Deliverable 9.7

Policy recommendations and stakeholder actions towards effective integration of EVs in the EU

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List of Abbreviations

AC	Alternating Current
BEV	Battery Electric Vehicle
BM	Business Model
CA	Consortium Agreement
CH	Clearing House
D	Deliverable
DC	Direct Current
DoW	Description of Work (Annex I of Grant Agreement)
EC	European Commission
EMC	Electro Magnetic Compatibility
EV	Electric vehicle
EU	European Union
EVSE	Electric Vehicle Supply Equipment
EVSP	Electric Vehicle Service Provider
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
ID	Identification
ISO	International Organization for Standardization
OEM	Original Equipment Manufacturer
O&M	Operation and Maintenance
TCO	Total Cost of Ownership
TOU	Time of Use
TSO	Transmission System Operator
T&D	Transmission and Distribution
WP	Work Package

1 Executive Summary

This report aims at identifying possible actions that electromobility stakeholders (with a focus on policymakers) can take to overcome the issues a massive deployment of electric vehicles would face. It first describes the various user groups that will use electric vehicles, which charging services will be provided, and shows how they match.

As a result of this matching, this report identified the following 5 needs:

- Attractive business cases: Several users groups will rely on the existence of a public charging infrastructure (to varying degrees). For operators to deploy and operate that infrastructure, they need an attractive business case. They will need to reduce their costs (purchasing, installing, and operating charging stations) and increase income (by growing the utilisation rate of their facilities).
- Consumer acceptance: Having a good case on paper does not ensure that consumers purchase EVs: They need to be sure that they can perform the same activities as before, without prominent constraints. They also do not necessarily base their decision on purely rational criteria.
- Stable and efficient grid: Managing the charging process and designing the charging infrastructure in order minimise the impact of EV charging on the electricity grid. This will reduce the amount of extra grid investment needed and ensure electric vehicles can charge at a competitive price. Electric vehicles can even be a means to improve grid reliability and efficiency.
- Interoperable networks: The various players in the charging infrastructure grid need standards in order to offer discrimination-free access to their services. This is a complex element that involves many stakeholders. It mixes technical, business and consumer-facing elements. It is a main focus of Green eMotion, which aims at allowing EV drivers to charge in any EU country they visit.
- Appropriate governmental actions: plans, laws and procedures need to be aligned to support electromobility. Policymakers and regulators of all levels (EU, national, local) need to set up a supporting framework and take efficient supporting actions.

This report identifies 18 issues that need to be overcome to satisfy these needs (together with recommendations for action). Out of these 18 issues, the following eight were identified as top priorities:

I) Drivers will typically park their cars at similar times, which coincide with a **peak** in the general **demand for electricity**. If those cars also all charge at the same time, they would require a large amount of peak production, which is more costly. To avoid higher electricity costs, it is necessary to spread the demand through smart charging (i.e. use devices and software to control the moment when charging occurs). Policymakers, regulators and infrastructure operators can provide support, enforce standards, set up networks for smart charging, and provide drivers with the right incentives to use smart charging.

II) An increase in EV ownership in a certain region can create **congestions** in the **local**, low-voltage **grid**. To overcome this, policymakers and regulators can setup the right frameworks for the introduction of smart grids, which DSOs will deploy. DSOs should also develop demand forecasts to identify grids that might get congested.

III) **Incomplete or competing standards** (for example different types of plugs or communication system protocols) can be an **obstacle to interoperability**, i.e. the possibility for drivers to charge their car at installations operated by other providers than their usual ones. To prevent this, policymakers, regulators, providers and equipment manufacturers should get together to further develop and implement standards.

IV) **Installing charging hardware is costly**, especially in existing buildings and structures. Regulators can help by putting requirements in building codes and tenders that require buildings and structures to have some degree of preparedness for charging infrastructure.

V) For public charging infrastructure, finding the **right matching services** (shops, restaurants, parking, etc.) can make or break a business case, and is difficult to do. EVSE operators and partners should work together to identify the right matches, according to the characteristics of services they offer. For example, quick charging should be proposed at locations where a quick customer rotation is crucial (such as on highway stations).

VI) The **utilisation of public charging infrastructure** will often be **low**, especially in initial phases. This would not attract investors, as they would face a long payback time (or no possibility to get their investment back). Policymakers can help by subsidising vehicle adoption and the deployment of charging infrastructure in its early (unprofitable) stages.

VII) Electric vehicles have a **purchase price** that is considerably **higher** than their combustion engine counterparts. Policymakers can use a variety of tax incentives to reduce this gap, but they can also introduce information requirements at dealerships. These requirements would be to display total costs of ownership, which would be more favourable for EVs than a purchase price comparison. They can also use other channels (such as websites and apps) to provide customers with such information.

VIII) Drivers have **range anxiety**, namely that they are worried that they won't be able to perform their usual activities with an electric car. Such issues are mostly issues of information on charging possibilities and optimal charging/driving behaviour, rather than actual extra range needs. Policymakers, EVSE operators, EVSPs and manufacturers should work together to provide drivers with information on charging possibilities and optimal behaviour. This can happen through the development of training/information materials (websites and apps), as well as proper signage of charging stations. The latter not only provides drivers with information about charging possibilities, it also shows them that charging is available.

2 Introduction

2.1 Purpose of this report

Electric mobility is a major component in the European Commission's ambitions for a more sustainable transport (see the 2011 White Paper on Sustainable Transport), and Green eMotion (GeM) aims at supporting its large-scale deployment. It aims at doing so by developing knowledge about technical and social issues, by contributing to the development of supporting elements (such as standards and a Marketplace to develop network interoperability), and by identifying possible actions and possible policy measures to support the deployment of electric mobility. This report draws on the results from other deliverables[1] of the GeM project to identify the issues the large-scale deployment of electric mobility might face, and what actions policymakers and other stakeholders can take to overcome these issues. Given its focus on the large-scale deployment of electric vehicles, this report will not address general mobility issues and actions such as reducing the amount of cars in city centres. It is also written from a current point of view, which is important to keep in mind for a subject that is at early stages of evolution and is expected to change significantly in the very near future. This means that some of the issues, solutions, and actions described in this report might not be valid a few years from now.

2.2 Structure of this report

This report starts with a discussion of the various user groups of electric vehicles and of their charging needs (Chapter 3), in order to provide the reader with a meaningful context and to define a series of needs related to the large-scale deployment of electric mobility. Each need is properly defined (Chapters 4-8), and issues associated to that need are then identified. For each issue, one or several solutions are identified, together with a series of recommendations for action to policymakers and other stakeholders. These recommendations focus on solutions to specific issues and are therefore not an exhaustive list of measures to stimulate the uptake of electric vehicles (see Figure 2.1). Chapter 9 presents an overview of priority issues.

[1] Note that the referenced deliverables can be found on the Green eMotion website: http://www.greenemotion-project.eu/dissemination/deliverables.php

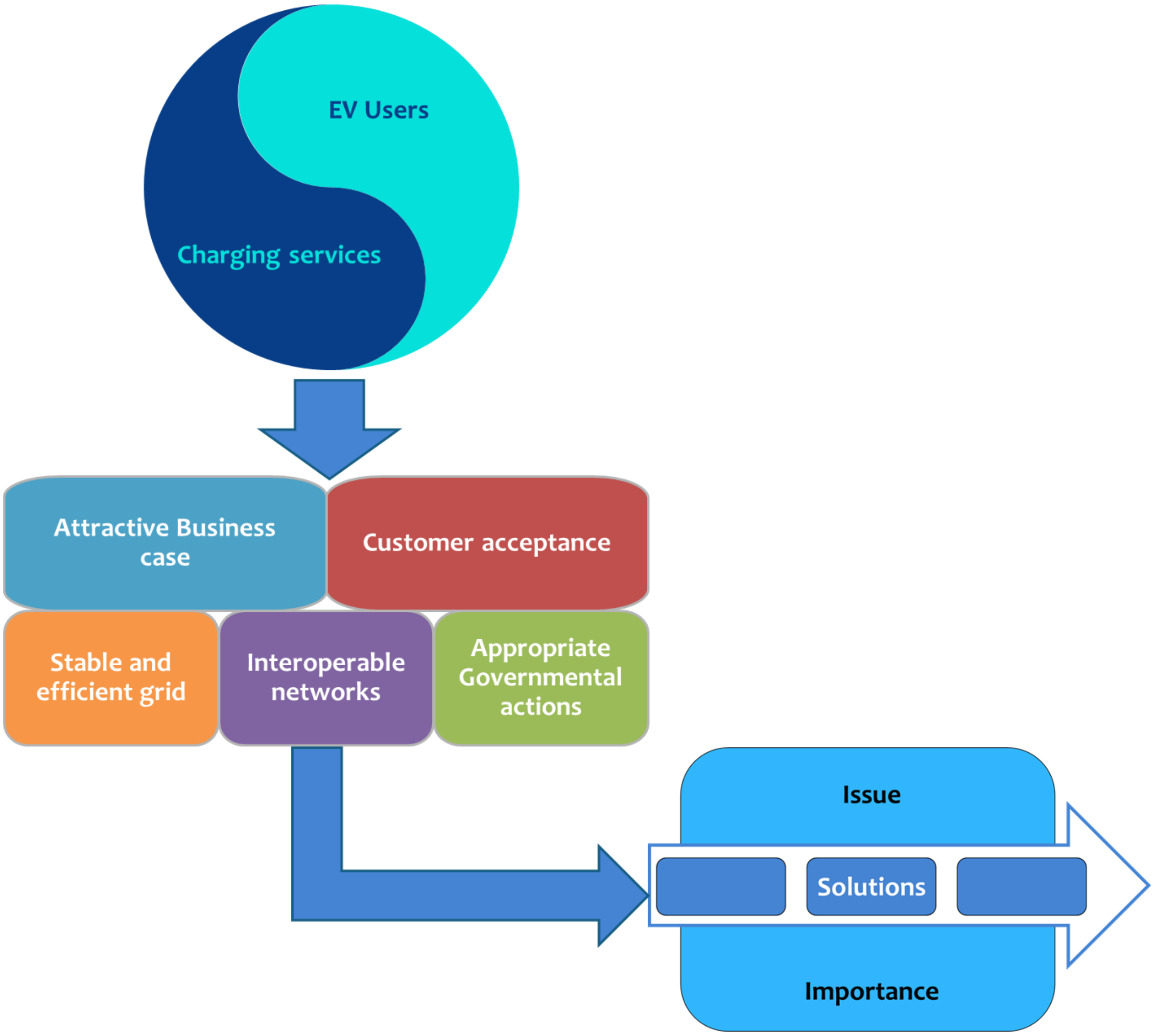

Figure 2.1 Needs, Issues, and Solutions

2.3 Glossary

Table 2.1 presents a list of the abbreviations used in this report. For detailed definitions of these terms (and others), see D7.10[2].

AC	Alternating Current
BEV	Battery Electric Vehicle
BM	Business Model
CA	Consortium Agreement
CH	Clearing House
D	Deliverable
DC	Direct Current
DoW	Description of Work (Annex I of Grant Agreement)
EC	European Commission
EMC	Electro Magnetic Compatibility
EV	Electric vehicle
EU	European Union

2 Not available as of publication of this report, but will appear at the page linked.

EVSE	Electric Vehicle Supply Equipment
EVSP	Electric Vehicle Service Provider
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
ID	Identification
ISO	International Organization for Standardization
OEM	Original Equipment Manufacturer
O&M	Operation and Maintenance
TCO	Total Cost of Ownership
TOU	Time of Use
TSO	Transmission System Operator
T&D	Transmission and Distribution
WP	Work Package

Table 2.1 List of abbreviations

3 EV user groups and charging needs

To define the actions supporting the uptake of EV, we need to look at what the various user groups are and what they need. The user groups are: private car drivers, fleets such as postal delivery, taxis and municipality fleets, and car-sharing schemes. These groups have different driving behaviour and different possibilities and needs for charging. What kind of infrastructure is required and how much it will be used depends on the number of trips people make with a certain purpose and the trip length. The different user groups are briefly described in Section 3.1. Section 3.2 describes the average number of trips and average trip length for different travel purposes. Section 3.3 briefly describes the main charging services and their most important characteristic. Section 3.4 discusses the charging needs of the various target groups. Finally, section 3.5 wraps this chapter together and connects it to the other chapters. Note that the focus on user groups is specific to this chapter, and that the other chapters focus on recommendations to policymakers, regulators and electric mobility service providers.

3.1 EV user groups

3.1.1 Private drivers

The private drivers group includes people owning a car, as well as people with a company lease car. They use the vehicle mainly for commuting, shopping and for leisure purposes, as seen in Figure 3.2. Most trips are below 40 km (see Figure 3.4), and so within the range of (current) electric vehicles. People that can charge at home will therefore use that as their main option to charge their vehicles. Paragraph 0 describes the various forms home charging can take.

