actors to invest in BEV solutions and therein charger infrastructure deployment.

The analysis also indicates that where governments have been ambitious with policy, the charging infrastructure deployment has been better. A key action among all of these cities are programs and policies to make chargers available in residential areas. Other notable actions include charger-ready building codes, public and private and workplace charger deployment subsidies. While progress in these cities is encouraging, there is still more that can and should be done. Specifically, adopting policies to enforce a 'right to plug', which would facilitate and accelerate the processing of charger requests for tenants in shared residential buildings and employees of workplaces.

1. Introduction

It is well established that internal combustion engine powered vehicles (ICE vehicles) have significant negative impacts on climate and local air quality. In the EU, road transport is reported by the European Environment Agency (EEA) to account for roughly 22% of greenhouse gas (GHG) emissions[1]. Of these emissions, passenger vehicles account for nearly three quarters (and represent 12% of total EU-27 GHG emissions)[2]. Meanwhile, the EEA reports exhaust from road transport to account for a significant portion of all main local air pollutants save SOx[3]. In cities specifically, passenger vehicles contribute to 47-55% of NOx emissions, and 13-39% of PM2.5 emissions[4]. The concentration of local air pollutants rises in the heavily congested urban environment, placing residents at increased risk to personal health. As demonstrated by an ICCT analysis, Europe is a special case with the 10 most risky places for transport related air pollution being European cities[5].

The confluence of ICE vehicle impacts on climate and local air quality is pushing governments at all levels to stimulate adoption of battery electric vehicles (BEVs), including plans to ban sales and use of ICE vehicles. These efforts are strongest among European cities like Amsterdam and London. The former is targeting the ban of ICE vehicles from city streets by 2030 and the latter is phasing in zero-emissions capability requirements to private hire vehicles (PHVs) and taxi licensing regulations by 2025. While the execution of these plans may have dramatically positive impacts on local air quality and is an encouraging step toward reducing GHG emissions, it is likely to raise complications for transport system users and providers unless effective BEV solutions are in place.

The leading solution to supplant the ICE vehicle is the battery electric vehicle (BEV). Over the past decade BEV adoption has witnessed considerable growth in Europe and the global market. In Europe (EU + EFTA + UK), sales reached 1,200,000 in 2021, making up over 10% of the region's overall passenger car market. The success of the technology is fueling dramatic investments in research and development that promise to make future BEVs increasingly cost and capability competitive with ICE vehicles. In Europe alone, Guidehouse Insights expects over 46 million BEVs will be in circulation by 2030[6].

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[1] European Environment Agency. *EEA greenhouse gases – data viewer,* 13 April 2021. https://www.eea.europa.eu/publications/data-and-maps/data/data-viewers/greenhouse-gases-viewer

[2] European Environment Agency. National emissions reported to the UNFCCC and to the EU Greenhouse Gas Monitoring Mechanism, 31 May 2021. https://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-unfccc-and-to-the-eu-greenhouse-gas-monitoring-mechanism-17

[3] European Environment Agency. *Emissions of air pollutants from transport*, 22 November 2018. https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-air-pollutants-8/transport-emissions-of-air-pollutants-8

[4] Tim Williamson & Dr Ben Marner, Air Quality Consultants. *Covid-19, Air Quality and Mobility Policies: Six European Cities*, March 2021 https://www.transportenvironment.org/wp-content/uploads/2021/07/J4178%20Covid-19%20and%20Mobility%20Policies_v5_final%20March%202021_1.pdf

[5] Susan Anenberg, Joshua Miller, Daven Henze, Ray Minjares. *A global snapshot of the air pollution-related health impacts of transportation sector emissions in 2010 and 2015.* ICCT. 26 February 2019. https://theicct.org/publications/health-impacts-transport-emissions-2010-2015

[6] Guidehouse Insights. *Market Data: EV Charging Equipment, 2021.* https://guidehouseinsights.com/reports/market-data-ev-charging-equipment

While the progress BEVs are making is encouraging, there are still considerable challenges to adoption in cities that global macro-economic forces will not be able to address. These challenges focus on the availability of charging infrastructure: the opportunities to deploy it, the systems to manage it, and the way in which drivers can use it. In this regard, each city is approaching the infrastructure challenge differently. In this context, European cities with ambitious plans for zero-emissions roads have been leading the effort to determine how to meet this challenge best.

The purpose of this report is to evaluate how seven major European cities –Amsterdam, Berlin, Brussels, Lisbon, London, Madrid, and Paris– are addressing the charging infrastructure challenge. To do so, this briefing provides an overview on the state of current and upcoming charging technologies critical to meeting infrastructure needs. The briefing then compares the examined cities on public charging infrastructure deployment to date and policies and initiatives for future charging infrastructure development. Lastly, it concludes with recommendations for city governments and market stakeholders on how the charging infrastructure gap can be closed.

