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How to build an electric vehicle city: deploying charging infrastructure

Transport

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Alongside driving a shift to walking, cycling and public transport, reducing transport emissions requires cities to electrify the vehicles left on their roads: their bus fleets, municipal vehicles and remaining private vehicles. As the technology advances and costs have come down,[1] the transition to electric vehicles (EVs) is increasingly feasible for cities. Shenzhen, Amsterdam and San Jose are among the cities leading the way.[2]

The potential of electric vehicles

EVs have great potential as a way for cities to reduce local air pollution, greenhouse gas emissions and transport sector oil use. When powered by renewable energy, EVs can produce zero emissions at the vehicle tailpipe and much lower life-cycle emissions. However, they still contribute to congestion and air pollution due to particles released from tyres and braking. Therefore, a shift to EVs should be positioned within a wider plan for most city journeys to be made by public transport, bike or on foot.

The deployment of EV charging infrastructure is critical for the growth of the EV market.[3] Cities must build EV charging infrastructure at scale, and encourage investment from other stakeholders.

Here, we explain:

- the numbers and types of charger required;

- the established funding models and policies to secure investment from others; and
- the stakeholders who need to be engaged to guide your city's EV deployment.

This was first published in 2019, and updated in 2021. Read our related articles for guidance on procuring zero emission buses, and incentivising the uptake of EVs by the public.

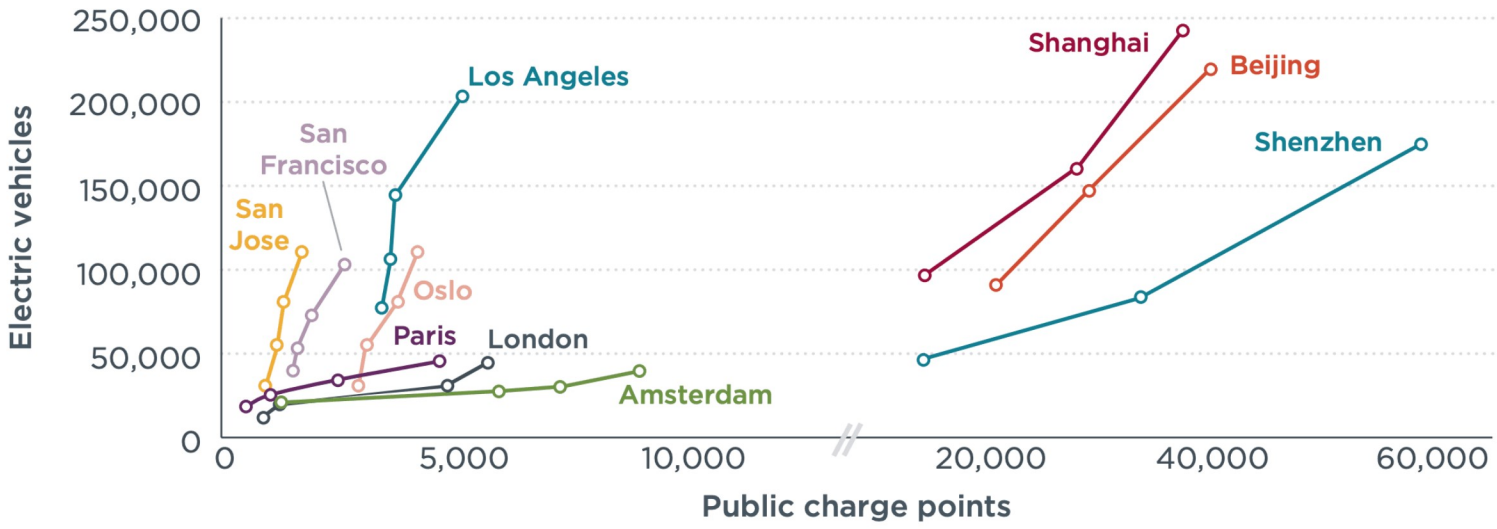
Charge point numbers: use benchmarks set by comparable cities and assess drivers' access to private charging

Plan the number of chargers based on a ratio per EV, rather than a fixed number. The key factors affecting the ratio for your city are EV drivers' access to home charging and the role of public charging in your EV uptake strategy. If more drivers are able to charge their vehicle at their home or workplace, like in Californian cities, fewer public chargers (a higher ratio of EVs per charge point) will be required. If private parking is rare, like in the Netherlands, you will need more public chargers (a lower ratio).