People that cannot charge at home will have to rely on public or semi-public charging infrastructure. The share of such people will generally be much higher in highly urbanized regions than in less urbanized or rural areas. Table 3.1 and Figure 3.1 show that only part of drivers across various European countries can park their cars on their own premises (between 30-60%). The actual part of the drivers that will be able to charge at home is even smaller than that, since not all parking premises can integrate charging devices.

UK	Percentage of cars parked: 25% street parking, 59% own premises, 17% garage (UK average)
Germany	Average share of 63.3% of households can park their car in garage or own premises. In urban areas this share is much lower.
Netherlands	• On average 30% of households can park car on own premises • Leiden (120.000 inhabitants, high urbanized) 77% cars on-street parking • Houten (50.000 inhabitants, commuter village) 47% parking place on own premises, 40% on-street parking directly in front of house.

Table 3.1 Characteristics of private drivers for the UK, Germany and the Netherlands[3]

3 National Travel Survey: England 2013 https://www.gov.uk/government/statistics/national-travel-survey-2013
- Rapport: Statistisches Bundesamt, Wirtschaft und Statistik 5/2009 „Ausstattung mit Gebrauchsgütern und Wohnsituation privater Haushalte in Deutschland“
- Stadsenquête Leiden 2013: http://www.leidenincijfers.nl/onderzoeksbank/6568-2013_40798_BOA%20Stadsenquete%202013_15_Digitaal.pdf.

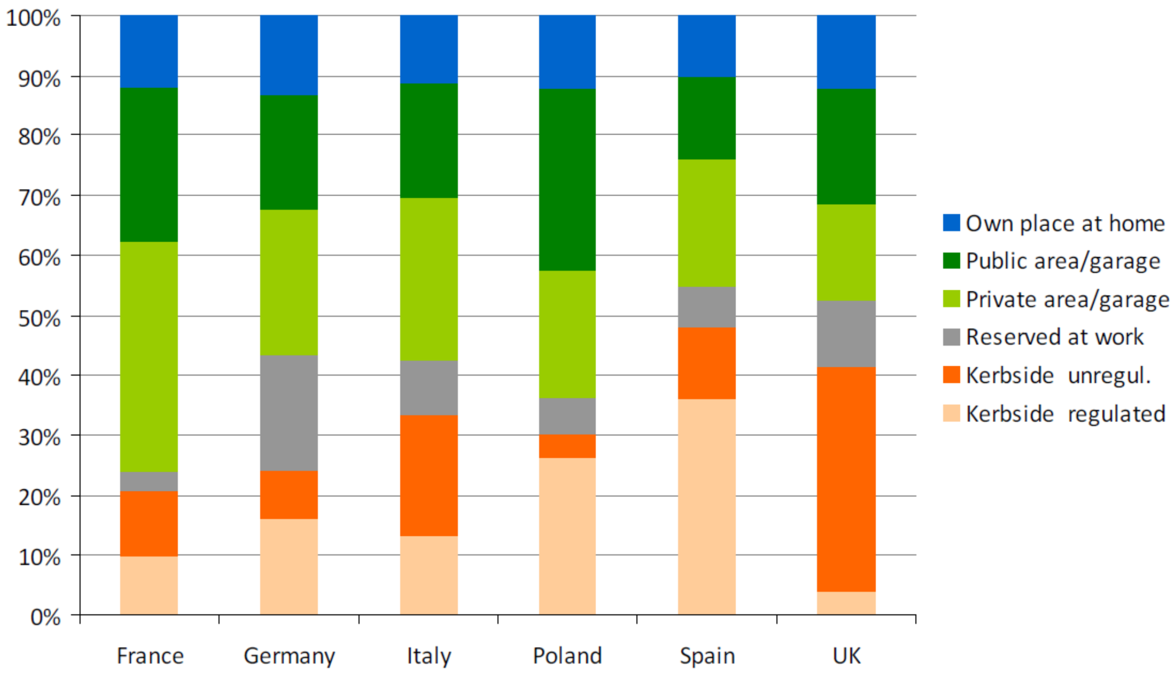

Figure 3.1 Distribution of parking places Monday to Friday for some European countries[4]

3.1.1 Company fleet drivers

Company vehicles, such as taxis, delivery vans (for goods and services), busses, garbage trucks, and other public works vehicles are good first target groups and market segments for the introduction of electric driving. The first reason for this is their high level of use, which is a key parameter to making electric vehicles competitive with Internal Combustion Engine Vehicles (ICEVs) (see D9.4 and D9.6). The second reason is the fact that individual trips are rather short (at least for some fleet types) and often include returning to and/or starting from a hub, where a charger can be placed. Taxis can charge at places where they usually wait for new customers such at airports, city centres and train stations. Buses can charge at the endpoint of their route or at bus stations and parking. Vehicles returning to company terrain can be charged at company hub. In addition to this, fleet managers are more likely than private drivers to make a purchase decision based on hard numbers (namely, total cost of ownership). Company fleet managers also make purchasing decisions in a more deliberate manner than private drivers. They weigh a number of criteria, such as price, environmental impact and image. The weight of the criteria will be different from one organisation to another. For example, a company with little public exposure will mostly focus on costs, while a company with a strong public presence might give some weight to image effects, and while the fleet manager of a governmental entity might value the image/example aspect even further. Another element that differentiates company fleets is the type of service they perform: taxis, delivery vans, busses, service vehicles all differ by average trip length and frequency. They also differ in how often they can return to a charging hub (taxis typically do that more often than delivery vans, who often perform a series a deliveries before getting back to a hub).

3.1.1 E-car sharing users

Car ownership is becoming a less attractive proposition to city inhabitants, for a variety of reasons. They include: high parking fees, tolls/congestion charges, traffic jams, limited (public) parking spots, and

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4 http://setis.ec.europa.eu/system/files/Driving_and_parking_patterns_of_European_car_drivers-a_mobility_survey.pdf.

access restrictions such as emissions-free zones. They more and more opt for other modes of transportation, such as public transport, scooter and bikes. These elements make car sharing schemes more and more popular among city dwellers, as they help them with punctual needs, without the hassle of the elements cited above. As for company fleets, car sharing fleets are good candidates for introducing electric mobility, since they are used for relatively short journeys, have a high degree of utilisation and return to a small amount of locations. The magnitude of the latter element depends on the specifics of the car sharing scheme. Station- (or hub-) bound schemes involve picking up a car from a hub and returning it to a hub (which might be different form the first one). Charging will mainly take place at those hubs. For free-floating-schemes, vehicles can be left and picked up anywhere, meaning that they will have to rely on (semi-) public charging. A certain number of electric car sharing schemes have started, mostly in highly urbanised areas. Examples of such schemes are Autolib' in Paris and Car2go in various places such as Amsterdam, Berlin and Stuttgart.

3.2 Driving behaviour

The parameters that define the frequency of use of various charging services are how often a vehicle is used for a given purpose and the length of the associated trips. The paragraphs below look at the cases of the Netherlands and the United Kingdom, which have readily available detailed behaviour data. While there are notable variations across the European Union (most notably on the yearly kilometrage) [5], they do not change the essence of our overall conclusions.

Figure 3.2 shows the average yearly number of trips a person makes as the driver of a car, in the UK and the Netherlands. A trip is defined as a one-way journey with a single main purpose. Those are averages, and the distribution for a specific group looks quite different. Commuters will have much more commuting trips than retired people or students. Sales representatives or consultants, for whom travel is a part of their work duties, will mostly drive on business trips and have much more of them than the average drivers. Non-work-related trips (such as shopping) have a much more uniform distribution.

Education, escorting and other personal business will generally occur on a weekly basis. People typically use their cars 1.5 times a week for shopping. Leisure trips, which occur on average twice a week, include high-frequency trips (several times a week), such as trips related to sporting activities and visiting friends, as well as monthly day trips to visit friends and relatives, and annual holiday trips.

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[5] http://setis.ec.europa.eu/system/files/Driving_and_parking_patterns_of_European_car_drivers-a_mobility_survey.pdf.

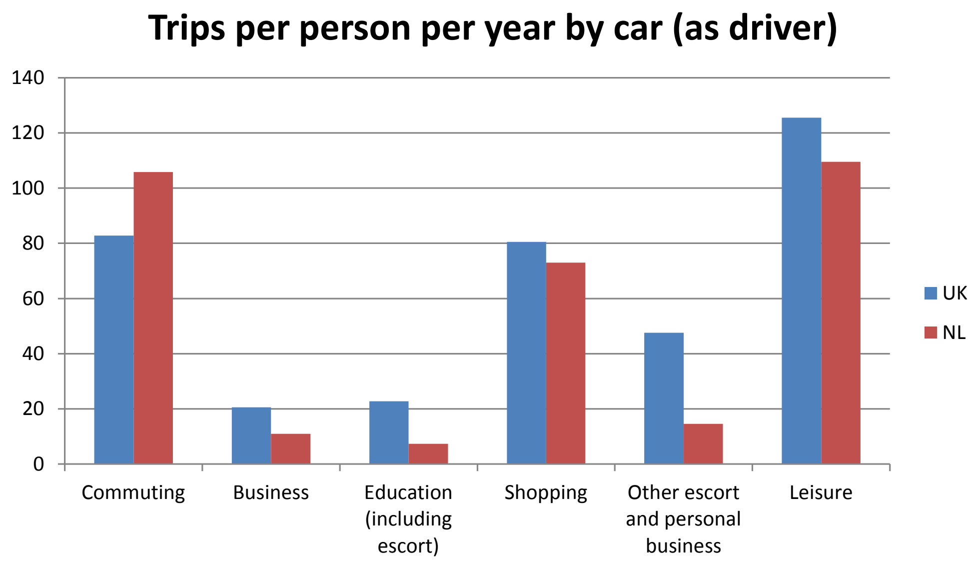

Figure 3.2 Trips per person per year as a driver for the UK and the Netherlands[6]

Car usage frequency for each purpose change by degree of urbanisation, as shown in
. In highly-urbanized regions, trips will more often be performed through other modes, such as public transport or walking and cycling. For example, city inhabitants in the Netherlands use their car 30% less for commuting than average drivers. They also drive much less often to go shopping, since the distances to shop are shorter.

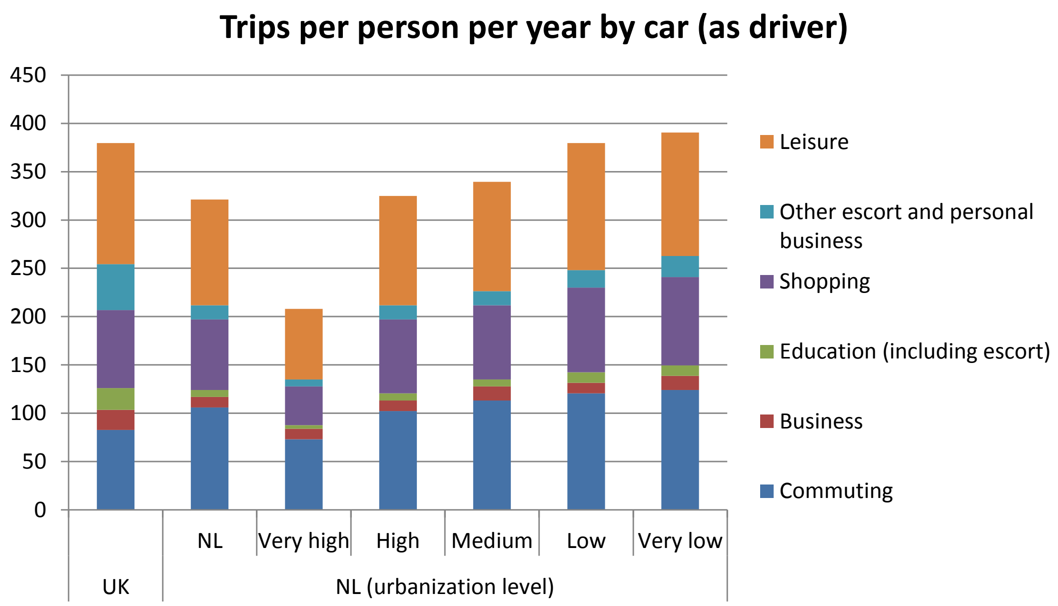

Figure 3.3 Driver trips per person per year by urbanisation level (NL)

Average trip lengths, i.e. one-way journeys, are shown in
. The average lengths for a round-trip for different purposes are all within the range of current models of battery electric vehicles. This means that, for most trips, charging on the way is not necessary. Some

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6 https://www.gov.uk/government/statistical-data-sets/nts04-purpose-of-trips [NTS0409]. http://statline.cbs.nl; Theme: Mobiliteit in Nederland; vervoerwijzen en motieven, regio's.

specific trips might exceed these averages considerably, but are either infrequent (such as holidays) or concern a smaller group with much higher trip lengths (such as business drivers or people with a very long commute).