1.1 Public Charging Infrastructure for the Urban Environment

Though BEV technologies have progressed significantly since 2010, vehicle range and charging infrastructure still pose operational hurdles for various types of car owners in the urban environment. The ideal BEV ownership scenario remains one where a driver has access to reliable off-street parking where a charger can be installed. This scenario is not common in cities. More common is the city resident with unreliable street parking, and the commuting PHV driver. For reasons discussed in the next two sections, these communities are affected most from city policies to promote BEVs. Hence, to accelerate BEV adoption, cities need to prioritise the development of charging infrastructure solutions for them.

1.1.1 Resident Drivers with Unreliable Parking

The urban environment is characterised by high traffic congestion. Residents have access to multiple mobility modes such as buses, trains, bicycles as well as cars. They have less space to park vehicles and hence many will not own a car but use alternative mobility options or car sharing options. For those that do own cars, many are likely to rely on highly unpredictable street parking in residential neighbourhoods. Deployment of charging infrastructure for parking spaces in these neighbourhoods has been limited due to a high dependency on public funding and development programs and physical space constraints.

For resident drivers with unreliable parking, to adopt a BEV means relying on a mix of public slow or fast charging infrastructure. Lack of, at minimum, a reliable nearby slow charging solution is hence likely to make BEV adoption a challenging inconvenience and deterrent.

1.1.2 Commuting PHV Drivers

Commuters from the city suburbs, or further afield, are more likely to rely on cars than city residents as proximity to nodes for public transit networks and feasibility of using bicycles decreases as the distance from the urban centre increases. As such, an outsized impact of a city's aspirations for EV adoption falls on these drivers. Regardless of whether the drivers have access to reliable off-street parking where a charger could be installed and used, PHV drivers are likely to see heightened daily utilisation rates that challenge the bounds of what current BEV ranges provide.

As detailed in the report *"Is Uber delivering on its promises?"* PHV drivers need reliable access to slow charging at or near their residence as well as reliable access to fast charging solutions[7]. Ideally fast charging infrastructure would be in city centres and near other congested city transport network nodes like airports, and train stations. But to date, fast charging deployments have focused more on existing petroleum retail fuel networks and on enabling inter-city travel via fast charging corridor developments on heavily trafficked highways.

2. Measuring City Progress

To prepare for BEVs, cities will need to play a strong role in public charging infrastructure development. Where city ambitions for BEV adoption are greatest, the city's role in addressing the infrastructure development gaps of its most vulnerable system users and providers should be equally great. To assess the progress cities in Europe are making to address the charging infrastructure challenge, this paper provides a comparative analysis of three performance indicators for 7 major cities: Amsterdam, Berlin, Brussels, Lisbon, London, Madrid, and Paris.

The performance indicators are based on the following metrics:

- Estimated number of BEV and overall vehicle registrations within the city's larger metropolitan area,
- Estimated power capacity of installed charger connections in the city,
- Adoption of government actions.

Primary sources used to determine the estimates for the above measures are Eurostat[8], the European Alternative Fuels Observatory (EAFO)[9], a series of reports from the International Council on

[7] *Is Uber delivering on its promises?* Transport & Environment. November 2021. https://www.transportenvironment.org/wp-content/uploads/2021/10/2021_11_Report_Uber_one_year_on.pdf
[8] Eurostat, Regions and Cities Illustrated. https://ec.europa.eu/eurostat/cache/RCI/#?vis=metropolitan.gen&lang=en
[9] European Alternative Fuels Observatory. https://eafo.eu/

Clean Transportation (ICCT)[10], and EcoMovement[11]. These sources provided consistent data for most of the seven cities. For some cities, additional local sources were used. Across all cities, quantitative estimates of BEV registrations were modelled to reflect the metropolitan area at the end of 2020. To do so Guidehouse Insights scaled reported BEV registrations within the metropolitan area from the date they were reported based on national BEV registration growth data as made available by the EAFO.

The key performance indicators used for the analysis are:

1. **Charging Power Capacity per BEV**[12] – this indicates the number of public chargers available for the fleet of registered BEVs as well as the speed at which charging services can be delivered. To determine this indicator Guidehouse Insights divided the total power capacity of chargers, as analysed by EcoMovement for Transport & Environment, by their estimate of metropolitan area BEV registrations. Cities with lower power capacities per BEV are more likely to see greater concerns from BEV owners regarding the availability and convenience of charging infrastructure. This could negatively impact BEV adoption if not addressed.

2. **Charging Power Capacity per 100 Vehicles** – this indicates how prepared cities are to convert the existing ICE vehicle fleet to BEVs. To determine this indicator Guidehouse Insights divided the total power capacity of chargers, as analysed by EcoMovement for Transport & Environment, by the overall metropolitan area vehicle fleet (divided by 100). Cities with lower power capacities per vehicle are less prepared to meet the demands of an increasing BEV fleet and therefore risk negative perceptions regarding the availability of public charging.