Building public chargers can increase the confidence of drivers to move to EVs, enable the provision of charging-related incentives, and place pressure on other stakeholders to build charging stations.[4] They should be placed to maximise usage and avoid traffic issues. Placement should also minimise stress on the power grid by placing them in areas with sufficient transformer and distribution capacity for the charger type being installed.[5, 6]

The graphic below by ICCT shows benchmark ratios of EVs to public charging points for cities in leading markets between 2015 and 2018. Ensure that charging infrastructure keeps up with demand by monitoring the numbers of EVs, EV charge points and demand for charge points. If not, this may limit EV uptake.[7] Find out about the current EV market in your country using the EV Volumes website.

Ratio of electric vehicles to public charging points for leading city markets from 2015 - 2018[8]



Read ICCT's *Electric vehicle charging guide for cities* and its companion Quick Guide to find out more about the key charging metrics for leading EV cities – including the public charge points per million population and proportion of fast chargers – as well as how factors such as your city's housing stock, commuting patterns and vehicle mix impact the number and types of public charging your city needs.

Lessons on electric fleet vehicle charging from Shenzhen

Shenzhen is the furthest along the pathway to full logistics electrification, having grown the city's fleet of electric logistics vehicles to over 70,000 by 2020. The deployment of charging infrastructure has been critical to this success. The Rocky Mountain Institute's *Putting electric logistics vehicles to work in Shenzhen* examines how the city became a global leader and draws lessons from Shenzhen's experience. It includes a chapter on Shenzhen's well-planned charger deployment, which recommends that cities prioritise fast-charging, shorten bureaucratic delays, and locate charging stations in areas with high logistics density, high charging demand, and near to overburdened public stations.

Charge point types: determine the mix of types necessary to meet local needs

Know what EVs are used in your city

EVs include plug-in battery electric vehicles (BEVs), which are the only all-electric vehicles, and plug-in hybrid electric vehicles (PHEVs). The relative dominance of each in your city is important because some EVs are limited in the maximum charging power they can accept. Many PHEVs are not capable of fast charging.

Cities can start by focusing on the vehicles they have the most control over. Often, this means electrifying buses, municipal fleets (public works, police and other city-owned vehicles) and taxis, and building the charging infrastructure they need. Buses can use slow or fast overnight charging, or fast on-route charging.[9] See Section 5: E-bus charging configurations in *Electric Buses in Cities* for more information about the electric bus charging infrastructure, as well as *How to shift your bus fleet to zero emission by procuring only electric buses*. Taxi fleets usually need fast charging, especially if they are in use 24 hours a day.[10]

An appropriate balance should be struck between rapid and slower charging points informed by where, when and what types of vehicles EV drivers will be charging.

To establish this balance, cities can undertake a market analysis of:

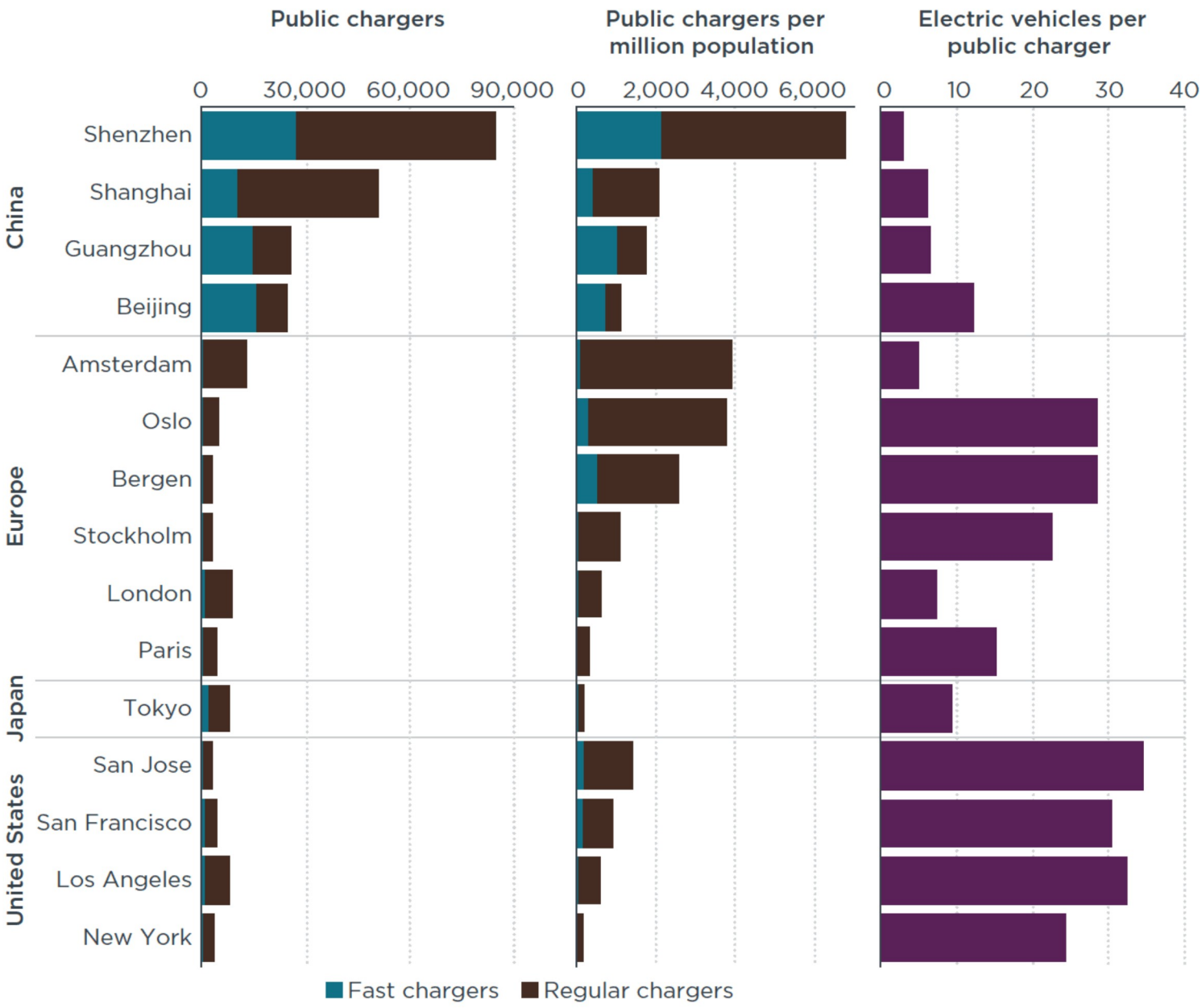
- The types of EV that residents are driving or projected to be driving according to city EV targets.

Higher percentages of PHEVs relative to BEVs will require more slower chargers, and vice versa.

- Where and when they are charging. Higher percentages of EV drivers charging on route, rather than overnight or at their workplaces, will require more fast chargers and vice versa.

These ratios vary greatly between leading city markets. Chinese cities typically have a high proportion of rapid chargers, for example, while cities in Europe and North America have a much lower amount, as show in the graphic below by ICCT.

Public charging infrastructure deployment in selected electric vehicle capitals through 2019[11]



Cities should also track how emerging trends affect the development of the EV market and update charging plans accordingly. For example, the range of EVs is increasing, while cities that are becoming denser may see more EV drivers living in multi-unit buildings with less private charging access.[12]

Charging standards

There is a lack of consistent standards for charging infrastructure across and within most EV markets. **It is important that partners in the deployment of this infrastructure in a city have a clear and shared understanding of which types and standards of charger are included in their plans.** We recommend using the standards set out by the International Council on Clean Transportation, as below.[13]

Charging speeds and standards are still improving, but the standards below will not change significantly in the near future, and cities will always need a mix of regular and fast charging.

Charging type	Voltage	Typical power (kW)	Setting	Indicative costs (based on European averages)[14]
Slow (Level 1)	120 V AC	1.2-1.8 kW	Primarily residential, in North America.	Most EVs come with Level 1 or Level 2 home charging equipment.
Regular (Level 2)	200-240 V AC	2-7 kW	Home, workplace and public.	€200-700 for hardware, up to €500 for installation.
AC Fast (Level 2)	240 V AC	7-43 kW	Public such as curbside and parking lots.	€2,500 for hardware, €5,000 for installation.
DC Fast (rapid)	480+ V DC	50+ kW	Public, particularly for taxis, and intercity. Works only with select (mostly long range) BEVs.	€15,000 for hardware, €10,000 for installation.

V = volt; AC = alternating current; DC = direct current; kW = kilowatt.

Commit government funding

The cost of electric vehicle charging infrastructure has declined substantially in the last decade due to technological innovation and greater scales of production. For example, Amsterdam saw the costs of their curb side charging stations fall from around €12,000 to €2,000 between 2009 and 2017.[15] Nevertheless, government investment will be needed, at least initially. This has been the primary funding model to date.[16]

The major costs to government-led programmes include upgrading the electricity grid to support rapid chargers, the purchase and installation of the charge points, and land procurement, administration and maintenance.[17] Cities can help to encourage innovation and drive down prices by setting ambitious targets for deployment at scale.