For the majority of commuters, for example, the trip length will remain within the range of a BEV. Figure 3.5 shows this for the Netherlands. Groups with trip lengths much higher than average (on a daily basis) will look at solutions such as plug-in hybrids or charging at work.

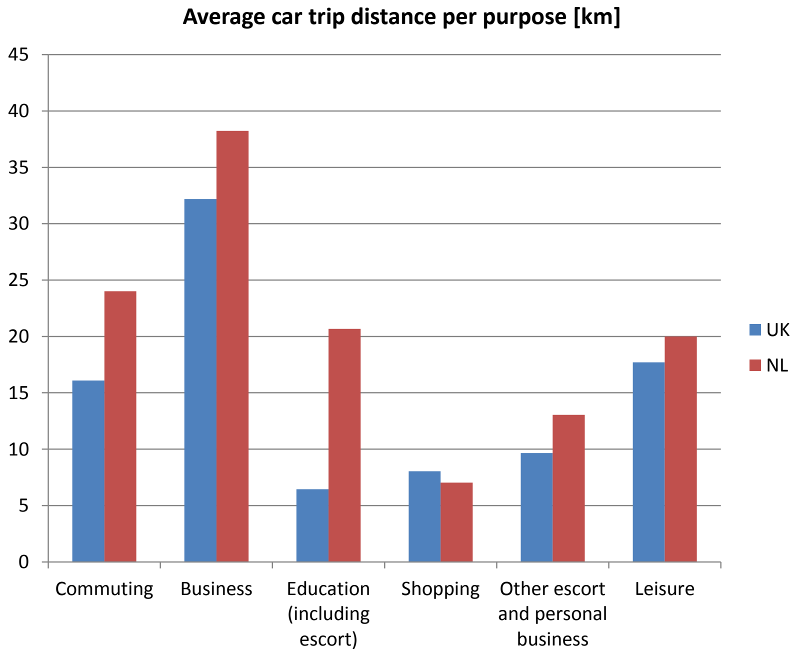

Figure 3.4 Average car trip distance per purpose for the UK and the Netherlands[7]

[7] Sources: https://www.gov.uk/government/statistical-data-sets/nts04-purpose-of-trips [NTS0409] and [NTS0410], and http://statline.cbs.nl; Theme: "Mobiliteit in Nederland; vervoerwijzen en motieven, regio's".

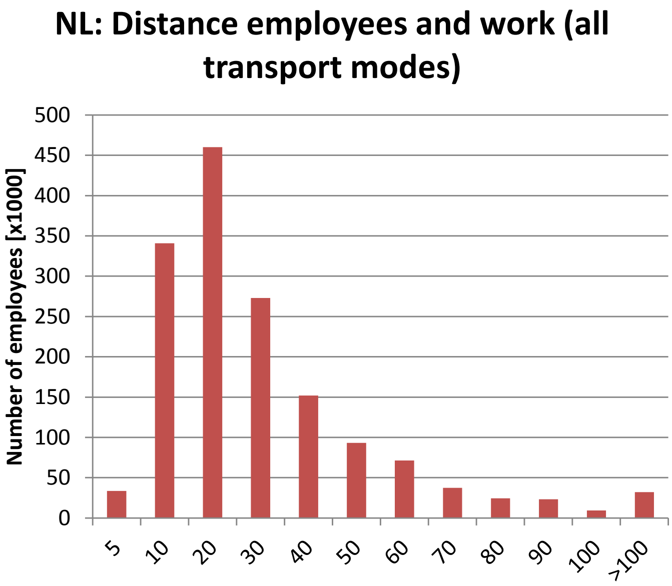

Figure 3.5 Average distance (kilometres) to work in the Netherlands (all modes)[8]

3.3 Characteristics of different charging services

This section defines the various characteristics of the possible charging services. It begins with a short description of each service, followed by a comparative description of their characteristics.

3.3.1 Private home charging

Private home charging is charging at home, where there is some form of access exclusivity. In most cases, the exclusivity will be both for the car, which will be parked in a private area, and for the charging pole, which will be owned by the EV driver and placed on private ground as well.

There are, however, multiple variants of home charging in which the location where the car is parked or the charging pole is installed are not privately owned by the EV driver. An example of such a situation would be a parking garage in an apartment building, where the parking spot and/or the chargers are not necessarily owned by the EV driver.

These various home charging configurations have certain common characteristics (e.g., slow AC charger, no connection to a roaming platform) that make them cheaper than public charging. The first is the existence of a grid connection. This removes the need to install and setup a new connection (reflected in an additional connection fee), which a public charger would need. The other cost-saving element is related to the fact that home chargers are placed on private terrain, which reduces the need for proofing against vandalism (since less people have access to it) and removes the need to get an authorisation.

There are a few exceptions to the general rule of home charging involving a car on private terrain with a charger on a private terrain as well. Such exceptions are more likely to occur in less urbanised areas and include the following:

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8 http://statline.cbs.nl; Theme: Banen werknemers en afstand woon-werk; woon- en werkregio's.

- A charger could be installed on a private terrain, such as a garden. This charger would serve cars parked on a public on a public parking space in front of the garden. This would involve a charging cable lying on the pavement, which would require the agreement of local authorities. Typically, this charger would be used by the garden owner only.
- Another possibility is that both the EV parking lot and the charger location are on public ground, but the connection to the grid is located inside a private house. The charger could be owned by the home owner, or by an EVSE operator. In this case the charger would be publicly accessible. The costs for charging would then be paid to the house owner, which would require interoperability. This option could also be seen as special case of public charging and could need permission from the municipality.

3.3.2 Employer parking charging

While the range offered by current and future electric vehicles is sufficient for most commuting trips, there are still several reasons for companies to offer charging at their locations:

- It is a useful complement to home charging , especially for people with a relatively long commute.
- It can push employees that cannot charge at home towards using electric vehicles, as their main use case (commuting) would be covered by this option.
- Opening charging to visitors would be a positive for customer relations and corporate social responsibility. Getting better rates from their electricity provider by entering smart charging schemes supported by EVs (see Chapter 6).

For these reasons, employers will not see the charging service as a source of revenue and will not need to earn money through it. They will count it as an employee incentive (for example by only passing the net electricity costs through to their employees).

3.3.3 Public charging spot for street/car park parking

Public chargers on the street will be primarily be used by people living in the neighbourhood that don't have private home charging. This can happen for people that don't have a fixed parking spot at or near their house and have to park on the street, or in car parks (at changing locations). These residents will slowly charge at night. Neighbourhood visitors (friends or service providers, for example) are a secondary target group. They will typically charge during the day, for a shorter time and with accelerated charging. Given that charging fees (based on time and energy consumed) are the only source of revenue for EVSE operators, a high degree of utilisation is key to their profitability.

3.3.4 Charging at shopping malls

In a similar fashion to what happens for parking fees, shopping malls might get interested in providing their customers with free/heavily discounted charging (at least for a given amount of time) to their potential customers, in an effort to drive sales. This offer might be conditional to a purchase.

3.3.5 Hotspot charging at place of interest

In the case of trips to relatively remote places of interest, such as amusement parks, (remote) touristic attractions, or sport arenas, customers might be willing to pay a premium for charging, compared to what they usually pay (for example by charging at home). Such trips are relatively long, creating the desire to charge. They are highly desired by car drivers, creating the willingness to pay (as they have a highly desirable purpose). They are also relatively infrequent, lowering the reluctance to pay a premium. This creates an opportunity for an EVSE operator that sees charging as a primary business. Given that these trips are typically around the edge of the EV range (i.e., drivers are worried about getting back home), the charging will mostly be a small “topping off” (in terms of power), using slow or accelerated charging for a relatively short time (corresponding to the site visit time).

3.3.6 Highway fast charging

Highway fast charging in necessary for trips where a single journey is longer than the EV range. It is also the case when the return trip is longer than the EV range and where there is no charging possibility at the destination (i.e., no hotspot charging at point of interest). Customers will then be willing to pay a premium for charging. Given that customers will want to get at their destination as quickly as possible, a short charging time is essential. The length of the trip also requires the amount of charging to be high. This requires a high-power (>22 kW) installation, with the right connectors (CCS/CHAdeMO for DC charging and type 2 for AC charging).

A crucial point for the EVSE operator is that a high degree of utilisation is needed, of the order of 3-5 charges a day per charging pole to have a positive business case(see D9.4). Another crucial point is to provide enough charging spot for all incoming customers. Balancing these two points can be difficult because of the large fluctuations in the amount of cars that go on long holiday trips: There will be much more demand on a summer week-end than during a fall weekday. Trying to match peak demand would mean having too many chargers during off-peak demand days (thereby having a too low utilisation average to be profitable). Only focussing on optimising the amount of charges per day per charging pole might lead to a capacity that is insufficient to meet peak demand. This means that EVSE operators will have to make their business case based on these two somewhat competing forces.

3.3.7 E-car sharing charging network

This concerns hub-based car sharing schemes (see section 3.1.1). One important point is that the hubs might be open to private cars (i.e., cars not in the car-sharing fleet), both for compliance reasons (as a condition to get authorisations to install chargers) and for business reasons (to increase charger utilisation). For scheme members, charging would be rolled in their membership and use fees. Non-members would pay based on time and/or energy consumption.

3.3.8 Company charging hub for fleets

Company fleets will require a private charging infrastructure, which will be used to charge the company’s vehicles. This infrastructure will provide off-use (overnight) charging, which will be long and draw enough energy to fully recharge the battery. It will also provide “topping off” charging (short, partial recharge) between trips. As this will essentially be an internal company affair, there will be no need for a positive business case for the charging service itself. There also won’t be a need for interoperability with other networks. Rental fleets fall under that category, as they match these charging characteristics rather than the above characteristics for car sharing.

3.3.9 Comparison of the various services

Table 3.2 shows the general characteristics of these services, and Table 3.3 shows more technical characteristics, and the paragraphs below briefly define the charging services.

The first general characteristic is the accessibility of the infrastructure, which can be private, or publically accessible (or something in between).The second general characteristic is the business model of the EVSE operator. If charging is a positive business proposition on its own (as needs to be the case for highway charging, for example[9]), then charging is the primary business of the EVSE operator. If, on the other hand, charging is an incentive to increase volume of a related service (for example to incite customers to stay at a mall and shop there), which is the primary source of income for the EVSE operator, then charging is a secondary business. In some cases (private charging at home, or at an employer), there is no business model as such. The final general characteristic is the necessity of interoperability/roaming with other providers.

The technical characteristics of charging services are the duration, energy amount, frequency, power and accounting basis of charging.

Charging services	Access	Business model for EVSE operator	Interoperability / Roaming
Private home charging	Private	None	No
Employer parking charging	Private	None	No
Public charging spot for street/car park parking	Public	Primary business	Yes
Charging at shopping malls	Public	Secondary business	No
Traffic hotspot charging at places of interest	Public	Primary business	Yes
Highway fast charging	Public	Primary business	Yes
E-car sharing charging network	Semi-public and Public	Secondary business (for own cars)/Primary business (for other cars)	Yes
Company charging hub for fleets	Private	Charging of company fleet (no business)	No

Table 3.2 General characteristics of charging services

9 To be more precise, highway operators might need to sell food and drinks at a high margin to make an interesting profit, in the same way gasoline/diesel stations on highways currently do. Nevertheless, providing energy for transport is still their primary focus.

Charging services	**Charging duration per event**	**Charging energy amount per event**	**Expected Charging Frequency per installation**	**Charging power per event**	**Charging accounting basis**
Private home charging	Long	Low/High (at night time)	Every day	Normal	n/a
Employer parking charging	Long	Low-high	Every working day	Normal, Accelerated	Employer incentive
Public charging spot for street/car park parking	Short and Long	Low	Twice a day	Normal, Accelerated	Time- and energy-based
Charging at shopping malls	Short	Low	Twice a day	Normal, Accelerated	Time-based
Traffic hotspot charging at places of interest	Short	Low	Depending on POI characteristics, from 1-2 per day to 1 per month	Normal, Accelerated	Time-based
Highway fast charging	Short	High	3-5 times per day	Accelerated, Fast	Time- and energy-based.
E-car sharing charging network	Short /Long (at night time)	Low/High (at night time)	Once-Twice per day	Accelerated	Included in car-sharing fee
Company charging hub for fleets	Long	Low/High (at night time)	Every day	Normal	n/a

Table 3.3 Technical characteristics of charging services

3.4 Charging needs

3.4.1 Vehicles with home charging possibility

As seen in section 3.2, most trips are below 40 km and so within the range of the electric vehicle. This means that vehicles with the possibility of home charging will charge mainly at home. For commuters, charging at work can be a useful complement to home charging, especially in the early phase when EVs will be mainly plug-in hybrids (which have a smaller electric range than BEVs).