[10] Dale Hall, Sandra Wappelhorst, Peter Mock, Nic Lutsey. *European Electric Vehicle Factbook 2019/2020*. ICCT. https://accesshub.sharepoint.com/sites/esiportal/Mobility/5.%20Projects/TE/Sources/EV-EU-Factbook-2020.pdf?CT=1640115301829&OR=ItemsView; Dale Hall, Nic Lutsey. *Charging infrastructure in cities: Metrics for evaluating future needs*. ICCT. August 2020. https://theicct.org/sites/default/files/publications/EV-charging-metrics-aug2020.pdf; Sandra Wappelhorst, Dale Hall, Mike Nicholas, Nic Lutsey. *Analyzing policies to grow the electric vehicle market in European cities.* ICCT. February 2020. https://theicct.org/sites/default/files/publications/EV_city_policies_white_paper_fv_20200224.pdf; Michael Nicholas, Sandra Wappelhorst. Spain's electric vehicle infrastructure challenge: How many chargers will be required in 2030? ICCT. January 2021. https://theicct.org/sites/default/files/publications/Spain-EV-charging%20infra-jan2021.pdf; Marie Rajon Bernard, Dale Hall, Nic Lutsey. *Fulfilling electric vehicle charging infrastructure needs in Greater London and its boroughs.* ICCT. November 2020. https://theicct.org/sites/default/files/publications/London-EV-charging-infra-nov2020.pdf; Michael Nicholas, Sandra Wappelhorst. *Regional charging Infrastructure requirementsv in Germany through 2030.* ICCT. October 2020. https://theicct.org/sites/default/files/publications/germany-charging-infrastructure-20201021.pdf

[11] https://www.eco-movement.com/

[12] This indicator is especially important for low EV-shares in relation to the total vehicle fleet. With high and very high EV shares the utilisation rate of existing networks will increase and the installed charging power per BEV can be significantly lower. In the long run 1 kW / BEV is likely to be sufficient.

3. **Government Actions** – this indicates the level of support governments have for the development of charging infrastructure development. Cities were evaluated based on the adoption of 10 commonly used measures at both local and national levels as follows:

    - Establishing a charging infrastructure deployment target,
    - Creating an infrastructure deployment action plan detailing the strategies a city will pursue to meet the declared target,
    - Charging incentives and benefits for drivers,
    - Charging interoperability requirements,
    - Public charger subsidies provided by the city government,
    - Public charger subsidies provided by the national government,
    - Private/Workplace charger subsidies provided by the city government,
    - Private/Workplace charger subsidies provided by the national government,
    - Charger-ready building codes,
    - Programs to develop public chargers in residential areas.

    Each of the above government actions were weighted based on how impactful the action is to expanding charger availability, and whether the action was taken by the city or the national government. Actions expected to have greater impacts and led by the city rather than the national government were weighted higher than those with less impact and led by the national government. The weighting of each action is provided in the appendix alongside an overview of which city is taking which actions[13].

The three indicators above are the foundation of the comparative analysis, and therein the ranking of the seven cities in the next section. Each city's indicators were compared to all others using a normal probability distribution curve. Similar to how each government action is weighted, each indicator is weighted. Of the three, government action has the highest weighting accounting for 40% of the total score. Meanwhile, charging power capacity per BEV and charging power capacity per vehicle each account for 30% of the total score, hence attributing more overall weight to actual charging infrastructure than to policies. Rankings align with the aggregate score of the weighted indicators.

[13] Of note, an additional area for policy development as described by Transport & Environment in the report "*Recharge EU*," is improving infrastructure planning and permitting processes at shared residential buildings and workplaces[#]. Standards for processing charger deployment requests are not well-established and may be a deterrent to EV adoption. A 'right to plug' in these cases could unlock significant portions of the vehicle market.

3. Rankings

The following sections profile the seven cities of the analysis in ranked order. The profiles provide background on the city's development of charging infrastructure to date, relevant policies and initiatives impacting future charging infrastructure development, and nuances in the data.

The overall ranking of the cities alongside their ranking per each indicator is summarised in Table 1 below.

London leads the 7 cities thanks to their higher average charger capacity and key policies to support the uptake of BEVs. Amsterdam and Berlin follow London with good charging infrastructure and appropriate policies, but Paris, Brussels, Madrid and Lisbon fall behind with either charging infrastructure that is lacking, policies that are inadequate to accelerate the transition to BEV fleets, or both.

