ELECTRIC VEHICLE CHARGING INFRASTRUCTURE

Guidelines for Cities

Clean Technica

Co-financed by the Connecting Europe Facility of the European Union

greenway

AUTHORS:

Aaron Fishbone (Greenway Infrastructure), Zachary Shahan (CleanTechnica), and Peter Badik (Greenway Infrastructure)

CONTRIBUTORS:

Creation of these guidelines took place in October and November 2017. A working group of electric vehicle charging infrastructure professionals debated each other and provided input and feedback on the document itself. This paper would not have been possible without:

Artur Sychov (Easycharge.me)

Bjorn Utgard (EVBox)

David Beeton (Urban Foresight)

Grzegorz Pizon (EY Partner)

Jacek Fior (Tesla Shuttle & ELMO CarSharing)

Jakub Tomczak (EY Partner)

Jarosław Wajer (EY Partner)

Lena Artemenko (Go To-U & Tesla Club Ukraine)

Lyubov Artemenko (Go To-U)

Michael Warner (Fortum Charge & Drive)

Monica Araya (Costa Rica Limpia)

Morten Edvardsen (Norwegian EV Association / Norsk elbilforening)

Nazar Shymone-Davyda (Go To-U & Tesla Club Ukraine)

Quentin Ducreux (Plugsurfing)

Stanisław Jedliński (City of Warsaw)

Witold Chmarzyński (CC Law)

Designed by EY Creative Services Warsaw

DECEMBER 2017, WARSAW

CleanTechnica

greenway

TABLE OF CONTENTS

01

EXECUTIVE SUMMARY

With over 2 million electric vehicles (EVs) on the roads today, the transition to mass electrification is well underway and EVs will soon be driving through your city, if they aren't already.

European Union Directive 2014/94 on alternative fuels for sustainable mobility in Europe obliges member states to develop national policies in this area[1]. Croatia, Czechia, Hungary, Latvia, Lithuania, Macedonia, Serbia, Poland, Romania, Slovakia, and Slovenia[2] all now offer some form of support to owners or drivers of EVs at the local or national levels, further encouraging more EVs and creating lots of work for municipalities to provide the proper infrastructure.

This paper is written for those municipal officials, especially in Central and Eastern Europe (CEE). The objective is to help them — you — properly prepare your community for the coming mass market of electric vehicles. After reading this paper, you should have an understanding of the practical issues involved in planning and installing EV charging infrastructure and be ready to to take the next steps.

Lessons Learned

Together, we have many years of experience installing, operating, using, and evaluating EV charging infrastructure around the world. We want to share some of the lessons we've learned with you:

1) Lead by example. Create the political will to make your community's transportation modes healthier and cleaner.

2) Clearly communicate the benefits of EV use in your city. The city leadership's role in leading the debate, educating the public, and championing electric transport is one of its most important and valuable tasks.

3) Don't delay. You don't have to wait to have a perfect plan for a full charging network. Even if you simply install a single charge point in your city, you can gain a tremendous amount of valuable knowledge and experience from operating it.

4) Build your internal competencies. You should clearly set the responsibility for electric mobility within your organisational structure and preferably define the person or department that will coordinate EV rollout issues.

5) Engage in expert discussions at all levels. Internally within the administration and externally with private enterprises active in this area or with other more experienced municipalities. Municipalities which start later can strive toward the leading benchmarks of comparable cities, while the more experienced can continue to set new benchmarks as the EV market evolves.

1 https://ec.europa.eu/transport/themes/urban/cpt_en

2 http://www.eafo.eu/incentives-legislation

6) Be active in the coordination of charging infrastructure deployment. It is extremely important to align the rollout of charging infrastructure with the rising number of EVs to avoid bottlenecks. In densely populated areas where demand for charging will quickly grow, coordination between private enterprises providing charging services, DSOs, city departments, construction companies and others is essential for smooth and effective infrastructure rollout.

7) Go smart. When choosing infrastructure, select smart, networked chargers with IT capabilities to allow you to monitor charger status and usage, invoice users, permit reservations, and much more.

8) Don't build isolated solutions. It is all about mobility, which cannot be limited to the boundaries of your city. Visitors needs to be able to access and use the infrastructure as smoothly and easily as local residents. Encourage the development of infrastructure which is interoperable, uses standardized solutions, and cooperates with partners that operate nationwide or internationally.

9) Design matters. Bad charging station design can deter EV adoption rather than stimulate it. Good station design can help make it highly visible, easy to access, pleasant to sit at, and unlikely to be blocked by other vehicles. Working such features into EV charging station regulations and plans in your jurisdiction can ensure that you move EV adoption forward.

10) Understand the underlying economics of providing charging services. To set up proper regulation, support and funding schemes, or even be effectively engaged in infrastructure rollout, you must understand what drives the economics of these services.

YES, EVs ARE COMING TO YOUR CITY

In 2017 over 2 million EVs were driving worldwide. By 2020 over 103 new EV models will be available on the market from all of the major car producers - Nissan, Renault, BMW, Mercedes, Volkswagen, Peugeot, Skoda - and more. Prices continue to drop while range increases. Bloomberg New Energy Finance predicts that before 2040 sales of EVs will overtake those of combustion engine vehicles.

02

THE VALUE OF E-MOBILITY

Why electric mobility? Why should you invest time, energy, political capital, and resources towards going electric?

1. **Health:** Air pollution is one of the greatest environmental health threats in Europe, according to the European Environment Agency. The World Health Organization labels outdoor air pollution – and especially particulate matter – a carcinogen. Air pollution causes cancer, as well as heart disease, dementia, asthma, and other health problems. A study by King's College has found that air pollution kills around 9,500 people a year in London[3]. The effects of pollution are especially severe on children.

   A leading cause of air pollution is emissions from vehicles. One of the fastest and most effective ways to reduce air pollution in your community – and thereby improve the health of your population, reduce their healthcare costs, and improve their lives – is to reduce the number of emissions-producing vehicles in your city or town. EVs have no tailpipes and produce zero local emissions so the more electric and fewer combustion engine vehicles on your roads, the less pollution.

   Do you know the air pollution levels and causes in your community[4]?

2. **Business, Tourism and Quality of Life:** Many cities are facing a crossroads – they can continue down the same, fossil fuel driven path and become dirtier, smoggier and louder, with corroding buildings, fewer tourists, an increasingly sick population and higher healthcare costs. These are not places people or businesses want to move to. Or, cities can compete by offering a cleaner, greener and quieter environment, a higher quality of life, where families want to walk around and play outside, tourists want to visit, and businesses want to have offices because the community is attractive to their future employees. Zero emission electric mobility is an essential part of this cleaner future.