The necessity for operators to make a profit and their need for staff and more expensive material (see above for this element and D9.4 for discussions about business cases) means that public charging (on the street, at points of interest, on highways or at shopping malls) will be more expensive than home charging. As a consequence, people with the possibility to charge at home will only use public charging infrastructure if necessary. This is the case for long trips (business or holidays), where drivers need access to highway fast charging and are ready to pay a premium for it. Home charging drivers might also want to pay the public charging infrastructure premium at their destination (on street, at e-car sharing hubs or at hotspots).

Home charging drivers would also use charging at shops or shopping malls, if the price was the same (or lower) than home charging. This could happen if the mall or shop owner subsidises part of the charging costs as an incentive to increase traffic and sales.

Table 3.4 shows the frequency a certain infrastructure place will be used by on average and the importance that the infrastructure is available, for a number of purposes. This will be repeated in the following paragraphs for other segments.

Infrastructure types / Purpose	Private home charging	Employer parking charging	Public charging spot for street/car park parking	Charging at shopping malls	Traffic hotspot charging at place of interest	Highway fast charging	E-car sharing charging network
Commuting							
Education including escort							
Shopping							
Other escort and personal business							
Leisure (short)							
Day trip (long leisure, business)		business					
Holiday base							

Daily	Mandatory
Weekly	Useful complement
Monthly	Incentive
Yearly	Irrelevant
Never	

Table 3.4 Infrastructure for the purposes of people with access to home charging

3.4.2 Vehicles without home charging possibility

Vehicles without the possibility to charge at home must rely on public charging. They prefer charging solutions located close to their homes, creating the need for public charging in residential areas. A given vehicle will not necessarily use them daily, but rather every second or third day, meaning that one residential area public charger can serve several customers. An additional element that would increase the number of customers using a charger is the possibility of opening access to the area's visitors at times where residents are away (for example to delivery vans during the day). The actual use frequency of residents will be a function of the capacity of their vehicles, their driving patterns and of the pricing system used by the EVSE operator. Pricing can be related to the time spent, amount energy charged, a fixed fee per session, or a (monthly) subscription fee (or a combination of these elements). The presence of a fixed fee will be a determining factor for the frequency of charging, as it will push drivers to wait longer between charges.

Other public accessible charging options will only be used when the price they need to pay is lower or comparable to public charging street/car park parking close to their homes. Charging at work will be a useful complement, especially if it is cheaper than public charging for street/car park parking. Since charging at work will on average cover the daily electricity demand, it will be even a more desirable complement then for people with the possibility of home charging. The charging needs for longer trips will be the similar to that of people with the possibility of home charging.

Infrastructure types / Purpose	Private home charging	Employer parking charging	Public charging spot for street/car park parking	Charging at shopping malls	Traffic hotspot charging at place of interest	Highway fast charging	E-car sharing charging network
Commuting							
Education incl escort							
Shopping							
Other escort and personal business							
Leisure (short)							
Day trip (long leisure, business)		Business					
Holiday base							

Table 3.5 Infrastructure for the purposes of people without access to home charging

3.4.3 Vehicles of company fleet

Vehicles of company fleet will mainly use the charging facility of the company itself. There are two reasons for this. The first is that charging there is cheaper than using public charging, as company fleet charging does not need to bring a profit to the operator (nor does it need a billing system). The other reason is control: By managing its own charging, the company gets data on the charging behaviour and needs of its vehicles. It can give instructions to its drivers to come back and charge (and swap vehicles), for example. For long distances, company fleet vehicles will need highway fast charging. In some cases, such as when visiting customers at a medium distance, private and/or public charging can be a useful complement, topping off the vehicle charge while the employee is busy with the customer. The proportion of such charging events outside of the company hub will strongly depend on the characteristics and nature of the fleet itself.

Infrastructure types / Purpose	Private home charging	Public charging spot for street/car park parking	Highway fast charging	Company charging hub
Passenger transport				
Delivery of goods				
Delivery of services				

Table 3.6 Infrastructure for the purposes of company fleet vehicles

3.4.4 E-car sharing fleet vehicles

For hub-based car sharing schemes (see section 3.1.1), almost all the charges take place at the company's hubs. It's only for medium-length trips (which are quite rare for car-sharing schemes) will public charging infrastructure be interesting. Free-floating schemes rely on the existence of a public charging network.

Infrastructure types / Purpose	Private home charging	Employer parking charging	Public charging spot for street/car park parking	Charging at shopping malls	Traffic hotspot charging at place of interest	Highway fast charging	E-car sharing charging network
Education including escort							
Shopping							
Other escort							
Personal business							
Leisure (short)							

Table 3.7 Infrastructure for the purposes of e-car sharing

3.5 Conclusion infrastructure needs

From the previous sections it can be concluded that for the large scale roll-out of electromobility the following charging infrastructure is required for travel purpose:

- Private home charging
- Public charging spots for street/car park parking
- Highway fast charging
- E-car sharing charging network
- Company charging hubs for fleets

Useful complements to these options are:

- Employer parking charging. Supporting the use of PHEV especially in start-up phase.
- Traffic hotspot charging at place of interest
- Parking at shopping malls

Combining these elements with the insights from a number of other reports[10], leads to the conclusion that there are essentially five categories of needs necessary for the large scale deployment of electromobility

[10] These deliverables can be found on the GreeneMotion website: http://www.greenemotion-project.eu/dissemination/deliverables.php. Links to relevant reports are shown in the needs lists, as well as within the text of this report.

and its underlying infrastructure. The first two are key business elements of the electromobility proposition, while the latter three are related to the underlying infrastructure and frameworks that support electromobility:

- Attractive business cases: Several users groups will rely on the existence of a public charging infrastructure (to varying degrees), as explained above. For operators to deploy and operate that infrastructure, they need an attractive business case. (See D9.4, D9.6)
- Consumer acceptance: Having a good case on paper does not ensure that consumers purchase EVs: They need to be sure that they can perform the same activities as before, without prominent constraints. They also do not necessarily base their decision on purely rational criteria. (See D9.1[11], D9.6)
- Stable and efficient grid: Managing the charging process and designing the charging infrastructure in order to minimise the impact of EV charging on the electricity grid. This will reduce the amount of extra grid investment needed and ensure electric vehicles can charge at a competitive price. Electric vehicles can even be a means to improve grid reliability and efficiency. (see D2.4, D4.2, D4.3-A1, and D9.2)
- Interoperable networks: The various players in the charging infrastructure grid need standards in order to offer discrimination-free access to their services. This is a complex element that involves many stakeholders. It mixes technical, business and consumer-facing elements. It is a main focus of Green eMotion, which aims at allowing EV drivers to charge in any EU country they visit. (See D2.4, D3.2, D3.8, D7.5[12] , D7.8[13] and D3.9)
- Appropriate governmental actions: plans, laws and procedures need to be aligned to support electromobility. Policymakers and regulators of all levels (EU, national, local) need to set up a supporting framework and take efficient supporting actions. (See D2.1, D2.4, D9.6)

In order to satisfy these needs, a number of issues will need to be overcome. The following chapters detail what the needs are, describe the associated issues and their importance for the large-scale deployment of electromobility, and provide policymakers, regulators and industry stakeholders with possible solutions and recommendations for concrete, practical actions. In order to achieve these needs, a number of obstacles need to be overcome, with associated actions. The following five chapters detail what the needs, obstacles and actions are (see Figure 3.6).

[11] Not available as of publication of this report, but will appear at the page linked.
[12] Not available as of publication of this report, but will appear at the page linked.
[13] Not available as of publication of this report, but will appear at the page linked.

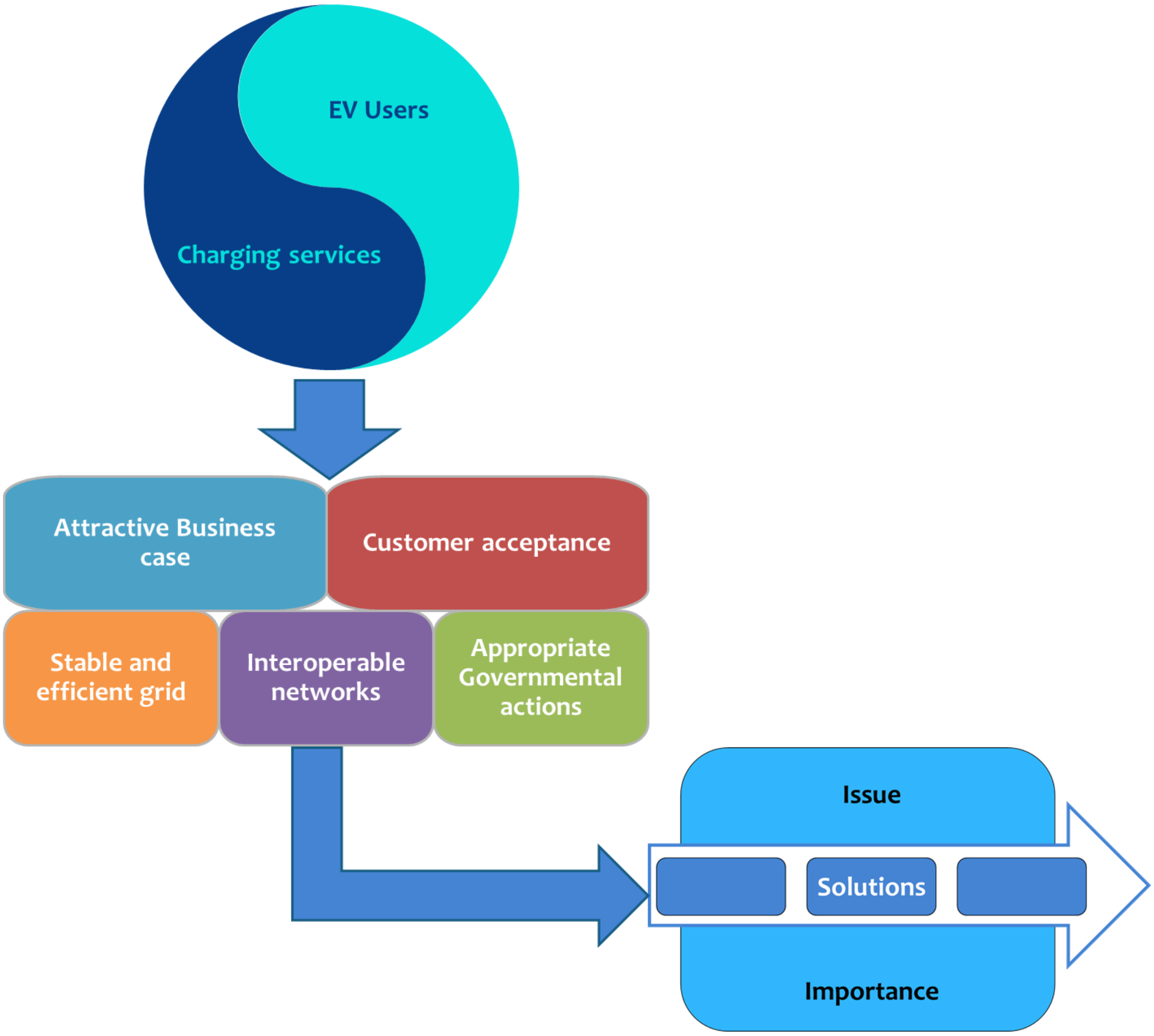

Figure 3.6 Needs, Issues, and Solutions

4 Attractive business cases: Deploying and operating a public charging infrastructure should be an attractive business proposal

As seen in the first chapter, deploying electric vehicles on a large scale will require both a private/home charging infrastructure and a public one. Even vehicle owners that have a home charger will have an interest in a public infrastructure being deployed, as its existence would reduce their range anxiety and would enable them to accomplish longer journeys, such as holiday trips, that they could not normally do (in that case, they would use highway fast charging). For details about the definitions of the various infrastructure types and use cases, see Section 3.3.

To be deployed, this public infrastructure needs a positive business case, so that private investors create and deploy it. Note that the analysis of a business case should not be limited to the charging services, but should include connected services, such as parking or shopping. Public entities such as the city of Amsterdam have deployed some public infrastructure, but these efforts were only experiments/kick-off/-starting efforts: Public entities do not necessarily desire to deploy, own and operate public charging infrastructure. There are exceptions to this, however. An example is Barcelona, where the public administration has taken the lead in the first stage of the deployment of a fast charging network, in order to create the necessary critical mass for future private investors.