To minimise the costs of constructing a charging network, cities can:

- use stations with multiple rather than singular connectors, and (cheaper) wall-mounted rather than freestanding charging stations;
- construct multiple stations in the same area, depending on demand, to reduce installation and electrical infrastructure costs;
- prioritise charge points in, or nearby, areas with sufficient electrical capacity; and
- install slower chargers, or low-power fast chargers of 50kW, wherever possible – particularly for on-street residential and workplace charging – as these are cheaper and are less likely to require upgrades to the electricity grid.[18]

In countries with high fuel prices, **selling public charge point electricity** at a mark-up can recover the cost of installation, or even make a profit.[19] Amsterdam, for example, is making a profit through electricity sales, with the cost of electricity regulated to be cheaper than gasoline on a per-mile basis.[20] However, this model doesn't work well where gasoline is cheap, or where free charging is used as an incentive for uptake. **Advertising** offers another avenue for governments to raise revenues directly from charge points.

> **Zero-emission urban construction sites: lessons from Oslo**
>
> Construction projects using electric machinery require the necessary energy capacity to be available on-site. Oslo is a clean construction pioneer, having begun operating zero-emission construction sites in 2019. Hear from the City of Oslo about their experience and advice, including for the electric charging infrastructure, here.

Update local policies and incentives to encourage – or require – others to build charging infrastructure

As the market grows, cities should seize opportunities to transition to commercially sustainable models, and secure investment from other stakeholders to reduce government costs. This will also help to increase the pace of charging infrastructure deployment. Proven alternative models for financing EV charging infrastructure are outlined below:

- **EV-ready building codes.** Cities can update planning regulations and building codes to require EV charging infrastructure in new developments and in redeveloped residential, commercial and municipal parking. Several cities have introduced these regulations, including San Francisco where 100% of parking spaces in all new commercial and residential buildings are required to be EV ready.[21]

- **Encourage investment from EV manufacturers.** Some are already investing in this infrastructure as it makes good business sense. BMW, Daimler, Ford and Volkswagen Group launched IONITY, a joint venture building 400 fast charging stations along major European highways, while Tesla's supercharger network now has more than 25,000 stations.[22] Cities can encourage investment from these stakeholders by committing to phasing out petrol and diesel vehicles in major urban zones, mandating EV charging at petrol stations, and incentivising EV uptake.

- **Secure investment from local businesses.** Some retailers are willing to install and host charging stations because they can earn revenue while EV drivers charge their cars. This happened in California: a major retailer installed Level 2 charging stations and found that customers' dwell time rose by over 250%, leading to an estimated US $56,000 in additional sales over 9 months.[23] Cities can engage local coalitions of businesses to promote awareness of the business case for their investment. They can also use incentives. In Berlin, small- and medium-sized businesses can get a 50% subsidy for constructing public AC charging stations.[24]

- **Incentivise landowners to make land available for charging.** Acquiring land is among the biggest costs for private charger operators. Cities can help to address this by providing tax incentives and other revenues to landowners who enable EV charging on their sites. This has been an important policy behind China's EV market growth.

- **Streamline the permitting process.** Many cities have expedited lengthy and bureaucratic permitting processes which can discourage investment in charging infrastructure. Stockholm's Charging Master Plan, for example, makes it as easy as possible for companies to instal charging stations.[25]

Collaborate with landowners, utilities and others to build support, secure investment and get the technical details right

EV charging infrastructure roll-out is typically led by the city's transport department, working closely with energy and planning sector colleagues. Your decisions about who to engage in developing EV charging plans should be guided by how the road, land and electricity systems work in your city.

- **Coordinate with energy companies.** Cities must work with energy providers and network operators to design the charging infrastructure, so as to minimise installation costs and stress on the power grid. In Vienna, the Wiener Stadtwerke utility created the DC fast charging infrastructure for the city's

electric taxi fleet.[26] If upgrades to local energy infrastructure are required, energy providers and network operators will need to align their investment plans with the city's EV infrastructure needs.[27]

- **Build support from landowners.** The mayor's office, or equivalent municipal office, often doesn't own or run aspects of the city fabric that need to be built upon or upgraded to build EV charging infrastructure. This means that the city typically needs the support of landowners – private landowners or other local authorities – and planning permission to build EV charging points.

- **Consider establishing a coalition of stakeholders to build a long-term strategy and align investment plans.** This is what London did in 2018. EV charging in London is heavily subsidised by Transport for London. The EV Infrastructure Task Force – made up of city officials, the car industry, electricity providers, fleet managers and others – came together to establish a long-term, sustainable delivery plan.[28]

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