Rank	City	Charger power (kW) to BEVs	Charger power (kW) per 100 vehicles		Government Actions Score (out of 10)
1	London	2.4 (1st)	5.6 (2nd)		8 (2nd)
2	Amsterdam	1.4 (4th)	6.0 (1st)		6.5 (4th)
3	Berlin	1.9 (2nd)	3.3 (3rd)		5 (6th)
4	Paris	0.7 (6th)	0.7 (6th)		9.5 (1st)
5	Brussels	1.4 (3rd)	2.7 (4th)		6 (5th)
6	Madrid	0.7 (7th)	0.3 (7th)		7.5 (3rd)
7	Lisbon	0.8 (6th)	1.1 (6th)		3 (7th)

Table 1: City Rankings by Key Performance Indicator

1 London

- 2.4 kW per BEV – 1st
- 5.6 kW per 100 Vehicles – 2nd
- Government Actions Score: 8 – 2nd

London is estimated to have over 11,000 public and semi-public chargers. Of these, 460 are estimated to be public fast chargers. These chargers serve the greater London metropolitan area, which has the most BEVs of the cities examined at nearly 70,000. This is an adoption rate of 2.3%, second only to Amsterdam. Overall there is 2.4 kW charging capacity for every BEV, and 5.6 kW for every 100 vehicles, well ahead of most other cities. London also scores strongly on government action with 8 out of 10.

The city has several key policies to support uptake of BEVs and has been a leader in establishing the world's first LEZ (low emissions zone). Regarding BEV ambitions, London is aligned with the UK's policy to ban the sale of ICE vehicles by 2030 and is phasing out ICE vehicles from the city's Taxi and PHV fleet by 2025. The latter is supported by subsidies to support zero-emissions capable vehicle acquisitions and the allocation of public chargers for specific use by Taxi and PHV drivers. Aligned with these policies are strong charging infrastructure policies. For example, all new homes and buildings, as well as those undergoing major renovation, are required to have chargers installed from 2022. Additionally, the Office for Zero Emission Vehicles (OZEV) provides a grant for 75% of the cost for on-street charger deployments in residential neighbourhoods. Workplace charging is also subsidised with a grant to cover 75% of charger deployment costs (up to £350 per socket for a maximum of 40 sockets) and businesses can claim a 100% first year tax allowance for chargers.

The charging infrastructure strategy for London is led by the city's Electric Vehicle Infrastructure Task Force which includes stakeholders from government as well as business, energy, and infrastructure. TfL (Transport for London) published an update to the city's EV infrastructure study at the end of 2021[14]. The strategy aims to increase the distribution of slower AC chargers whilst minimising the impact of street furniture by equipping lamppost chargers and deploying pop-up charge-points. Fast charging infrastructure is to be centred around rapid charging hubs, and London aims to have one of these hubs in every sub-region of the city by 2025. The deployment of public charging is led by each of the London boroughs that collaborates with the local distribution network operator (UKPN) to determine charger sites and to nominate a charge point operator.

2 Amsterdam

- 1.4 kW per BEV – 4th
- 6.0 per 100 vehicles– 1st
- Government Actions Score: 6.5 – 4th

Amsterdam is estimated to have over 7,600 public and semi-public chargers, second only to London in this analysis. Of the seven cities, BEV adoption is highest in Amsterdam's metropolitan area with 4.4% of the fleet estimated to be BEV. This equates to over 60,000 BEVs. The adoption rate is 70% higher than the next closest city, London.

The significant lead on BEV adoption is in part driven by the Dutch charging infrastructure strategy that maximises overnight charging potential and leads to significant development of slow chargers relative to fast chargers throughout the country. This has been important since the availability of home charging in the Netherlands is limited, with 70% of households relying on public parking[15].

[14] Transport for London. London's 2030 electric vehicle infrastructure strategy. December 2021. https://tfl.gov.uk/modes/driving/electric-vehicles-and-rapid-charging

[15] Netherlands Enterprise Agency. *The National Charging Infrastructure Agenda*. https://english.rvo.nl/sites/default/files/2020/10/Factsheet%20The%20National%20Charging%20Infrastructure%20Agenda.pdf

Amsterdam has strong policies to encourage EV adoption and ambitious plans to phase out the use of ICE vehicles. The Clean Air Action Plan includes the city's Low Emissions Zone, which currently prevents diesel cars up to Euro 4 from entering. By 2025 mopeds and scooters, as well as commercial vehicles including goods vehicles, taxis/PHVs, public transport buses and coaches will all need to be zero emission to enter, and by 2030 all forms of transport must be zero emission within the city. To back up these targets the city has rolled out EV charging incentives and benefits, charger deployment subsidies, and charging interoperability requirements. City policy efforts are also strengthened by national policies like charger deployment subsidies and programs to develop charger access in residential areas.