3. **Economic Development:** In addition to a high quality of life being attractive to workers and employers, the cleantech economy is one of the fastest growing portions of the broader global economy. E-mobility is one of the core sub-sectors of the cleantech economy. Cities such as Essen and Ljubljana that lead the way with pro-cleantech policies are attracting and stimulating startups and large corporations that are most prepared to benefit from this transition. The economic fruit of that leadership then flows back to these places and the people living in them.

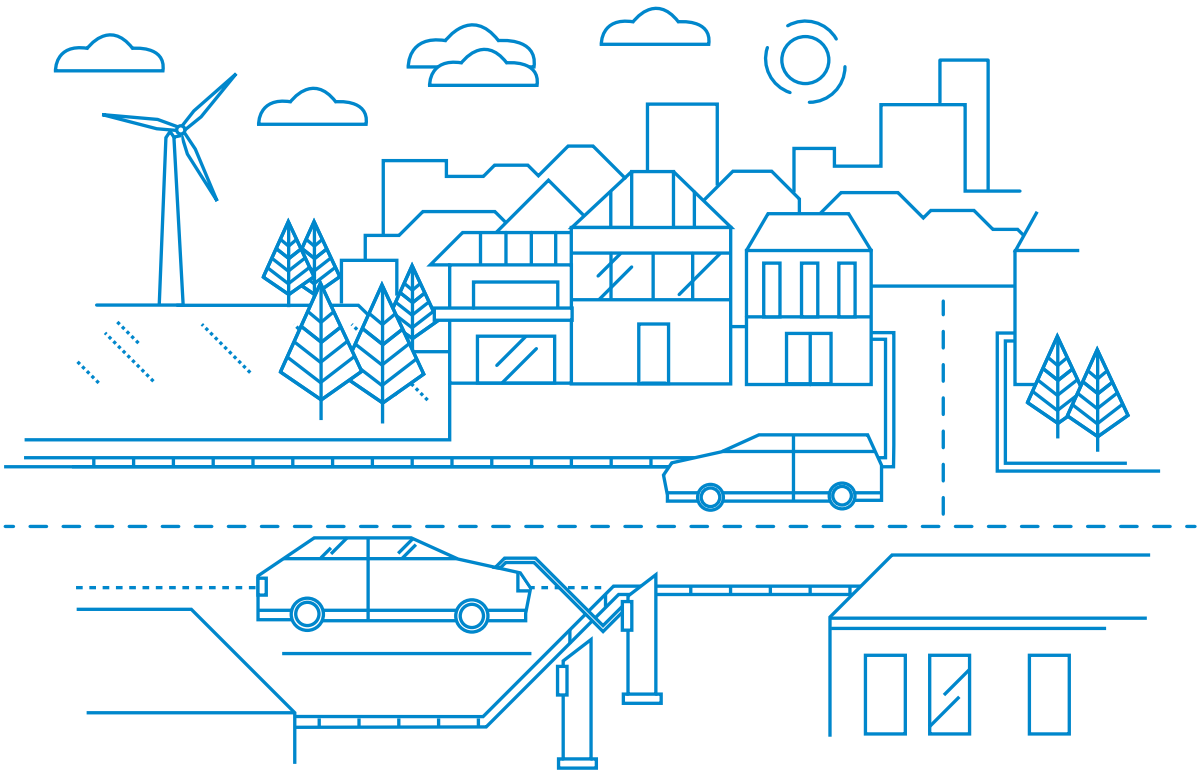
3 https://www.london.gov.uk/sites/default/files/hiainlondon_kingsreport_14072015_final.pdf

4 https://www.eea.europa.eu/data-and-maps/data/aqereporting-2#tab-data-by-country


4. **Energy Independence:** In many places, petrol and diesel need to be imported. Electricity, on the other hand, can usually be generated from local energy sources, thus boosting the local or national economy, not sending that money abroad, and without relying on other countries.

5. **Smart Cities:** Smart cities are places where objects and infrastructure are networked and able to communicate with each other, thus increasing the ability to monitor, control, and connect them. EVs have onboard GPS, software, and batteries that can easily network with other devices, creating many more opportunities for cities to become smarter.

6. **Climate Change:** If society continues with a "business as usual" approach, we are threatening the livability of the planet. Even before that chilling point, communities will face more regular and violent storms, some cities will be submerged by rising sea levels, heatwaves will take countless lives, and society will grapple with unprecedented levels of migration, war, and disease. Diesel exhaust emits very high levels of CO2 and is a particular culprit of global climate change. Moving to zero emissions electric transport is one of the key things your city can do to reduce these risks and change our direction.



03

ROLES MUNICIPALITIES CAN PLAY IN THE EV INFRASTRUCTURE LANDSCAPE

There are numerous different ways municipalities can be involved in the transition to electric vehicles and installing EV infrastructure:

1. **Champion:** Installing charging infrastructure is a core part of building an EV ecosystem, but it is not the only part. Championing the low carbon economy and electric mobility are ways that city leaders can be especially helpful. This can be in the form of supportive public statements or events, policies to support and encourage entrepreneurs and the market, sending encouraging signals to government employees to help find creative solutions, rewarding and incentivizing EV driving, and generally creating an environment that is pro-EV.

   Awareness raising: Educating the citizenry is vital. It is among the most important needs in today's market. Many people are simply not aware of what electric mobility is, what it involves, the capabilities of the vehicles themselves, and why they are better (both for consumers and for society). City leaders have ideal platforms for raising awareness about e-mobility. Ways to do this include: public statements, media campaigns, public events, festivals, EV rallies, branding electric buses or the poles of charging stations, providing EV "one-stop shops" or information kiosks to answer residents' and businesses' EV questions.

   Direct Incentives & Privileges: Municipal, as well as national governments, can offer a range of direct support to EV drivers which are very powerful and strongly correlated to EV utilization[5]. They include driving and parking privileges for EVs (such as driving in bus lanes or reducing/eliminating parking fees), reducing or eliminating vehicle registration fees or road taxes, and more[6].

   Purchasing power: Cities can lead by example and buy EVs for their own fleets too. Many cities are now buying electric transit buses[7], electric school buses[8], electric police cruisers[9] and detective cars[10], electric garbage/refuse trucks[11], electric mail trucks[12] and other fleet vehicles[13]. Lower total cost of ownership (TCO) often makes EVs more financially competitive for certain uses anyway.