There are five main issues that can lead to a negative business case for a private company to invest in public charging infrastructure:

- The hardware is expensive
- Installing the hardware at charging points is expensive
- Operating charging points is expensive
- Combining charging with other services is difficult
- The utilisation levels of public infrastructure are expected to be low, especially in early stages

Issue **The hardware used by charging points is expensive**

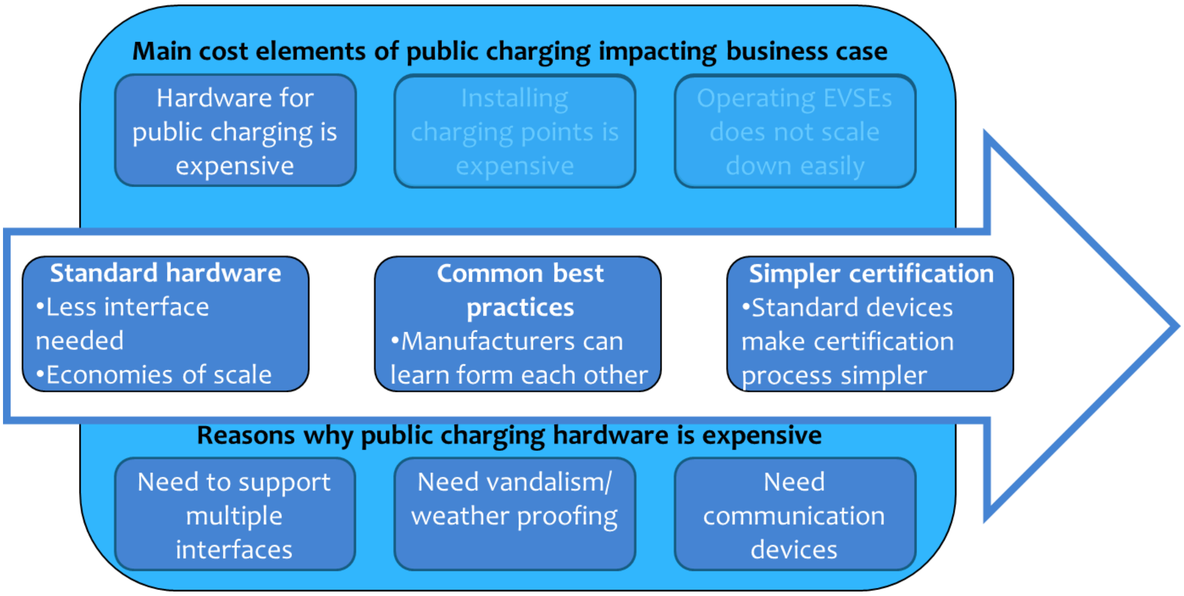

Figure 4.1 Solving public charging hardware costs

Current hardware costs for a public charger with two outlets are about six thousand euro (2013 price, from NPE 2014[14]). The reasons why public chargers are considerably more expensive than home chargers is that they (currently) need to support multiple interfaces (both hardware and software), that they need to be made vandalism- and weather- proof, and that they need communication devices. This price is however expected to drop due to scaling effects and technological improvements. This drop in price will be stronger for electronics, but not for the enclosure of the charging station.

Solution Standards reduce hardware costs

Standardisation reduces hardware costs in several ways:

- **Hardware simplification:** Having standardised pieces of equipment such as plugs means that other pieces of equipment have to support less interfaces and can thus be simplified and made for a lesser cost.
- **Economies of scale:** If equipment is standardised, then all manufacturers all produce one piece of equipment, instead of every manufacturer producing a number of different pieces of equipment. This means that this unique piece of equipment will be produced in numbers equal to the sum of all previous pieces of equipment, thereby generating economies of scale.
- **Common best practices:** Process improvements implemented by one manufacturer can be implemented by others, thereby reducing their production costs.
- **Simpler certification:** When setting up a charging station and connecting devices to the electricity grid, EVSE operators have to go through a certification that DSOs require in order to ensure that grid reliability is maintained. Having standard devices makes that certification process simpler, as it is simply a repetition of previous certifications.

For a more detailed discussion on standards, see the interoperability chapter and D7.6).

Actions EU, national policymakers facilitate adopt and enforce standards; EVSE operators and suppliers develop and implement them

Stakeholders	Actions
Policymakers	EU, national and local: facilitate/support collaboration platforms such as eMI3 [15]
Regulators	Act through legislation to remove competing standards, if appropriate (see interoperability chapter)
DSOs	Provide equipment manufacturers with requirements helping create standards
Equipment manufacturers	Participate in standardization and interoperability efforts and implement them

Table 4.1 Hardware costs actions

[14] http://www.bmub.bund.de/fileadmin/Daten_BMU/Download_PDF/Verkehr/emob_fortschrifttsbericht_2014_bf.pdf.

[15] eMI3 (http://emi3group.com/) is an open group of significant actors from the global Electric Vehicles market who joined forces to harmonize the ICT data definitions, formats, interfaces, and exchange mechanisms in order to enable a common language among all ICT platforms for Electric Vehicles.

Issue **Installing the charging points is expensive**

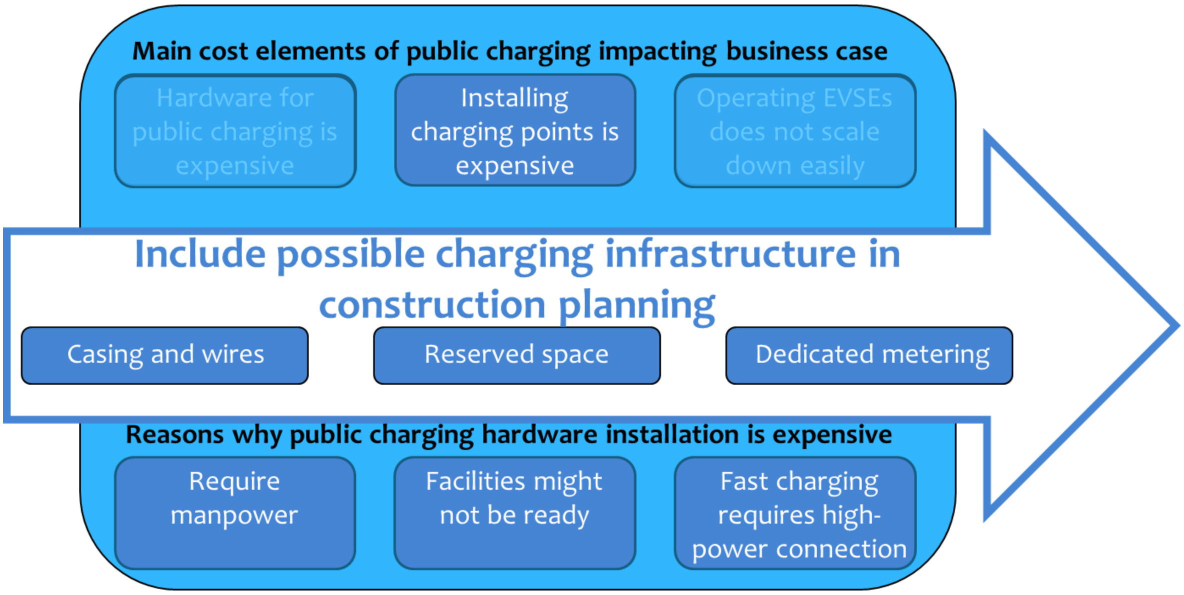

Figure 4.2 *Solving public charging hardware installation costs*

Buying hardware only represent one part of the investment costs EVSE operators incur when setting up a charging spot. Current hardware installation costs for a public charger are about 4'500 euro (2013 price, from NPE 2014[16]). The reasons for these costs being so high are the fact that they require costly manpower and that the layout of facilities, where chargers are installed, such as parking spaces, might not be made by taking the possibility of installing chargers into account. This can manifest itself by the lack of space to install chargers or the lack of wiring to connect devices. These costs are not expected to drop on their own (see D9.4), because these issues won't be solved by the expansion of electric mobility or standardisation. Special attention should be paid to fast charging facilities, as a key enabler for regional mobility, due to the higher power requirement from the distribution network. New technologies such as storage-supported fast charging stations will contribute to reduce these costs, due to their lower grid impact (see D4.5 and D8.5[17]for further details on this technology).

Solution **The (possible) integration of charging infrastructure is taken into account in construction planning and in network extension**

The key to save money on installing hardware into existing facilities such as parking spots in buildings is to have some form of preparedness to the possible integration of hardware. This should happen at the design and building phases of facilities, both for new constructions and for renovations. European, national and local policymakers can ensure that this happens through building code legislation and conditions to tenders. California has already made such requirements by requiring that new housing and parking lots have conduit and service panel capacity starting in 2015. In that same state, the City of Palo Alto has mandated that all new homes are prewired and are now moving on to charging and parking

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16 http://www.bmub.bund.de/fileadmin/Daten_BMU/Download_PDF/Verkehr/emob_fortschrittsbericht_2014_bf.pdf

17 Not available as of publication of this report, but will appear at the page linked.

requirements for apartments, hotels, and commercial buildings. According to estimates cited by the Mayor of Palo Alto, the cost of wiring an EVSE outlet in a new home is four times lower than into an existing structure, so such measures clearly have interesting saving potential. Similar rules are in place in Portugal and Ireland.

These integration requirements can be of 3 levels/stages, as shown in Figure 4.3.The centralised metering room in the passive infrastructure level would put all the meters needed for car charging in one location. These meters would be separate from meters for other uses. This enables smart functions, such as energy management (see smart charging discussion in the grid electricity chapter).

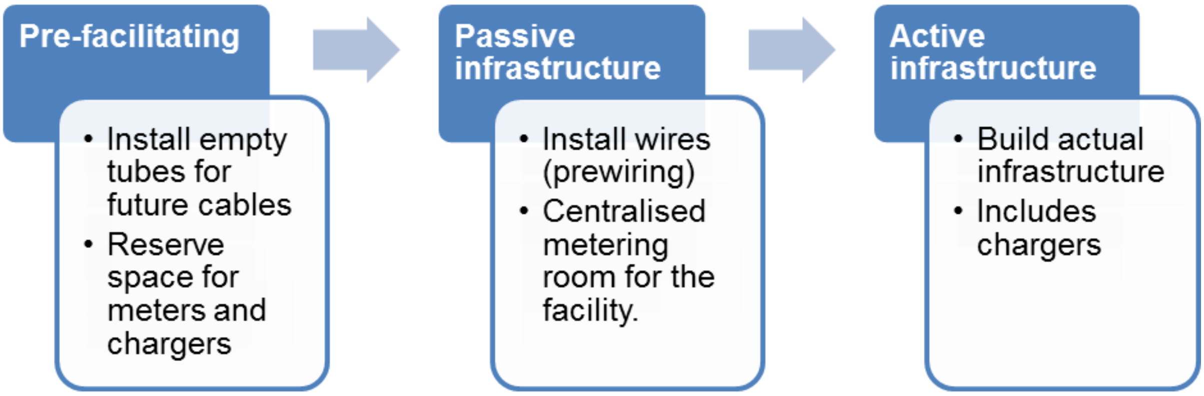

Figure 4.3 Levels of integration of charging infrastructure

Actions **Regulators set requirements that facility builders execute**

Stakeholders	Actions
Regulators	Put requirements in building codes and tenders
EVSE operators	Select locations that are ready to accommodate their operations
Facility builders	Integrate charging infrastructure requirements into their work