3 Berlin

- 1.9 kW per BEV – 2nd
- 3.3 kW per 100 Vehicles – 3rd
- Government Actions Score: 5 - 6th

Berlin has over 2,100 public and semi-public chargers. These chargers support a metropolitan area BEV fleet of nearly 23,000 – equivalent to a penetration rate of 1.7%. This is the fourth highest penetration, behind Brussels and ahead of Lisbon. Overall there are 1.9 kW per BEV and 3.3 kW per 100 vehicles placing Berlin second and third. The city is a leader on charger deployment but it lags behind on government actions.

Berlin's ambitions for BEVs are behind its peers. Its LEZ is less advanced than other cities, only restricting entry to vehicles not meeting Euro 4 for diesel or Euro 1 for petrol vehicles. Actions impacting the market have primarily taken place at the national level, such as workplace charging tax exemptions, and grants up to €100,000 for grid connection costs[16][17].

The rollout of chargers in Berlin is based on its "Berliner Modell" that bases expansion on demand from charger installation requests. The approach standardises the installation operation and data requirements of all public chargers, requiring a contract between the charge point operator and the city that stipulates the rules for charger operation. This includes the stipulation that all EV chargers must be fully supplied by renewable energy.

4 Paris

- 0.7 kW per BEV– 6th

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[16] BMVI. https://www.bav.bund.de/DE/4_Foerderprogramme/6_Ladeinfrastruktur_fuer_Elektrofahrzeuge/6_1_Ladeinfrastruktur_vor_Ort/1_Antragstellung/Antragstellung_node.html

[17] The city has supplemented these national measures with grants up to €2,500 for slow chargers, €30,000 for fast chargers, €5,500 for low voltage grid connections, and €55,000 for medium voltage grid connections: IBB. https://www.ibb-business-team.de/welmo/finanzierungsfoerderung/

- 0.7 kW per 100 Vehicles– 6th
- Government Actions Score: 9.5 – 1st

Over 7,000 public and semi-public chargers are deployed in Paris. However, unlike all other cities in this analysis, a vast majority of Paris' chargers are semi-public rather than public. Relative to other cities, this reduces overall charger accessibility significantly. Hence, on charging metrics Paris lags behind. The larger Paris metropolitan area is slow in terms of BEV adoption. With nearly 65,000 BEVs estimated in use, the region has a penetration of just over 1%, ranking sixth among the seven cities.

The city was once far ahead in Europe, thanks to the development of a BEV car-sharing program, Autolib', in 2011. Following financial difficulties however, the program was closed in mid-2018. As of 2020, operation of the Autolib' chargers has been contracted to Total, which is in the process of refreshing the equipment and combining it with the city's other major network, Belib'. While the city's infrastructure deployment metrics are behind, it should be noted that on government actions it is ahead, having adopted nearly all actions except charging interoperability requirements.

Like Amsterdam, Paris aspires to ban ICE vehicles in the city by 2030. To achieve this, the city has implemented a number of measures to encourage the roll out of charging infrastructure[18]. These actions supplement national level incentives and programs for charging infrastructure development like ADVENIR, which aims to finance the deployment of over 60,000 chargers by the end of 2023[19]. As of the end of 2021, the program had financed more than 55,000 chargers.

Planning of public charging infrastructure deployment is led by the city authority. The city collaborates with the grid operator to determine charge point locations to ensure even distribution of chargers across the city rather than basing locations on demand. The installation and operation of public chargers is outsourced to a charge point operator and is overseen by the city.

5 Brussels

- 1.4 kW per BEV – 3rd
- 2.7 kW per 100 Vehicles – 4th
- Government Actions Score: 6 – 5th

Brussels has nearly 1,000 public and semi-public chargers within the city and a BEV penetration rate within its metropolitan fleet of 1.9%. This is the third highest penetration rate among the cities and equates to nearly 11,000 BEVs. The city's charging infrastructure metrics place it within the middle of the seven. However, government action lags.

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[18] Actions of note include incentivizing the development of private chargers with subsidies up to €500 per charger for apartment complexes and a subsidy of up to €4,000 for charging equipment at car parks: Paris. Les aides financières pour inciter à des mobilités propres. https://www.paris.fr/pages/lutte-contre-la-pollution-les-aides-a-la-mobilite-5373/

[19] ADVENIR. https://advenir.mobi/

Brussels does intend to improve its situation. The city is looking to phase out ICE vehicles progressively by 2035 and, aligned with this objective, has plans to double charger deployments and to deploy a program for residential public charger deployments. By 2035 the city is aiming for 11,000 chargers, equivalent to London's current public and semi-public charger base, but serving a metropolitan vehicle fleet 1/6th the size. The city has also established policies to subsidise public and workplace charger installations. For example, companies are exempt from a tax of €5 per m^2 on parking space if they equip parking with charging stations[20].