5 http://www.theicct.org/publications/emerging-best-practices-electric-vehicle-charging-infrastructure

6 http://www.eafo.eu/incentives-legislation

7 http://zeeus.eu; 100% Electric Bus Fleet For Shenzhen (Population 11.9 Million) By End Of 2017

8 https://cleantechnica.com/2017/11/22/emirates-transport-launching-first-electric-school-bus-region

9 https://cleantechnica.com/2016/06/09/los-angeles-ev-police-fleet-gets-100-electric-bmws

10 https://cleantechnica.com/2017/11/20/ford-unveils-new-phev-police-government-fleets

11 https://cleantechnica.com/2017/11/21/byd-delivers-1st-electric-automated-side-loader-garbage-truck-city-palo-alto-greenwaste

12 https://cleantechnica.com/2015/12/01/240-electric-renault-kangoos-for-norwegian-postal-service

13 https://cleantechnica.com/2017/09/30/indias-government-purchase-10000-evs-tata-motors

Zoning & Building Codes: Regulating how land is used in a community is one of the most powerful tools that local government has. On the infrastructure side, you can use your zoning laws to allow extension of the electricity grid, installation of charging infrastructure, vehicle parking, and the creation of charging hubs. The building code can be used to permit charging points in existing construction and encourage or require it in new construction. On the driving side, over 200 cities across Europe have created low or zero emission zones to regulate the type of vehicles which can enter them[14].

Lobbying: Cities can also support each other by expressing a shared support for a national policy. For example, mayors can lobby the national government to push for low emissions zones, smog day regulations, or financial support for EV programs like exist in France, the United Kingdom, Norway, Slovakia, Slovenia, Croatia and Romania[15], among others.

Planning: The Norwegian EV Association, Norsk elbilforening, thinks creating an e-mobility strategic plan is one of the most important things a city can do. Having an e-mobility strategic plan is useful for putting the full picture of the city's goals, objectives, policies, and efforts together, as well as aligning the various actors towards clear and shared objectives. An "ecosystem approach" is now widely seen as the most effective way to stimulate quicker EV adoption, and a plan is a good way to map that ecosystem.

The remaining roles municipalities can play largely center around charging infrastructure:

2. **Owner:** The city can pay for new EV infrastructure out of its own budget and thereby own the infrastructure and the land it sits on. It can manage the infrastructure itself or develop an arrangement to entrust a Charging Point Operator (CPO) with all that responsibility. However, the city doesn't need to go "all in." It can also contribute some, but not all, of the cost of the infrastructure and be a partial owner.
3. **Landowner/Lessor:** The city can provide the land for EV charging infrastructure for free or it can lease the land. The city can use its leverage to require a certain standard of infrastructure, to set maximum pricing or use certain pricing models, to share or make public usage data, to include city branding, or to implement specific design requirements (see below). We recommend that the city require high quality station design, smart charging capability, and the sharing of usage data. Under a leasing agreement, we also recommend that that city not require the CPO to pay for the parking spaces, but only the land on which the charger itself sits. The parking spaces should remain public spaces, albeit for EVs which are charging at that time.
4. **Operator:** The municipality could also operate the charging infrastructure itself, though this is uncommon. When the chargers are networked (connected to an IT system), this is a much more complex task, so municipalities often work with a specialist CPO to manage these functions.

14 http://urbanaccessregulations.eu

15 http://www.eafo.eu/incentives-legislation

5. **Legislator/Regulator:** Depending on local laws, municipalities must also oversee and regulate the energy infrastructure in their jurisdiction. They are responsible for the zoning and land-use code which allows certain actions in certain places, and enforcement of those rules. They should consider where EV infrastructure fits into the city code, consider making changes to the building code to permit infrastructure in existing buildings, etc.
6. **Infrastructure for use of municipal government fleet:** Many municipalities are already converting their fleets to electric, from postal to police vehicles, and will need their own infrastructure to charge them. Here, the infrastructure may be in depots or private parking garages, and not available to the general public. In this case, the chargers could be AC wallbox chargers, not the more highly priced fast chargers. This situation - where tracking energy usage by individual user may not be necessary - is also the only case where we see it being reasonable to have un-networked charging infrastructure.

There are thus many roles that a municipality can play in building the EV ecosystem and charging infrastructure. A lot depends on the level of decentralization and specific powers of the municipal level of government in a country. Laws and other actors (like DSOs) may enable or prohibit certain types of support. These are varied and must be understood on a region by region basis.

TO UNDERSTAND THE EV CHARGING INDUSTRY FROM THE USER'S PERSPECTIVE, CONSIDER THE CELL PHONE INDUSTRY.

When drivers are charging at charging stations in their "home" network, they are using a card from the EMP they are registered with and all is "normal." But when drivers charge at an out-of-network charging station, they are "roaming." Their home provider may have a "roaming agreement" with the other EMP, providing seamless access to that network. If not, the driver may need to contact the EMP for ad-hoc, temporary access. Some EMP companies' entire business models are based on providing seamless charging for drivers traveling through different networks. EV drivers looking to use out-of-network charging stations while traveling is one reason it is so important to have call center support available for users of your network.

04

TECHNICAL & DESIGN GUIDELINES FOR CHARGING INFRASTRUCTURE

TO NETWORK OR NOT TO NETWORK...

There are two basic options with charging infrastructure. It can be connected to a central backend system via wireless internet (networked or "smart"), or not networked, meaning that it is not connected to an IT system ("dumb").

While dumb/un-networked chargers are cheaper to purchase up front, the smart charger provides many more benefits and functionalities. As such, early leaders in charging infrastructure that started with dumb chargers are now switching to smarter ones (e.g., Norway and California). Because dumb chargers cannot identify users or connect to an invoicing system, when public they are free of charge, which has market consequences. When there is no cost to charging, vehicle owners may leave their vehicle charging for a longer period, thus blocking the charger for others. Furthermore, when the station is not networked, the operator would not know if it wasn't working properly unless they visited it personally. There is a high likelihood that a driver would discover that first, and have a very negative experience.

Smart charging infrastructure can be managed by the municipality, but it's most common to have private EMPs manage the systems since they are complex and customer facing. Services offered aim to enhance the end user customer experience and further promote the ease and convenience of charging EVs. These could include smart end user applications to show location and real time status of the chargers, simple methods of payment, expert customer support, and service and maintenance of the stations.

WHAT SHOULD THE CHARGING INFRASTRUCTURE MIX BE?