Table 4.2 Hardware installation actions

Issue **Operating EVSEs does not scale down easily**

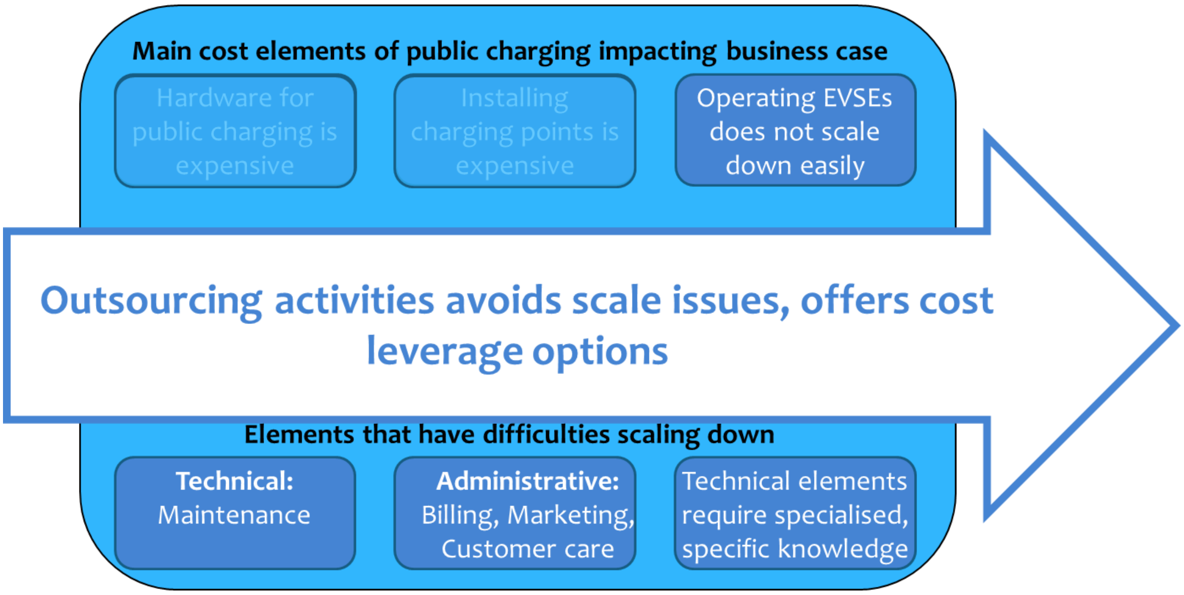

Figure 4.4 Solving scaling down problems

Operations of charging infrastructure can be technical, such as maintenance, or administrative, such as billing and marketing. The issue here is that scaling down operations does not scale down costs in the same way. Even if a provider has only a small number of clients, it will still need to have staff to operate the infrastructure and the business (billing, marketing, etc.) at a level that would be sufficient to serve a much larger customer base. This also holds for maintenance: A provider having only a few charging poles that may need a few hours per year to maintain would still have to employ at least one person to do so. That same person could take care of a much larger number of poles. The latter is actually a larger problem than the former, as EVSE operators usually have other activities that also have people performing administrative tasks, which do not change too much between business types. For example, existing call centre manpower can be scaled up to accommodate EVSE activities. In contrast device maintenance requires specialised and specific knowledge.

Solution **Outsourcing some activities can avoid scale issues and offers cost leverage options**

If providers such as EVSE operators and EVSPs do not have the required technical or administrative capabilities in house and if it does not make economic sense for them to set them up because of the issues discussed above, they might outsource these activities to a different company, if economically feasible.

This already happens often for administrative activities such as HR or marketing, mostly for costs reasons. Companies can use the fact that labour costs can vary quite a lot from country to country to save money by outsourcing activities that can be performed remotely. Outsourcing can also help for technical activities such as maintenance, where one company (or several) can serve all EVSE operators . This external company will have enough activity to avoid the scaling issues discussed above. Moreover, it will have the focus and drive to develop its technological capabilities. EVnetNL is an example of such a company: Founded by a consortium of Dutch DSOs, it operates and maintains a network of 3'000 public charging points. Obviously, outsourcing is only effective, if the operation of the infrastructure is similar (technically, process-wise) for several manufacturers. This leads to a strong demand of an harmonised operation principle of charging stations. The work on this proposed communication protocol is going to start in early 2015 and could be a major driving force for reaching simultaneous processes for operating charging infrastructure and establishing competition on 'real' USP's for customers.

Actions **EVSE/EVSPs outsource the activities that they cannot perform at the right cost**

Stakeholders	Actions
EVSPs	Outsource activities that they cannot perform at the right cost
EVSE operators	Outsource activities that they cannot perform at the right cost
Services companies	Propose the services EVSE operators and EVSPs need; can be created by a collaboration of providers (EVSE operators , EVSPs, DSOs, or a combination of them)

Table 4.3 EVSE operation actions

Issue **Combining charging with other services is not always an easy sell**

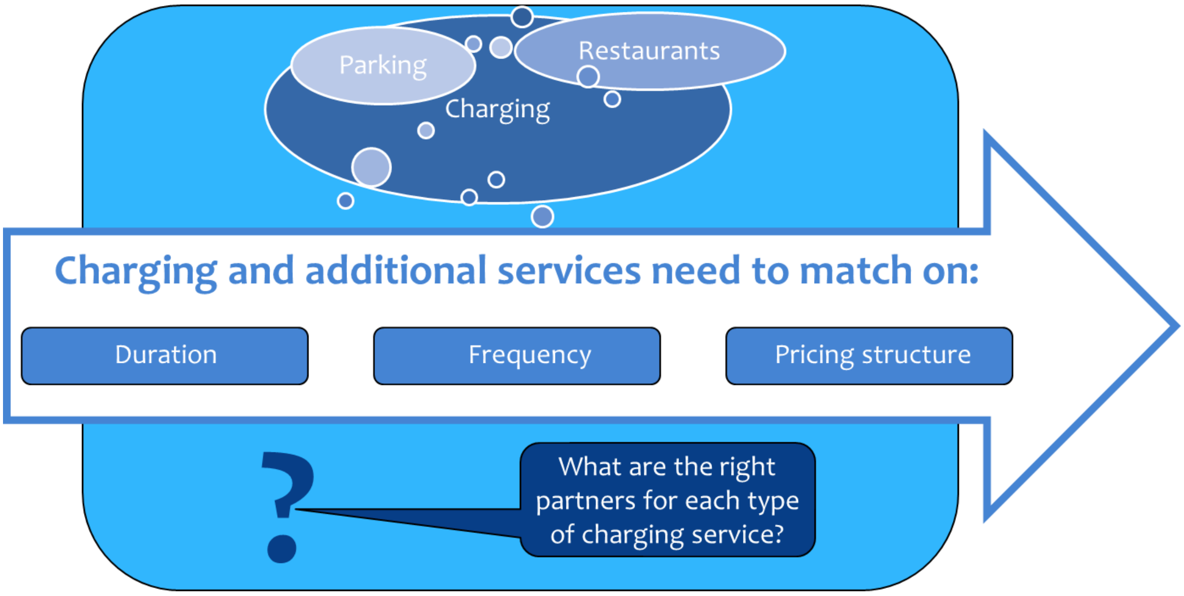

Figure 4.5 Solving matching with additional services

A possible way for EVSE operators to overcome a negative business case is to combine their offerings with other services. These services could be performed by the EVSE operators themselves. Alternatively, a partner could perform them. This partner is inclined to do this because they expect extra revenue generated by car owners staying at the EVSE location. They would retrocede a portion of this extra revenue to the EVSE operator. Examples of such additional services are: parking, restaurants, cinemas, shopping, advertisements on poles, or Wi-Fi hotspots. The first four examples are existing services, where charging is an add-on, whereas the latter two are add-ons to charging. The issue here is that it is unclear if such opportunities will exist, because EVSE operators will have to convince their partners that installing a charging station will generate extra volumes to existing businesses.

Solution **Identify new opportunities for combining charging with other services**

To overcome this issue, EVSE operators need to match their activities to the services they try to partner with. They need to propose charging services that match the interests of their potential partners. This means that the charging length should match the ideal customer staying time of their partners. This time is basically the time in which the customer performs the activity they come for: eating, watching a movie, buying something, watching a movie, etc. In some cases, it might mean that slow charging is a good proposal and fast charging is not, and vice versa. This is especially true when analysing possible cost structures. Another issue to take care of is that some activities might not be interesting for EVSE operators , if they are too infrequent to bring enough customers to provide enough charging volume. This would for example be the case for football stadiums, which only have customers once every two weeks and where a charging spot would only serve one customer who would stay just for the length of the game and not be replaced by another customer that day.

An additional element to take into account when matching additional services to charging is the actual product sold as charging. This actual product can be an amount of energy or time, or a fee per charging session. This choice is important for the charging service, as can change its business case from a negative one to a positive one, or vice versa. It will also affect the frequency and length of charging sessions. For example, a fixed fee per session will drive customers to charge less often, but for longer sessions. This will influence which type of service is best matched to charging.

Actions **Providers actively look for partners to provide additional services**

Stakeholders	Actions
EVSE operators	Identify partners and propose the right kind of infrastructure at their locations
Partners	Retrocede a portion of their additional revenues

Table 4.4 Combination with other services actions

Issue **The utilisation levels of public infrastructure are expected to be low, especially in early stages**

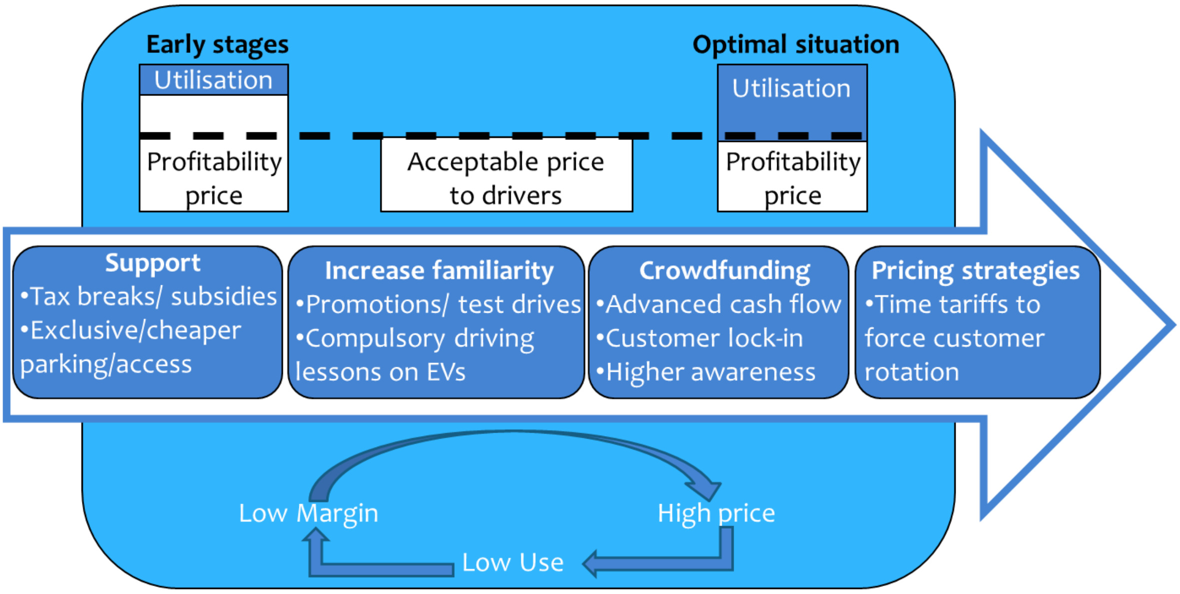

Figure 4.6 Solving low utilisation

Another revenue-based issue is that the utilisation rates of public charging infrastructure are expected to be too low for that infrastructure to be self-sustaining in the near future (see D9.4). Low use of public charging infrastructure means a low margin for the EVSE operator, who then has to raise its price, leading to an even lower utilisation rate. This vicious circle needs to be broken in order for the utilisation rate to rise and the profitability price for the EVSE operator to decrease, reaching a level that is acceptable to customers.

Solution — Stimulate EV adoption rate and support infrastructure in its early unprofitable stages

There are two ways policymakers can help alleviate this issue: they can stimulate EV uptake so that public charging infrastructure sees higher revenues, and/or they can subsidise public charging infrastructure. For vehicles, this support can take the form of direct payments or tax breaks. Tax breaks include (partial) exemption of car taxes such as registration or road taxes. National policymakers can also provide electric vehicle owners with better rates in home-work mobility plans. The way those plans work is that employees get reimbursed for their commute by their employees. Such reimbursements are tax-free (so they allow employers to pay a given sum to their employees cheaper than a regular salary). They also typically have a set rate per kilometre (about 35 eurocents in Belgium, 19 eurocents in the Netherlands). Policymakers could differentiate that rate according to the car's emissions (providing electric vehicles with an advantage). Public entities can also purchase EVs. It can also be non-financial: Electric vehicles can get exclusive or discounted parking or access to certain areas. Such measures can however create a backlash from ICE vehicle drivers, which might perceive that as an unfair disadvantage. Another angle would be to increase driver familiarity through promotions, test drives, or requirements for some driving lessons to take place on electric vehicles.

For charging infrastructure, it can be done with direct payments, tax breaks, through co-founding a structure with private companies, such as a public-private partnership (PPP), as Barcelona did with Renault and Nissan. They can also take place in the form of guarantees, such as longer concessions for public charging, or lower concession fees, for the cases where regulators decide to connect authorisations to a concession system.

Another possibility to support the charging infrastructure would be indirect subsidies: Cities would cede (part of) the parking fee revenue they earn to EVSE operators , but would be compensated by national or European entities. Yet another possibility would be to build the infrastructure and hand it over to a private operator after a period of time (with the possibility of selling it at a discount).