6 Madrid

- 0.7 kW per BEV – 7th
- 0.3 kW per 100 Vehicles– 7th
- Government Actions Score: 7.5 – 3rd

Madrid has nearly 700 public and semi-public chargers, the lowest of the seven cities. These serve a BEV fleet of nearly 22,000 which is roughly 0.5% of the metropolitan area's overall vehicle fleet. As a result, Madrid has 0.7 kW per BEV And 0.3 kW per 100 vehicles, the lowest metrics of the cities analysed. Overall Madrid's charger deployment lags. However, it does have strong scores for government actions.

BEV adoption in Madrid is primarily tied to national aspirations, such as the target of 5 million BEVs by 2030[21] and banning ICE vehicles from 2040 on. To support these targets, the country supports charger deployments by providing grants of up to 50% or €100,000 towards the cost of purchasing and installing public chargers[22]. The grant scheme aims to deploy 100,000 chargers in the country by the end of 2023. Madrid's actions focus more on reducing BEV costs: for example, the city has implemented beneficial policies for purchase, registration, company car taxes, parking, and road access.

7 Lisbon

- 0.8 kW per BEV – 5th
- 1.1 kW per 100 Vehicles– 6th
- Government Actions Score: 3 – 7th

Lisbon has over 700 public and semi-public chargers. These serve the metropolitan area BEV fleet estimated to be over 17,000, 1.4% of the area's overall vehicle fleet. The penetration rate is third to last among the cities. Lisbon's charger deployment metrics lag leading cities with 0.8 kW per BEV and 1.1 kW per 100 vehicles. It lags greatest, however, in government action.

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[20] The City of Brussels. https://www.brussels.be/electric-charging-points

[21] Integrated National Energy and Climate Plan. https://ec.europa.eu/energy/sites/ener/files/documents/es_final_necp_main_en.pdf

[22] IDAE. https://www.idae.es/ayudas-y-financiacion/para-movilidad-y-vehiculos/plan-moves-ii/convocatorias-de-las-comunidades-autonomas

From a policy perspective Lisbon is markedly less ambitious than other cities. Policies to promote development of charging infrastructure have been driven at the national level via the public charger program, MOBI.E. The program is targeting to increase network size to 20,000 by 2025 from over 2,000 at the end of 2021[23]. While the development of public EV charging infrastructure is managed by MOBI.E, utilities like EDP have focused on increasing the deployment of EV chargers for residential complexes and workplaces[24]. On charging infrastructure actions, the city lags the others significantly.

4 Conclusions and Recommendations

The seven cities evaluated in this study demonstrate a wide range of performance across the key indicators for charging infrastructure progress. Cities that rank highest –London and Amsterdam– clearly stand out with a high roll-out of public charging infrastructure and bold targets for transitioning away from ICE vehicles as quickly as possible with assertive plans to prohibit their use.

The key element that really makes a difference to position a city high up in the ranking is the current status of charging infrastructure –i.e. how many public or semi-public charge points are available– in the seven metropolitan areas. London and Amsterdam are standing well above the rest of the cities in public or semi-public charger numbers, with about 11,000 for the former and close to 8,000 for the latter, and therefore lead the ranking. With the exception of Paris –standing at around 7,000 chargers– the rest of the cities don't even come close, while at the bottom of the ranking, Madrid and Lisbon really struggle with around 700 chargers only each. Moreover, London stands out as the only city that has over 2 kW of average charger power for existing BEVs, while Amsterdam also stands out by being the only city with over 6 kW of average charger power per 100 vehicles (which shows the great potential of Amsterdam for converting ICE vehicles fleet to fully electric).

Ambitious infrastructure roll-out with appropriate chargers and in areas where they are needed is hence key: a combination of city fast-charging hubs in key areas of the city and slow on-street chargers where people live has proved to be the way forward, as London and Amsterdam clearly show. The more public charge points are installed, combining fast-charging hubs and slow on-street charging stations where people live, the higher a city will rank on the list.

4.1 City recommendations

In addition to banning the sales of ICE vehicles at national or EU level, assertive plans at city level to prohibit the use of ICE vehicles will set the right policy signals for private market actors to invest in BEV solutions and therein charger infrastructure deployment. Amsterdam and Paris' declarations to ban access to ICE vehicles by 2030 are notable examples of this, while London's ULEZ zone presently

[23] MOBI.E. https://www.mobie.pt/en/redemobie/rede-como

[24] Of note, the city has established LEZs requiring PHVs to be zero-emissions to gain access. This policy is seen as a primary driver for speeding the electrification of Uber's fleet within the city with 9% of rides being electric as of late 2021: https://www.transportenvironment.org/wp-content/uploads/2021/10/2021_11_Report_Uber_one_year_on.pdf

has the most stringent emissions restrictions and widest scale. Berlin, Madrid, Lisbon, and Brussels have been less ambitious and could stimulate their uptake of BEVs and deployment of public chargers with greater ICE vehicle restrictions.