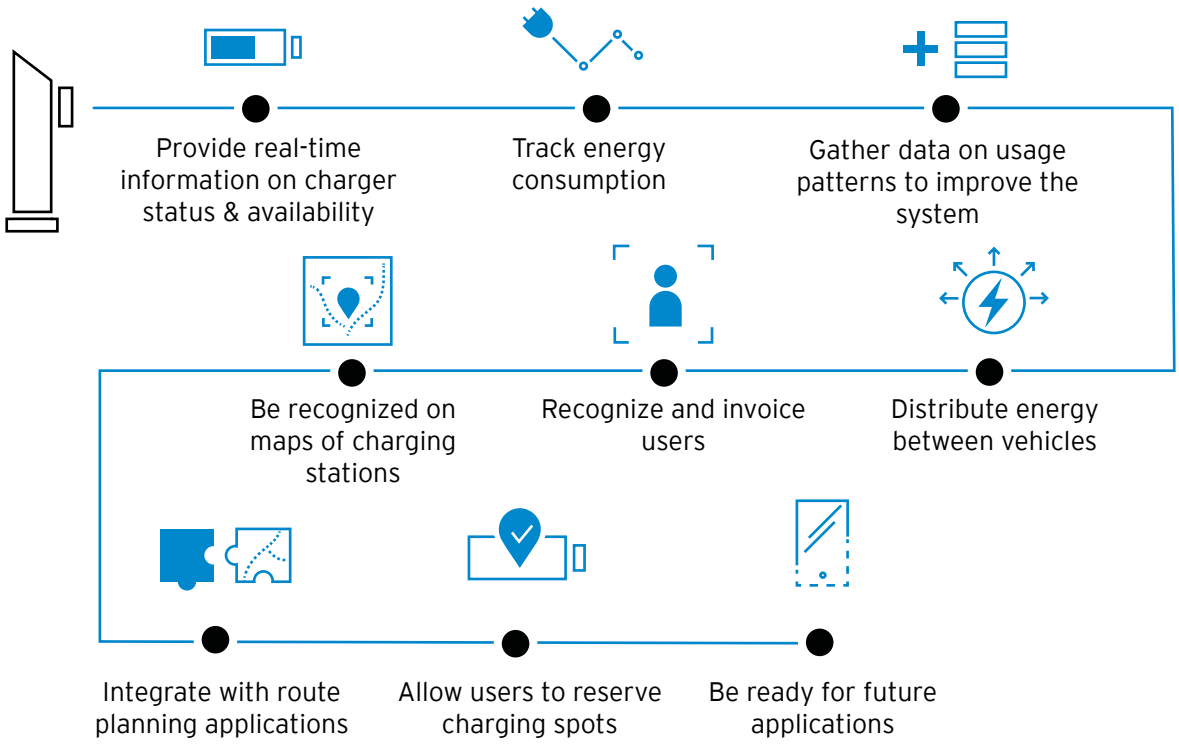
Just as there are different makes and models of combustion engine cars for different needs, there are various types of EV users who have different places they can charge at different times. A municipal EV infrastructure plan must consider these different users, as well as how to plan, zone, and legislate for the charging needs of the future.

Home & Work

Around 80% of EV charging is done at home if drivers have a place at home to charge. If they have home charging and workplace charging, 96-97% of charging is done at home or work[16]. For people without a charger near their home, being able to charge at work is the next best thing.

16 https://cleantechnica.com/2015/10/31/cleantechnica-busts-into-electric-car-wilderness/

BENEFITS OF A "SMART" CHARGER:



The convenience and low cost of plugging in when you get home or get to work is such a major benefit of electric cars that cities should work hard to maximize these options. People who have a garage or designated parking place can install a plug or charger there. However, most people in European cities live in multifamily apartment buildings, often without their own designated parking space.

Drivers may have parking garages at their home, but getting permission from the building owner or manager to install a charging station is extremely difficult for an individual. Municipalities have tools to incentivize or encourage charger installation in these places, which we outline below.

People who don't have parking garages or dedicated parking spaces at their homes (i.e., residents who use public on-street parking) have separate needs. They can't just install a charging station on a public street themselves. These are locations where cities should either come in and install stations themselves[17] (with a dedicated municipal budget for such infrastructure) or invite charging station companies to do so under specific guidelines.

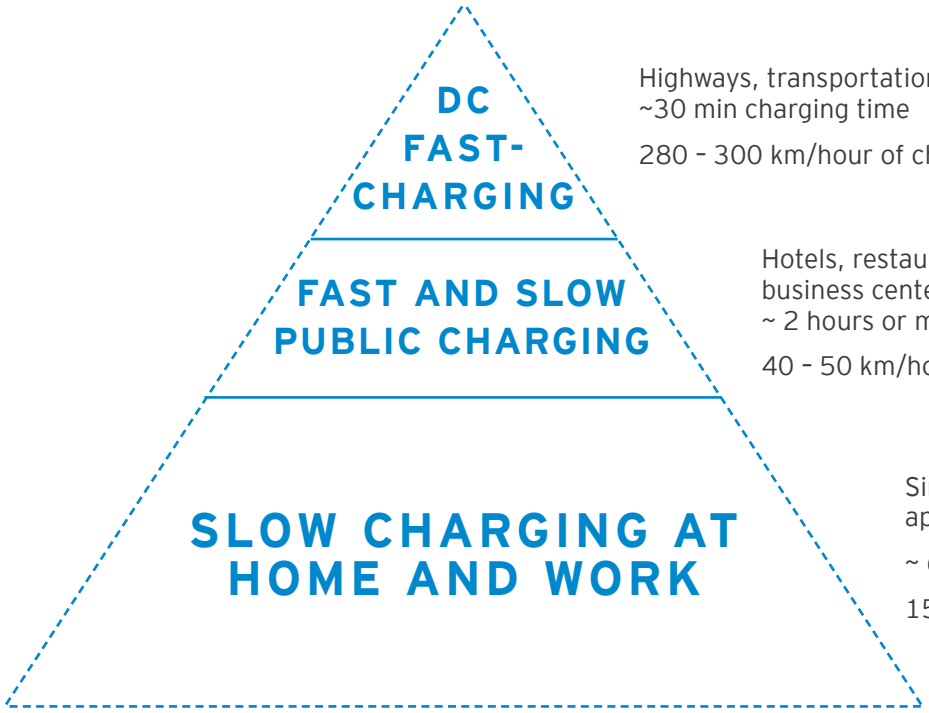
Here are some suggestions for each area:

Public Spaces:

- In dense areas without reserved parking, allocate a certain percentage of the spaces (i.e., 10-20%) for EV charging.
- Create charging hubs. These would be areas with a large number of chargers next to each other (i.e., 10-20). This could simplify grid access issues, create construction/installation economies of scale, be much cheaper, reduce queues, and allow siting near services or apartment blocks to attract and conveniently serve users.

17 http://evobsession.com/ev-charging-in-amsterdam-holland-original-video/

CHARGING INFRASTRUCTURE MIX



- Adopt a policy of installing public AC charging stations as residents request them. This is a market-driven (not top down) approach that has worked exceptionally well in Amsterdam[18], one of the top cities in the world for EV adoption.
- Special consideration should be given to electric taxi charging and charging of other predictable, high-utilization vehicles. They can provide a regular revenue stream but also occupy available charging stations for extended periods of time.
- In dense areas, overarching EV charging station coordination is needed to optimally plan charging infrastructure (and maybe some charging hubs) Local government can best play this role.