The actual actions from policymakers will depend on their resources and powers, which change greatly from one region/city/country to another. The actual tools available to policymakers also depend at which level they are (local policymakers will be able to act on parking, whereas national ones will have more subsidy/tax break tools at their disposal).

For more details about these elements, see D10.7[18].

In all cases, **consistency** is important. The eligibility rules and level of support should be know well in advance and should not be abruptly stopped. This will provide certainty to EVSE operators for their investment. **Timing** is also very important, as this support is most needed in the early phases of deployment, where EVSE operators do not get their full potential revenue yet. Another key point is to **focus** the support on the infrastructure that needs it: In some cases, public infrastructure might be viable and does not need subsidies, which can then be redirected to infrastructure that needs them.

[18] Not available as of publication of this report, but will appear at the page linked.

Solution Use the features brought by crowdfunding to overcome issues related to low utilisation

EVSE operators can look at alternative funding models that might solve some of their funding problems. One example is crowdfunding. Entrepreneurs use crowdfunding for a variety of reasons, some of which could be useful to overcome low utilisation of public infrastructure. A pure charity-based crowdfunding effort probably would not yield many results, as EVSE operators are corporations that are not seen as needy by their customers, even if contributing to a sustainability initiative would be a motivator. Instead, they will need to offer rewards, in the form of discounted charging services (for a given period of time). The sacrifice of a part of their revenue would bring the following advantages to EVSE operators struggling with low utilisation rates:

- It would bring some cash flow forward, which would help EVSE operators that have issues coming up with financing.
- It would "lock-in" customers to the EVSE operator's installations, both in terms of going to competitors, but also in terms of getting customers used to use public infrastructure (as opposed as avoiding it in favour of exclusive home and employer charging)
- It would generate awareness on the existence of public charging infrastructure (both to the funders and their friends/social media acquaintances).

Crowdfunding schemes have already taken places in various locations, such as the UK[19], Austria[20], or the USA[21].

Solution Use right pricing strategies

A sometimes overlooked aspect of optimising a business case for public charging infrastructure is the choice of a pricing strategy. EVSE operators should look at the reasons why their installations have a low utilisation rate and how they can improve that.

In some cases, this low utilisation rate can be caused by a low rotation between customers: If a vehicle stays at a charging station after it is done charging, it deprives another vehicle from the chance of charging as well. This can be a concern for installations that need a heavy rotation to achieve enough utilisation to be profitable. This would be the case for some forms of daytime public charging such as hotspot charging. This should not be the case for installations where users charge overnight, as users will not get back to their cars in the middle of the night to move it. EVSEs facing that problem can overcome it by adding a time-based component to their tariffs (or increase it if it already exists), which will push their customers to free up their spot as soon as their vehicle is sufficiently charged. It should be noted that this recommendation is for specific business cases of specific installation and is not a generality.

Other possibilities include introducing a subscription model (to even out the cash flow), or charging per event (to force customers to charge less often, but for a larger amount of electricity).

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19 https://www.seedrs.com/startups/pod-point, https://transitiontownforres.wordpress.com/tag/electric-vehicle-charging-station/

20 http://www.ella.at

21 http://www.forbes.com/sites/peterdetwiler/2014/01/22/chargepoint-building-out-the-electricity-highway-one-parking-lot-at-a-time/

Actions	Policymakers stimulate EV adoption and subsidise unprofitable infrastructure, EVSE operators try new financing models and tariffs

Stakeholders	Actions
Policymakers	Stimulate EV adoption (financially, through exclusive/discounted parking/zone access), promotion, requirements for some driving lessons to be on EVs, and subsidise unprofitable infrastructure
EVSE operators	Launch crowdfunding campaigns (or other alternative funding models); use right pricing strategies

Table 4.5 Low utilisation actions

5 Consumer acceptance: Having a good case on paper does not ensure that consumers purchase EVs

The other chapters cover the needs, issues, solutions and actions related to the massive deployment of electric mobility, from the point of view of the various providers, most notably EVSE operators, EVSPs, and DSOs. They essentially tell what should happen for the electric mobility proposition to be interesting to providers. On paper, this should also be of interest for consumers, but their decisions to buy and use an electric vehicle will not be solely based on a purely rational analysis. Rather, there are a number of issues that need to be overcome to gain consumer acceptance. D9.1[22] surveyed several issues that have an impact on EV demand, including objective characteristics of vehicles and infrastructure, and attitudes of consumers towards EVs. Among all these aspects, three main issues emerged as obstacles towards purchasing EVs:

- The **purchase price** of electric vehicles,
- Their **driving range**, and
- The **access to (fast) public charging infrastructure**.

In addition to these issues, the work related to standardisation (D7.6) has identified another potential issue, namely the **privacy of data** collected while electric vehicles are being used and charged. This data (which is also collected for ICE vehicles) about driving behaviour is collected for improving performance, but also for other purposes, such as preventing theft or to ensure lease payments are made (see below for details).

Improving the characteristics of EVs and charging infrastructure would not be enough to increase their adoption. The attitudes and perceptions of consumers regarding these characteristics (and EVs in general) are, as discussed below, what will drive EV adoption.

The issue of desired access to public infrastructure that might not be profitable is already addressed in the business case chapter, while the other issues will be discussed below.

The above mentioned issues are more explicitly described and some possible solutions and necessary actions are proposed in the following paragraphs.

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[22] Not available as of publication of this report, but will appear at the page linked.

Issue **The purchase price of electric vehicles is considerably higher than for comparable ICEVs**

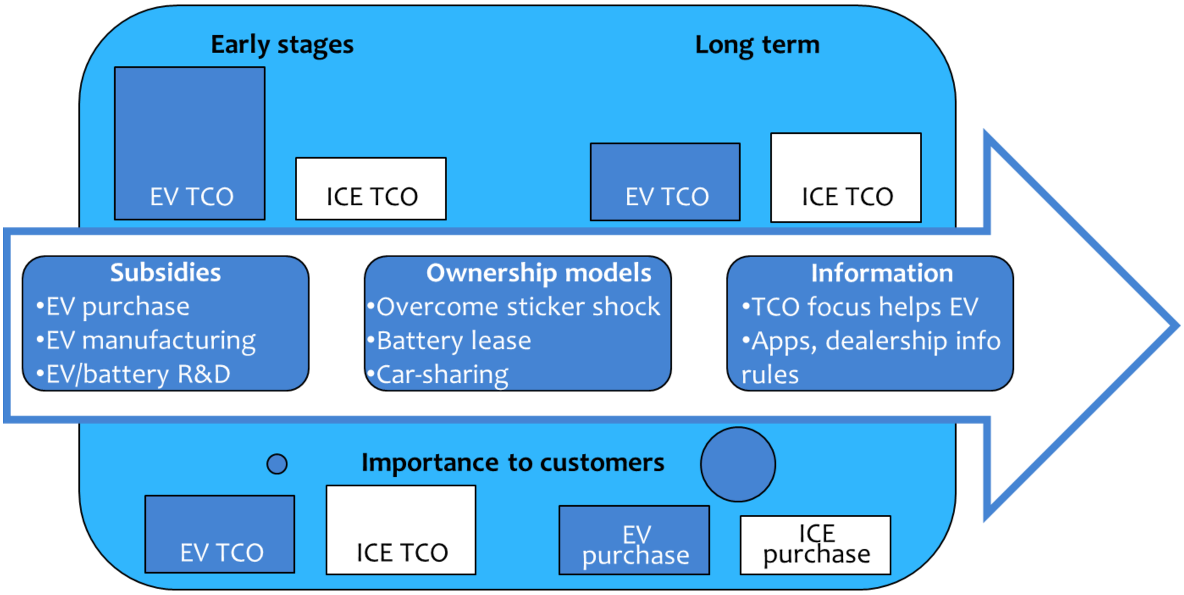

Figure 5.1 *Solving high EV purchase price*

As an emerging technology, electric vehicles are relatively expensive. Their price is expected to drop as their adoption level goes up. This transition means that for the first buyers, even the total costs of ownership[23] might not be favourable to the average user. In the mid-to-long term, the total cost of ownership might be favourable for many potential consumers, but the purchase price is expected to remain higher than the purchase price of diesel or gasoline vehicles. Consumers often do not base the financial part of the purchase decision on total cost of ownership. Rather, they focus on the purchase price of vehicles. This can be seen in the results of the survey in D9.1[24], where the high purchase price of electric vehicles has been identified as the element consumers were the most sensitive to.

Solution **Tax breaks, subsidies and other advantages can help**

In the short term, where the total cost of ownership of electric vehicle is not advantageous, policymakers can help stimulate the uptake of electric vehicles through tax breaks, such as a registration tax exemption. They can also provide direct subsidies. Such instruments have been shown to be very effective, but costly (see D10.7[25]): According to RVO[26], there were about 30’000 registered electric vehicles at the end of 2013 in the Netherlands, versus 7’500 at the end of 2012. These ~ 22’500 newly registered vehicles represent about 5% of new sales in 2013. This increase, mostly focussed on plug-in hybrids is attributed to advantageous fiscal rules on the registration tax. The efficiency of such instruments is not limited to electric vehicles: countries such as the Netherlands, Denmark and France have huge differences in registration taxes for cars according to their CO_2 performance, which boosts the purchase of low-emission cars. In 2013, the Netherlands achieved the lowest CO_2 emissions from new cars in the whole EU (109 g/km). On the other hand, Germany’s average intensity was 136.1 g/km in 2013. Germany does not have a significant registration tax and the CO_2 tax differentiation for circulation

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[23] Sum of the purchase costs of the vehicle, maintenance costs, and energy (electricity, gasoline, diesel, etc.) costs to travel.
[24] Not available as of publication of this report, but will appear at the page linked.
[25] Not available as of publication of this report, but will appear at the page linked.
[26] http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/stand-van-zaken/cijfers

taxes is too low to have an effect on consumer choice[27]. Other advantages, such as free or reserved parking or reserved lanes could also push consumers towards buying electric vehicles.
To overcome possible backlash against those advantages to a certain category of consumers, policymakers should clearly communicate how these measures are part of a series of actions that benefit every citizen by reducing pollution and reliance on oil.

Policymakers can also subsidise the manufacturing of EVs through tax breaks for setting up manufacturing and assembly plants, as they sometimes already do for ICE vehicles. They could shift some of that money towards EV manufacturing. A possible condition to this support would be to require OEMs to launch lines of low- and mid- priced EVs. Current available EVs are mostly in the mid- to high-range, compounding the high purchase price perception of EVs. A possible reason for this is that OEMs often introduce new features and technologies (advanced cruise control, park assist, but also hybrids) through their high-range vehicles because it is easier to introduce features and technologies in smaller production runs and because such technologies and features appeal more to people with a higher disposable income.

Another possibility is to help reduce costs on the long term by financing R&D, especially for batteries, as they are the main reason electric vehicles are more expensive than ICE vehicles. A possible condition for such subsidies would be to require data openness and knowledge sharing, so that the findings and improvements can be adopted by all OEMs, further bringing costs down.

Solution New ownership models might help overcome sticker shock[28]

In the long term, where the total cost of ownership would be advantageous to consumers, but the purchase price difference might still be too large for consumers, other tools could be used. One way to overcome sticker shock would be to propose new ownership models that rebalance purchase and use costs. This can for example be done by separating the car from its battery. The car would be sold to the consumer, but not the battery, which would be hired by the consumer for a monthly fee. Renault proposes such a model for its ZOE vehicle. This could of course also be useful in early stages of the deployment of electric vehicles.

Such new ownership models actually could fit more general trends in vehicle ownership, such as the reduction or time-delay in car ownership among the youth, which can be an opportunity for car sharing to grow. Elements such as increasing computing power on cars or car automation are also enablers of car sharing and a good fit with electric vehicles (as they can gather, transfer and process more information about car use pattern and enable new functions such as booking a charge without needing driver input).

Solution Information might be key in the long term

The other way to overcome sticker shock would be to focus on informing the consumers on total costs of ownership. This information should be accurate, easy to understand and as specific as possible.

This could take the form of an app where consumers could enter their driving needs. Regulators would require the existence of such a tool, which would be developed by OEMs. Policymakers could have a supporting role by financing the development of such a tool (if necessary) and a promotion role to spread knowledge about its awareness.

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27 http://www.transportenvironment.org/press/netherlands-tops-eu-ranking-lowest-co%E2%82%82-emissions-new-cars-%E2%80%93-germany-and-poland-laggards
28 A feeling of surprise and disappointment caused by learning that something you want to buy is very expensive

Another way to reach this information goal would be to require the total cost of ownership information to be displayed at dealerships, in the same way emission information is currently required to be displayed. Dealerships usually avoid steering the discussion towards total costs of ownership, as it would increase the total sum presented to the consumer and as it would show models with a larger consumption in a more negative way. The models command higher prices and are therefore more interesting for dealers. Electric vehicles on the other hand would benefit from the comparison and would also be more interesting for dealers to sell, due to their higher prices (and margins).