However, regardless of the targets adopted, further actions to support the market are needed. In this regard, leading cities have implemented policies that affect multiple areas of charger deployment and use. This includes subsidisation of charger deployment, policies regarding public charger deployment in residential neighbourhoods, charger-ready building codes, incentives and benefits for the use of charging infrastructure, and interoperability requirements of publicly accessible chargers.

While no city has adopted all actions, leaders have adopted most, supplemented national actions, and distinguished themselves in specific actions. London and Amsterdam have focused on expanding access to slow chargers in residential districts. London, Madrid, and Paris have also adopted charger-ready building codes, while Paris also has multiple financial incentives in place for both charger deployments supplementing national programs, and for charger use.

Situations for cities lagging the leaders could be significantly improved through stronger actions. The strategy for the rollout of public charging in Lisbon, for example, lags the leaders on multiple fronts, but most markedly on financial incentives and programs for charger deployment. While Portugal has strong financial incentives for purchasing a BEV, and Lisbon has decent incentives for operating a BEV, government actions supporting charger roll-out were not identified at national or local levels. Recently, Brussels has taken strong steps on charger deployment and this may help boost the city's deployment metrics in the near-term. However, lack of charger deployment actions at the national level will likely keep Brussels behind the leaders for the foreseeable future.

4.2 EU policies

At the European level two major legislative files are important when it comes to the deployment of charging infrastructure: the Alternative Fuel Infrastructure Regulation (AFIR) and the Energy Performance of Buildings Directive (EPBD). AFIR is mainly focusing on publicly accessible infrastructure, while EPBD sets out minimum requirements for the deployment of private charging infrastructure e.g. in multi-dwelling residential buildings but also non-residential buildings, such as office buildings etc. Both files are currently under negotiation in the Council of the EU and the European Parliament.

What AFIR means for cities is that many more publicly accessible charge stations will need to be deployed by 2030 to meet the requirement for all EU Member States to provide at least 1 kW charging power for every BEV. In addition to the actual infrastructure requirements, the EU Commission is also aiming for better user-friendliness of the charging infrastructure, which should translate into better price transparency and easier payment options. The fleet based targets set by AFIR should hence help ensure that publicly accessible charge points installations increase in cities in line with the number of EVs on the road.

Complementing the AFIR implications at city level, the impact of the revision of the EPBD could be even more crucial for cities: an ambitious revision will ensure enough charging infrastructure for all building types –both residential and non-residential– and would facilitate the process of installing charge points for private individuals, notably through the right to plug rule.

However, both proposals have weaknesses. Hence, AFIR and EPBD should be improved in order to remove remaining obstacles when it comes to EV charging, whether it happens in private or public settings.

4.2.1 Public charging - Alternative Fuel Infrastructure Regulation (AFIR)

The AFIR proposal is already a solid framework that will ensure sufficient publicly accessible charging infrastructure across Europe by mandating a minimum installed charging power of 1 KW for each BEV that is registered in the territory of a member state. While T&E sees this as sufficient in the long run, policy makers **should improve this fleet-based charging infrastructure targets** by linking them to the EV-share in a country's fleet and ensure an absolute minimum target. This ensures member states with a relatively low EV-share in their total vehicles fleet are obliged to provide sufficient infrastructure:

- **Minimum power output per BEV**: If EV fleet share is < 1% ➜ **3 kW**; <1 - 2.5% ➜ **2.5 kW**; < 2 - 5% ➜ **2 kW**; < 5 - 7.5% ➜ **1.5 kW**; above 7.5% ➜ **1 kW.**
- **Safeguard mechanism**: minimum charging infrastructure in every member state for at least 2% EV-share in 2025, 5% in 2027 and 10% in 2030.

Furthermore, AFIR should **enable cars to charge where they park** and enable especially people in urban areas without any access to private charging to charge their EV by making it mandatory for medium and large commercial properties to equip 15% of their parking spaces with public accessible chargers.

4.2.2 EU targets for charging in buildings

The EPBD proposal on the other hand is important to address private charging, which according to the Commission's own impact assessment will account for 60 - 85% of all charging cycles in 2030. T&E sees a clear improvement in the Commission's new proposal when taking into account the requirements of the directive that is currently in force, namely ambitious requirements for new buildings and buildings undergoing major renovation –with all parking spaces having to be 'Ev-ready' and pre-cabled for possible future charging points.

The proposal is however, weak when it comes to requirements for existing buildings - especially existing residential buildings - which make up the vast majority of all buildings in the EU. T&E thus recommends to have pre-cabling requirements for all parking spaces for all existing buildings (>3 parking spaces) latest by 2035 with intermediate targets of 15% in 2027 and 30% in 2030. For publicly owned or occupied buildings all parking spaces should be already pre-cabled by 2030 at the latest.