Multifamily & Office Buildings:

The core challenge with parking garages at many existing buildings is that tenants do not have permission to have an electricity outlet/charging station installed. Additionally, many parking spaces don't have adequate wiring in place for adding a charging station.

You can:

- Require parking garage managers to permit individuals to add or upgrade the wiring to support charging stations at their parking space and have charging stations installed.
- Require that parking garage managers include a certain number of charging stations themselves.
- Educate key decision makers such as apartment building boards, parking garage and managers, etc. on the technical requirements, safety, and benefits of EV charging infrastructure, as is done in California[19], so that they are comfortable with it.
- Offer incentives to employers who install charging points in their offices/garages, such as is done in France and the United Kingdom.

18 https://cleantechnica.com/2017/11/14/amsterdams-electric-vehicle-leadership-cleantechnica-video/ & http://evobsession.com/ev-charging-in-amsterdam-holland-original-video/

19 http://www.pevcollaborative.org/multi-unit-dwelling

- When it comes to new construction, it is far cheaper for this wiring to be installed during original construction rather than added in later, so:
  - Require or incentivize that new construction projects be "EV ready" by including wiring for charging stations in the walls, floors, or ceilings near parking spaces. This is already the case in London[20] and many cities in California[21], and the EU has already proposed legislation requiring this by 2025[22].
  - Go a step further by requiring that new construction projects include EV charging stations as a certain percentage of the parking spaces[23]. Require that 10% of parking spaces be parking for electric vehicles, including the station, signage, and special coloring on the pavement.

AT HOMES AND WORKPLACES

6–11 kW charging ports may be fine, but if these are parking areas in which each parking space isn't dedicated to an individual, 22 kW charging ports would be more effective for maximizing EV charging access and convenience at a reasonable cost.

Shopping Centers, Cafes, & Restaurants

It is also very important that a public charging network offers convenience in terms of location and charging speed for those persons needing a 'top up' during the day or for EV drivers who don't have home or workplace charging.

Key locations for such charging stations should be medium-stay "hot spots" such as:

- Shopping centers
- Restaurants
- Coffee shops
- City centers
- Sports/exercise facilities
- Major government administrative offices

While 3–11 kW charging stations are okay for "topping up" an EV, real-world experience shows that such charging rates often don't serve the full needs or preferences of drivers. It is ideal to have at least 22 kW charging stations at these locations, and/or CCS and CHAdeMO DC fast chargers (see glossary).

20 https://www.london.gov.uk/what-we-do/planning/london-plan/current-london-plan/london-plan-chapter-six-londons-transport/pol-27

21 http://www2.oaklandnet.com/oakca1/groups/pwa/documents/report/oak063669.pdf

22 http://eur-lex.europa.eu/resource.html?uri=cellar:4908dc52-b7e5-11e6-9e3c-01aa75ed71a1.0023.02/DOC_1&format=PDF

23 http://www2.oaklandnet.com/oakca1/groups/pwa/documents/report/oak063669.pdf

Motorways

Charging stations along motorways are important for people driving long distances. In general, major points of entry/exit into a city should also have charging stations nearby. These should be fast charging locations with a minimum power capacity of 50 kW, but more ideally 100–350 kW.

Such charging stations need to be highly visible and easy to access, especially for visitors coming from others cities or countries and unfamiliar with the area.

OKKO FILLING STATION NETWORK, UKRAINE

Okko saw the potential in EVs early on. The innovative filling station company worked with Go To-U to deploy 34 free-to-use 22kW charging stations at their filling stations on motorways in Ukraine. Many of these OKKO rest areas also include coffee shops or restaurants allowing drivers to relax over a coffee or a meal while their vehicle is charging. In this way, Okko was able to leverage its locations to take a leading position in the EV charging market and establish a solid reputation. The stations are free for drivers to use, but paid for by OKKO.

CHARGING STATION DESIGN

Critical Design Guidelines for Charging Stations

EV charging stations should be highly visible and easy to access. As such, the following are some key tips for charging station design:

1. **Strong colors**

   Colors that catch the eye should be a notable element of any charging station.

2. **Lights**

   Lights should be included as part of the station in an elevated position designed to catch the eye and illuminate the whole space. Lights should also be included around the charging ports and/or control screens to help with user visibility at night and to help signal if a car is charging or not.

3. **Good height**

   The tops of charging stations should stand well above the height of an average car, including an SUV.

4. **Cords/cables included**

   Instead of just including a port for charging, stations should have the cords/cables included, so that a driver can just get out of the car, grab the cord from the station, and plug it in.

5. **Cord/cable holders**

   The charging stations should also have integrated systems to help keep cords/cables completely off the ground and limit tripping.

6. **Clear Instructions**

   Stations should have very clear, simple instructions for how to use them, ideally in a graphical or illustrated format. This is especially helpful with new drivers or those coming from abroad.

7. **Clear and simple pricing information**

   People like to know what they are paying for and how much it costs. It also helps with transparency and building trust, especially as e-mobility is still a young industry with differences between countries and providers.

8. **Customer support information**

   A 24/7 phone number is almost essential. It is guaranteed that some drivers will have problems and you can usually make sure they are quickly and responsibly handled with a short phone call.

9. **Branding/marketing/placemaking**

   Charging stations also offer an opportunity for city placemaking, branding, and public education about the benefits of using EV or renewable energy. Slogans such as "My Warsaw" or "I ❤ Lviv", an environmental/health message about the source of the energy, a carbon offset tracker/thermometer, etc. can look nice, make people care more about their environment, and enhance community cohesiveness.

Surrounding Area

For many drivers, the most important design elements of a charging station are the quality of the area around it. Like a favorite cafe, if they have a choice, they will go to the station that they enjoy being at. These important considerations are highly correlated to how much a station is utilized.

Accessibility

The convenience and ease of getting to and from the charge points matters a great deal. Is there road access from both directions? Are there other barriers? Is it handicap accessible? In a parking lot, having the stations near an entrance or elevator is helpful.

Aesthetics

The overall look and feel of the place can drive utilization a lot. Is it clean or is there trash everywhere? Is there a nice view or park nearby to look at, or a collapsing building? These things matter.

Safety

Does the space look and feel safe? It should be safe to get to (not having to cross a lot of busy traffic) and then safe to sit or leave your car at for a while. Is it safe from other cars, bicyclists, and people? Lights help here. There should be minimal obstructions or things to trip over.

Protection from the weather

While it is safe to charge your EV at an exposed, outdoor charging station in the rain or snow, it is far more pleasant to do so at an indoor station or under the protection of a canopy.

Opportunities for recreation and relaxation

Drivers spend from 20 minutes to a few hours charging their vehicles. Shopping malls, restaurants, and coffee shops which have charging facilities all benefit from these customers. Being near a park provides the opportunity for some exercise. These things all matter to EV drivers.

05

FINANCING YOUR NETWORK: COSTS, REVENUES & BUSINESS MODELS

Regardless of how many EVs are currently registered in your city - many more are coming, and soon, and you should get ready.

For you, this may mean investing in your own infrastructure, developing a plan, or passing laws or regulations to encourage the private marketplace. There is an ongoing debate as to whether to invest in infrastructure before the mass onset of EVs, or to wait until they have already become far more common - the so-called chicken and egg dilemma in our industry. Even if it's just a single charging station, we encourage you to start now, to gain our own experience with EV charging and the habits of your local drivers.

Core Elements in Balancing Costs & Revenue

Whether for a public or private entity, there are a number of proven ways to fund EV charging infrastructure and then generate revenue from it. While we are not suggesting any specific approaches here, we think it's important for you to have a clear understanding of the real costs and key cost drivers of these activities, and the sustainable business models.

The costs include:

- Fixed costs: Hardware, installation costs (capital costs), capacity charges
- Variable costs: Energy costs (energy and power), service, maintenance, operations (billing, invoicing)

The revenue comes from a mixture of:

- Price per charge, kWh, minute/hour of charging, and/or minute/hour of parking
- Utilization – how much the charge point is used
- Other uses of charging station or area - such as marketing on charger and concessions sold

While public charging needs vary from location to location, many in the EV industry use the assumption that

A MARKET SHOULD HAVE 1 PUBLIC AC CHARGER PER 10 EVS AND 1 DC CHARGER PER 100 EVS.

Depending on the market, though, higher or lower ratios may be more ideal.

FAST CHARGING IS A SERVICE THAT HAS SIGNIFICANT VALUE FOR USERS,

since the high charging speed gives drivers flexibility when required. Experience from Europe and North America shows users are willing to pay for this value. The two largest charging networks in Norway charge around €0.30 per minute of charging, bringing a 20-minute charging session to €6.00 including 25% VAT. In the UK, the largest fast charging service charges £7.5 per 30-minute charging session, which would be equivalent of £5 for a 20-minute session.

Charging Infrastructure Costs

Hardware & installation: First, an appropriate site needs to be found and selected, and the proper approvals and contracts drawn up for its use (landowner, DSO, energy regulator, etc.) Then, the appropriate construction work needs to be performed to extend or upgrade the electricity grid connection (where necessary) and establish the point where the charger will connect to the grid.

When it is free-standing, a concrete foundation needs to be poured for the charger to stand on. Or it needs to be attached to the wall or other object.

Appropriate parking next to the charging point needs to be provided, reserved, and marked.

For outdoor chargers, a covered canopy is worth considering.

When it comes to the charger itself, there are two main types of chargers used for public charging:

Type 2 AC chargers: The cost of this infrastructure can run as low as €500 if they are placed on private premises and dedicated for one user or a closed group of users. If they are public – which in the case of municipalities would be more common – the charging stall will require more robust framing and construction and most likely need to have the ability to recognize and bill each EV user. Therefore, the charging point has to be "smart" – equipped with IT intelligence and capable of communicating with the IT system of the charging point operator. In this case, the units will cost €1500+. These prices do not include installation costs. Significant savings per chargers apply if they are bundled together in a configuration (hub), where several outlets use one intelligent central unit for communication and intelligent energy management.

Fast DC chargers: Despite the significant drop in their cost in recent years, DC chargers remain expensive and cost more than €25.000 each. That it is high-power equipment also translates into higher costs for physically connecting the charger to the grid, or even upgrading the grid connection point (transformer and other equipment). This could bring the installation costs up to €40.000. The second consequence of fast chargers is the high demand for power and thus high demand charges from the DSO on a monthly basis. These are fixed cost and usually paid on a monthly basis regardless of whether the charger is used often or not. The connection cost represents the most significant part of the operational costs and needs to be carefully considered along with the cost of energy and maintenance of the unit.

Capacity Charges: Is the fee paid to the DSO based on the kW power connection. This cost varies significantly between countries and even between various DSOs. It is different if you are connected to a low voltage or medium voltage line using your own transformer or not. In any case, it is a significant cost driver, particularly in the case of fast charging technology. Being a fixed cost, capacity charges have the most significant impact on the overall economics in low utilization environments.

Energy cost: In home and some workplace charging, the cost of the energy itself is the largest – and sometimes the only – variable cost. However, in terms of public infrastructure, it represents only a fraction of the total cost structure, especially in the case of fast charging. This is why charging at home or work could be as cheap as 2EUR/100km while the cost of public AC or DC charging needs to be higher, as you can see in the below table.

Maintenance: Like any piece of machinery, charging stations require occasional maintenance — sometimes on the backend with their IT software and sometimes on the physical unit as well.

Billing, invoicing, & user support: This body of work includes setting the prices, creating a system to charge and invoice each user, maintaining this system and its security, and debugging it when technical issues arise. Real-time user support is also essential. New people encounter the system and routinely call with questions, and answering them clearly is vital to ensuring a positive user experience and satisfied customers. These are complex, time-consuming, and personnel-intensive tasks carried out by the charging point operator, which are critical to the successful functioning of a charging service business.

Charging Infrastructure Revenues

The main drivers of revenue are the price you charge for energy or time combined with the rate of utilization of the charger. Here is a simple table, showing an example of the costs vs revenue balance a charging company needs to evaluate.

	Scenario					Profitability	
Fast charger (DC)	**Initial investment**	**Customer facing price in kWh**	**Costs of electricty**	**Utilization scenario**	**Daily utilisation in hours (lifetime average)**	**NPV (Net Present Value)**	**IRR (Internal Rate of Return)**
low prices and utilisation	€25 000	€0,26	€0,18	50%	2,4	-€7 927	2%
medium prices and utilisation	€25 000	€0,34	€0,18	100%	4,8	€19 321	25%
high prices and utilisation	€25 000	€0,43	€0,18	150%	7,2	€47 551	44%
Standard charger (AC)							
low prices and utilisation	€2 500	€0,20	€0,18	50%	3,8	-€1 962	-14%
medium prices and utilisation	€2 500	€0,25	€0,18	100%	7,6	€4 918	39%
high prices and utilisation	€2 500	€0,30	€0,18	150%	11,5	€17 532	87%

As you can see, the main variable inputs are price to the customer and utilization. Adjusting these will help you find your sustainable operating costs.

(Note: These are illustrative figures only, included to show cost–revenue considerations but not to share specific figures from the industry.)