Furthermore, for all existing non-residential buildings (>10 parking spaces) at least 15% of all parking spaces should have an installed charging point by 2030 and 30% by 2035. New non-residential buildings and those undergoing major renovation should have a charging point for every second parking space as a minimum.

Last but not least, to lower the entry barriers to e-mobility, the EPBD should guarantee a ‘right to plug’ that would ensure that the latency between the application or a private charging point and the actual installation is no longer than three months.

Appendix

City Charging Infrastructure Metrics

City	Public Chargers (#)	Semi-Public Chargers (#)	Charger Capacity (kW)	Metropolitan Area BEV Fleet (#)	Metropolitan Area Vehicle Fleet (#)
Amsterdam	5,227	2,407	83,536	61,673	1,389,380
Berlin	1,698	420	43,583	22,729	1,328,836
Brussels	536	428	15,306	10,653	570,077
Lisbon	625	111	13,926	17,167	1,216,370
London	5,303	5,862	163,892	68,104	2,913,465
Madrid	550	141	15,527	21,704	4,625,861
Paris	1,143	5,925	47,017	64,665	6,334,433

Government Actions by City

Action	Weight	Amsterdam	Berlin	Brussels	Lisbon	London	Madrid	Paris
Charging infrastructure deployment target	5%		X	X	X	X		X
Infrastructure action plan	5%	X	X	X	X	X	X	X
Charging incentives and benefits for drivers	15%	X		X	X	X		X
Charging interoperability requirements	5%	X	X	X	X			
City public charger promotions	15%	X	X	X		X	X	X
City private and workplace charger promotions	15%			X			X	X

National public charger promotions	5%	X	X			X	X	X
National private and workplace charger promotions	5%	X				X	X	X
Charger ready building codes	15%					X	X	X
Residential area public charging programs	15%	X	X			X	X	X
Total Government Actions Score (out of 10)	100%	6.5	5	6	3	8	7.5	9.5

Bibliography

Dale Hall, Nic Lutsey. *Charging infrastructure in cities: Metrics for evaluating future needs*. ICCT. August 2020. https://theicct.org/sites/default/files/publications/EV-charging-metrics-aug2020.pdf

Dale Hall, Sandra Wappelhorst, Peter Mock, Nic Lutsey. *European Electric Vehicle Factbook 2019/2020*. ICCT. https://accesshub.sharepoint.com/sites/esiportal/Mobility/5.%20Projects/TE/Sources/EV-EU-Factbook-2020.pdf?CT=1640115301829&OR=ItemsView

Guidehouse Insights. *Market Data: EV Charging Equipment, 2021.* https://guidehouseinsights.com/reports/market-data-ev-charging-equipment

Marie Rajon Bernard, Dale Hall, Nic Lutsey. *Fulfilling electric vehicle charging infrastructure needs in Greater London and its boroughs.* ICCT. November 2020. https://theicct.org/sites/default/files/publications/London-EV-charging-infra-nov2020.pdf

Michael Nicholas, Sandra Wappelhorst. Regional charging Infrastructure requirements in Germany through 2030. ICCT. October 2020. https://theicct.org/sites/default/files/publications/germany-charging-infrastructure-20201021.pdf

Michael Nicholas, Sandra Wappelhorst. Spain’s electric vehicle infrastructure challenge: How many chargers will be required in 2030? ICCT. January 2021. https://theicct.org/sites/default/files/publications/Spain-EV-charging%20infra-jan2021.pdf

Netherlands Enterprise Agency. The National Charging Infrastructure Agenda. https://english.rvo.nl/sites/default/files/2020/10/Factsheet%20The%20National%20Charging%20Infrastructure%20Agenda.pdf

Sandra Wappelhorst, Dale Hall, Mike Nicholas, Nic Lutsey. *Analysing policies to grow the electric vehicle market in European cities.* ICCT. February 2020. https://theicct.org/sites/default/files/publications/EV_city_policies_white_paper_fv_20200224.pdf

Transport & Environment (November 2021). *Is Uber delivering on its promises?* https://www.transportenvironment.org/wp-content/uploads/2021/10/2021_11_Report_Uber_one_year_on.pdf

Susan Anenberg, Joshua Miller, Daven Henze, Ray Minjares. *A global snapshot of the air pollution-related health impacts of transportation sector emissions in 2010 and 2015.* ICCT. 26 February 2019. https://theicct.org/publications/health-impacts-transport-emissions-2010-2015

Transport & Environment. *Recharge EU*. (January 2020). https://www.transportenvironment.org/wp-content/uploads/2021/07/01%202020%20Draft%20TE%20Infrastructure%20Report%20Final.pdf

Transport for London. London's 2030 electric vehicle infrastructure strategy. October 2021. https://tfl.gov.uk/modes/driving/electric-vehicles-and-rapid-charging#2030

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