Revenues can also be generated in other ways too, such as:

A) Advertising on the charging station.

B) Concessions. Depending on who owns the station and nearby services, the overall revenue-generating capacity of the charger should include if people purchase food and drink while charging.

Grant Funding

Grants – such as from a national government, the European Commission DG Move, or the Innovation and Networks Executive Agency (INEA) – are one of the primary ways that infrastructure – especially fast chargers – are financed (or co-financed) in Europe. The grantor issues a Request for Proposals (RfP) for a specified project, companies apply, and the winner is selected based on the criteria outlined. Often, the grant is not for the whole cost of each piece of infrastructure, requiring the private entity to co-finance the rest somehow. Nonetheless, especially in Central and Eastern Europe, this is a very common approach. Municipalities should encourage central governments to prepare specialized funding schemes specially designed for municipalities and communities. Development of alternative fuels infrastructure and decarbonisation of transportation are among the top priorities of the EU and therefore the involvement of various EU funding streams is appropriate.

A NOTE ON OFFERING FREE CHARGING

While the motivation of public authorities to provide infrastructure for electric vehicles doesn't have to be only commercial, the early introduction of fair prices for the use of chargers is important.

Free charging may seem like a good way to initiate a market - and it would be. However this sends incorrect price signals about the cost of charging/using electric vehicles and creates an outcry and drop in usage later when the free/subsidized charging ends. This undercuts the ability of commercial operators to create a sustainable business in the community.

On the other hand, there are other commercial models in operation which do not require payment for charging from the drivers. For example, Go To-U's model involves location hosts/business owners paying for the stations and providing them free of charge to drivers as a way of capturing the EV driving market. This model is working very well for them.

Scotland's national public electric vehicle charging network, ChargePlace Scotland, with 700 charge points as of this writing, is also largely free to users, beyond a £20 annual fee. It is otherwise subsidized by the Scottish government.

06

GLOSSARY

Alternating Current (AC) – the type of electricity that comes from the electricity grid. Most EVs have a small onboard charger/converter that converts that AC electricity to a form of power (DC) that the battery can handle, but it comes in slowly and at low power. AC charging is what most regular home or workplace electricity outlets produce (3.5 to 22 kW). In general, it can fully charge a vehicle over 4–7 hours. Around 80% of EV owners charge their vehicles overnight at home using AC power.

Battery Assisted Fast Chargers – are fast/DC chargers with an auxiliary battery pack, allowing them to draw energy slowly from the grid and store it locally until it is needed to charge a vehicle. By drawing energy slowly from the grid throughout the day, the vehicles put less stress on the grid and can help balance it later.

CCS – This is a DC fast charging standard supported by Volkswagen, General Motors, BMW, Daimler, Ford, FCA, Tesla, and Hyundai. As of 2017, this charging standard goes up to 350 kW.

Charging Point Operator (CPO) - operates physical charging infrastructure, which includes technical and IT maintenance, setting commercial terms for its use, payments for its electrical connection and managing the energy supply. The portfolio of a CPO might consist of its own charging stations and those of 3rd parties.

CHAdeMO – This is a DC fast charging standard developed in Japan which goes up to 62.5 kW. Nissan, Mitsubishi, and Fuji Heavy Industries (which manufactures Subaru vehicles). Toyota later supported the standard as well, and Tesla sells an adapter allowing its vehicles to use CHAdeMO chargers.

Direct Current (DC) – is used for fast charging because the amount of power it can provide to a vehicle is up to 50 kW. DC fast chargers are charging stations or equipment that include an AC-DC converter and send already converted DC power directly to the vehicle's battery. DC fast chargers can power most EV batteries up to 85% in 30 minutes. They are commonly located in public places and on highways and major roads, but are more limited in number (and higher in cost) than AC charging stations.

Electric Mobility Provider (EMP) - is oriented towards the EV users, providing them with a seamless access and billing experience on charging infrastructure owned and operated by multiple parties. Its main activities are negotiating and maintaining commercial contracts with CPOs to bring their infrastructure under an umbrella of its own value proposition towards an EV owner, and building an ecosystem of user friendly (access) charge cards, mobile app / web interface and billing system.

Fast Charging – is the common name for DC charging that provides an EV with up to 50 kW of power at a time.

Fully electric – Fully electric cars use only electricity, generally stored in batteries, to power their movement. This means that they also include a plug to charge, just like your laptop and cell phone. Most electric cars can charge using fast chargers, and all of them can charge using normal electricity outlets – with the right cord and plug, of course.

Home – 80% of EV charging is done at home, via regular AC power outlets. Public chargers are meant to supplement this home charging and provide "range extension" to allow people to go further – or if they find themselves in need of a charge sometime during the day. Certain types of residences present challenges to home charging, but there are solutions.

Plug-in hybrid electric – Plug-in hybrid electric vehicles can power their movement on electricity or on gas or diesel (depending on the powertrain). They typically have smaller batteries than fully electric cars. Unlike conventional hybrids, they have a plug to be recharged directly from the grid.

Public – This refers to any charging that is done at a public location, not at home or at a private workplace charging location. This doesn't mean that the charging station can be used for free or without a special access card, just that anybody can drive up to the station.

Roaming - Most users belong to a home "network" at which they do most of their charging. They have an access card or code to allow them to charge in public and receive an invoice from their EMP. When they leave the network and charge at chargers in another network they are 'roaming'. This is very common.

Superfast/Ultrafast – A newer level of technology, superfast/ultrafast chargers can provide 100–350 kW of power. They usually include a series of charging stands connected to an auxiliary energy storage/battery pack. The battery pack draws energy slowly from the grid and stores it until it is necessary. Multiple vehicles can charge at the same time, and the smart technology in the charging stands communicates with the battery pack, allowing the energy to be distributed properly among the vehicles based on how much they can handle (some electric cars cannot use DC fast charging, and all cars have a limit to how much power they can take).

Workplace – In addition to home charging, the workplace is a favored charging location, since many people leave their vehicles parked there for several hours at a time. Some parking lots now include special wall box chargers designed for this purpose. Studies in the United States have found that even with low-range electric cars, 97–98% of charging is done at home or work when drivers have access to both options.

APPENDIX 0.1

CASE STUDIES

WROCLAW, POLAND

The city of Wroclaw in southwestern Poland has taken a multi-tiered approach to promoting e-mobility. In 2016, it put out a request for proposals (RfP) for an electric carsharing program to be implemented in the city, requiring a minimum of 200 electric cars. That program launched approximately a year later, in November 2017. The city did not directly provide the carsharing company with money, but it offered free parking for these as well as other electric cars in zones B & C of the city. For parking in zone A, an attractive discount was implemented: a 3 day pass costs 1zł, a 1 month pass costs 10zł, a 6 month pass costs 50zł, and a 1 year pass costs 100zł.

Electric vehicles in Wroclaw can also use bus lanes and are allowed to drive on some streets where combustion vehicles cannot. For example, there's a useful connection near the city center that cars and trucks cannot usually drive across (with police often set up there to catch and ticket violators, once even nabbing the mayor of the city). Electric vehicles can now drive in this location, a very practical and useful benefit for Wroclaw's EV drivers.

There has been limited charging infrastructure in Wroclaw for several years. One or two dozen charging stations were installed ahead of the market charging stations, primarily by a Polish company named Galactico. Some companies and shopping centers have also installed charging stations for employees and customers. Most recently, approximately a dozen stations were installed in a new parking garage at the Narodowe Forum Muzyki (The National Forum of Music).

Currently, there are 280 electric vehicles registered in Wroclaw (as of 01.11.2017).

AMSTERDAM, THE NETHERLANDS

Amsterdam has several incentives for electric vehicles, but there is one in particular that stands out. The city added a budget item for EV charging infrastructure years ago but followed a market-driven approach to roll out this infrastructure. Most Amsterdam residents park their vehicles on the street, not in private or designated parking. When residents decide they need on-street EV charging near their home, they tell the city and the city pays a private EV charging station company to put the station in.

These stations are public and generate an invaluable set of data without compare, resulting in valuable input to optimize the ongoing rollout and decisionmaking regarding EV charging stations and vehicles. The availability of reliable charging, greater visibility of electric cars charging there, and intelligent pricing system stimulates other residents to "go electric" and has resulted in a significant number of new EV owners on streets where these charging stations were installed.

STOCKHOLM, SWEDEN

Stockholm decided to boost the city's electric vehicle (EV) charging infrastructure by expanding the existing charging infrastructure and build a fast charging network.

In 2014, the City Council commissioned the building of 10 new fast charging stations and 100 normal ones.

The Environment and Health Committee, Stockholm Parkering AB (a city-owned company responsible for Stockholm's parking infrastructure), three municipal housing companies, and the Traffic Committee worked together to expand charging infrastructure.

(Reprinted and abbreviated with permission of the author; available on the Eltis portal at: http://www.eltis.org/discover/case-studies/stockholm-implementing-public-electric-vehicle-charging-network-sweden)

The business model sees private companies offered free access right agreements for parking places in exchange for installing charging points on or near their premises. City authorities set clear standards with regards to the charging facilities, including reliability and access to user data. Access right agreements are granted for five years. Following this, they can be extended annually if both parties agree.

During 2017, 15 on-street charging points have been added, with 8 fast and more than 100 normal charging points built in total. 101 of these are on-street charging points. Petrol stations, fast food restaurants, and large supermarkets have proven to be the main types of business choosing to install charging points.

The usage of fast and normal charging infrastructure differs. Fast charging is comparable with refuelling, i.e. only a short stay, whilst normal charging is similar to parking. Most EVs are charged overnight.

Data from normal (AC) charging stations shows that:

- They are used more on weekdays than weekends, implying that EV usage is linked to work/commuting. In addition, when they are used depends on location.
- Their usage doubled during each quarter of the project's evaluation period (May 2014 – October 2015). The number of charging facilities also doubled in this time. The charging period typically lasted 1 - 5 hours.

Data from fast charging stations shows that:

- Most users are commercial EV drivers.
- When payment was introduced in 2015, usage declined. Although there has since been a slow increase, many previous customers have stopped using the charging points.
- Fast chargers are used in two different ways: a "top-up" of up 10 minutes, and longer charging sessions of 10-30 minutes. The charging point's location affects what type of behaviour predominates.

Most fast charging stations are located in Stockholm's inner city.

Stockholm's City Council has decided on a common long-term goal, whilst in the short term it aims to have 500 on-street charging points installed by 2020.

Solving associated administrative and legal issues is time consuming. Issues such as traffic signs and access right agreements proved more complicated than expected, whilst existing legislation does not seem suited to new EV technology

By using a business model in which private companies install charging points at their own expense and cover service and maintenance costs, local authorities can avoid a high outlay. Some form of incentive is required to generate interest, however; free access rights represent one possibility.

With regards to indoor public parking, Eva Sunnerstedt, the Head of Unit responsible for the City of Stockholm's work on electric vehicles and charging infrastructure, says: "*it is best to create lots of parking spaces and not reserve them all for EVs. However, those for non-EVs should be further away from the entrance*".

However, she is also unsure as to "*what constitutes the right mix of regular and fast charging infrastructure. Chargers require lots of street space - are they a good use of it? We should use our streets for walking, biking, bus lanes, and moving cars. Fewer locations with fast/ultra-fast charging points are perhaps better, and will be needed for courier companies and taxis*".

APPENDIX 0.2

LIST OF MEASURES THAT MUNICIPALITIES HAVE TAKEN TO INCENTIVIZE EV ADOPTION

Parking Incentives:

- Free parking for EVs citywide, downtown, or in select sectors of the city
- Free parking while charging
- Parking for EVs allowed in otherwise restricted areas
- Parking spaces reserved for EVs only
- Reduced parking fees for EVs in public lots

Access:

- EVs allowed when other vehicles banned (i.e., smog alerts)
- Permitted into Congestion Charge Zones/ Umweltzonen, Zero Emission Zones, etc.
- Permission to use bus lanes, high occupancy vehicle lanes, and priority lanes

Infrastructure

- Tax rebate on installation of EV home chargers
- Reduction in connection charges
- Local grants/incentives to support installation of home or workplace charge point
- Municipal support for installation of on-street charging points where off-street parking is limited
- Municipal requirement that commercial properties and/or workplaces install EV charging stations in a certain percentage of parking places
- Municipal requirement in building code that requires parking garage owners to install EV charging stations in a certain percentage of parking places
- Municipal requirement in building code that requires parking garage owners to allow tenants to install EV charging stations if they want to
- Municipal requirement in building code that requires parking garages to be "EV ready" by including proper wiring and power capacity within walls/floors/ceilings to eventually install EV charging stations
- Time-of-use pricing for EV charging that offers lower rates at certain times (i.e., off-peak times at night)
- Quick, streamlined EV charging station permitting

Direct Incentives for Vehicles:

- Direct subsidies for EV purchase or lease from local municipality or utility
- Exemption/reduction on local taxes for EV ownership, incl. road tax, registration tax, etc.
- Exemption from local use fees and tolls for EV owners
- Discount on electricity bill for ownership of EV
- Discounts for EV owners at other public activities - events, concerts, museums, etc.

Information and encouragement

- Informational website or webpage about electric vehicles
- Citywide EV plan or strategy
- Outreach and promotional events