This could of course also be useful in early stages of the deployment of electric vehicles.

Actions **Policymakers stimulate the uptake of EVs, support TCO information; Regulators enforce its use; OEMs propose new models of ownership**

Stakeholders	Actions
Policymakers	Stimulate EV uptake with tax breaks, subsidies, parking and lane advantages; support total cost of ownership information development
Regulators	Require total cost of ownership information to be displayed and OEMs to develop information tools
OEMs	Propose new models of ownership; develop information tools

Table 5.1 Purchase price actions

Issue **Consumers have range anxiety issues**

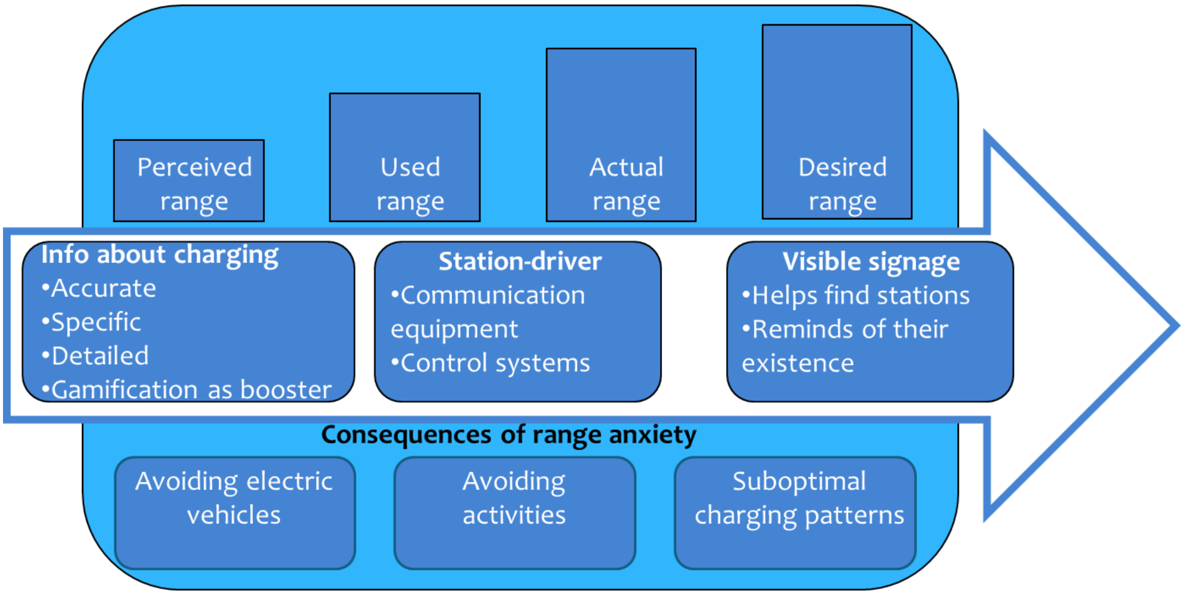

Figure 5.2 Solving range anxiety

A survey cited in D9.1[29] indicates that although 86% of respondents travel less than 100 km per day, the average range they would require to consider buying an electric vehicle is 308 km, which is considerably more than the average weekly kilometrage done by Europeans (about 222 km[30]). While this figure could be reached in the near future, it is considerably more than the ranges proposed by current electric vehicles. A possibility to overcome this issue would be to deploy enough fast charging infrastructure so that EV drivers would always be able to satisfy this need. This would, as seen in the business case chapter, be expensive and would take time to get profitable.

On the other hand, this required distance is much larger than the average trip length (2.6-16.8 km), and even the maximum distances (38 km-129 km) indicated in D9.1[31]. These distances also fall well within the ranges proposed by current models. In addition to this, consumers keep a battery stage of charge between 67% and 82% before a trip and that the average discharge during a trip is 10%. This indicates one (or more) off the following:

- Overcompensation due to range anxiety
- Development of habitual charging patterns, i.e. charging each time they can, even if it is not necessary.
- Easy access to charging infrastructure.

The fact that the driving range is the second most important attribute for consumers in the D9.1[32] survey, seems to indicate that range anxiety is at least a leading factor for this behaviour of keeping a high state of charge and low discharge per trip. Interestingly, the importance of the range increases after the consumers have experienced regular driving for several months with an EV. Given the fact that vehicles deliver the performance that consumers need, the anxiety might not be so much about the range, but rather about the uncertainty of being able to find a suitable charging solution after a trip.

Another element supporting that conclusion would be the fact that drivers would drive longer distances on EVs than on ICEVs. Nissan data about the behaviour of LEAF drivers[33] seems to support that: LEAF drivers travel more than 40% more than average drivers. On average, they amass 319 km per week (coincidentally very close to the 308 km desired range cited above). This should not necessarily be taken as proof, since that data is about a fairly small number of vehicles (31’000 LEAFs have been sold in Europe), and other factors (different consumer populations, for example) might be at play, but it is an extra indication towards showing that range anxiety is more an information issue than a technical one. Another interesting fact about that data is that there is quite some variance between the extra percentage of kilometres driven by LEAF drivers: Spanish LEAF drivers driver 92% more kilometres than the average Spanish drivers, whereas the extra percentage is 24% in France.

This issue is also less relevant for households with multiple vehicles, as these households could use an ICE vehicle to perform their long-range, exceptional trips. The electric vehicle would be the primary vehicle, as its use costs would be lower than those of an ICE vehicle.

Solution — Insightful information and advice about charging help increase the realised range and relieve anxieties

A possible solution to the range anxiety issue would be to provide drivers with accurate, specific, and detailed information and advice about charging possibilities. This should combine the needs of the drivers (planned activities, car status and capacity) and the capacity of the charging network (availability, charging modes, etc.). A possibility to exploit this information is gamification, i.e. in a form that challenges drivers to achieve a longer range by better driving or to improve their average state of charge. Fuel

[29] Not available as of publication of this report, but will appear at the page linked.
[30] Or 11’539 km per year http://newsroom.nissan-europe.com/EU/en-gb/Media/Media.aspx?mediaid=128267
[31] Not available as of publication of this report, but will appear at the page linked.
[32] Not available as of publication of this report, but will appear at the page linked.
[33] http://newsroom.nissan-europe.com/EU/en-gb/Media/Media.aspx?mediaid=128267

economy indicators already help push a similar aspect, and the richer information and processing power that would come with this insightful information could enable even more sophisticated schemes, such as achievements/challenges similar to ones used in video games.

This would require the vehicles and the charging infrastructure to be able to interact and needs seamless access to respective data. For this, they would need analysis tools that provide the necessary information, communication equipment (supported by a communication infrastructure) to share that information, and control systems to act on that information or display it to the driver/EVSE operator. The factors discussed in the interoperability chapter are also relevant here.

In addition to such technological solutions, having clear and visible signage showing the location of charging stations would be useful in two ways: It would help find the stations more easily, and it would act as a reminder of the existence of charging stations.

Actions **EVSE operators, EVSPs and OEMs, supported by policymakers provide insightful information to their consumers**

Stakeholders	Actions
Policymakers	Support development of information systems (promotion, financially if necessary)
EVSE operators	Develop and implement common information providing systems; signal the presence of charging stations
EVSPs	Develop and implement common information providing systems
OEMs	Develop and implement common information providing systems

Table 5.2 Range anxiety actions

Issue **Driving habit data privacy issues are more visible for EVs than ICEVs**

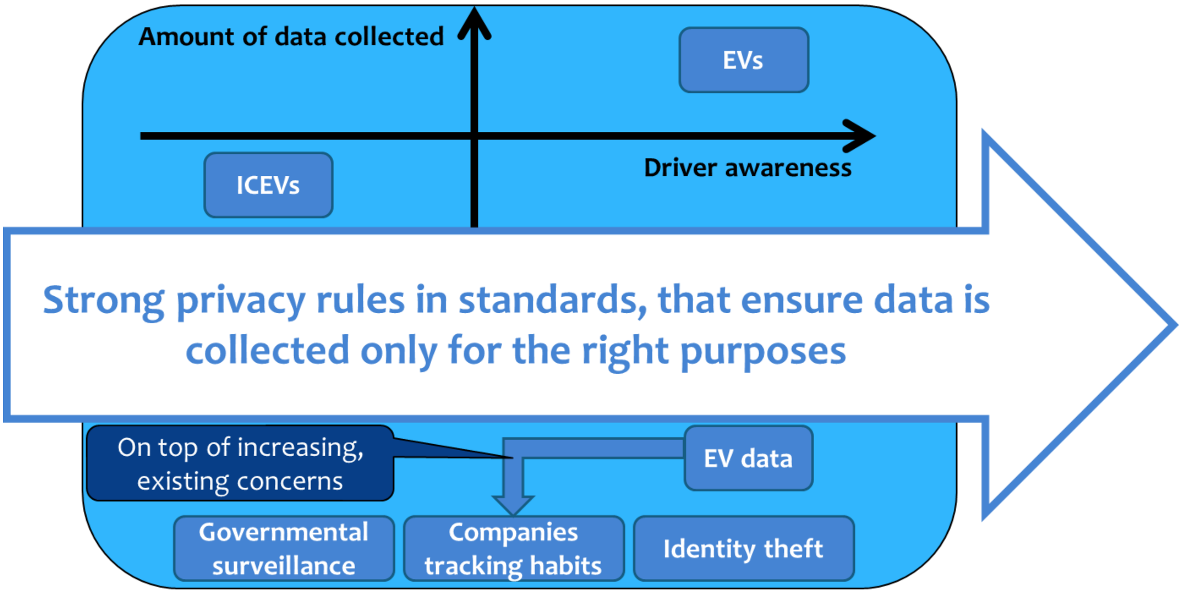

Figure 5.3 *Solving privacy issues*

Privacy is a general, growing concern that stems from the realisation by citizens that their ever-more connected lives are producing a huge amount of information that is being accessed by a growing number of parties, both for surveillance and for advertisement purposes. Privacy issues related to Internet and smartphone use have been at the forefront of the news for several years (through the Edward Snowden reveals, among others). Similarly, there has been a lot of concern about the increase in connectivity of many devices, such as household appliances. These concerns are one of the obstacles smart meters face in their roll-out.

Data about a vehicle's status, location, speed and other characteristics is currently being collected by OEMs and lease companies. This is done for a variety of reasons, mainly for providing drivers with appropriate information about charging infrastructure, but also for understanding driving behaviour, improving vehicle performance, fighting theft, or preventing drivers that do not pay their monthly payments from using their car[34].

The potential disadvantage electric vehicles might have compared to ICE vehicles would come from the fact that more data is being collected in a more visible and centralised manner. This extra, more visible, more centralised data is collected in relation to the charging process. The various necessary improvements discussed in the other chapters, such as the ones related to interoperability or smart charging, can require even more extra, visible, and centralised data. This could create a backlash from consumers if they think that this data is being used in inappropriate ways.

Solution **Strong privacy protection embedded in standards and open information about rules would bring confidence to consumers and information about collection, storage and usage of data**

The solution to this issue is to introduce strong and clear privacy rules. These rules should make sure that only data with a specific purpose, such as cheaper charging through smart management or telling a driver where they can charge their car, may be collected. This collected data should only be available to people directly involved with the process at hand. These rules should be widely available, in an easy to understand way. Regulators, EVSE operators, EVSPs and OEMs should take a proactive stance into spreading this information.

Constantly informing the user about what kind of data is collected, about the purposes of that collection, about how it is handled and treated after usage (deleted or anonymised, e.g.) may help to overcome privacy concerns of consumers.

Actions **Regulators introduce strong privacy rules. Together with EVSE operators, EVSPs and OEMs, they inform the public**

Stakeholders	Actions
Regulators	Introduce strong privacy rules; inform the user and the public
EVSE operators	Inform the public
EVSPs	Inform the public
OEMs	Inform the public

Table 5.3 Privacy actions

34 http://dealbook.nytimes.com/2014/09/24/miss-a-payment-good-luck-moving-that-car/?_r=0

6 Stable and efficient grid: Managing the charging process and designing the charging infrastructure in order minimise the impact of EV charging on the electricity grid

The main element electric vehicles will need is electricity from the grid. For a car that drives 15,000 kilometres per year and consumes 0.15 kWh/km, the demand would represent 2,250 kWh. This is a bit more than half the electricity consumption per household in the European Union (about 4,000 kWh per year per household).

The magnitude of this demand is however not widely seen as an issue, as increases in production should easily match the increase in demand, since the total amount of vehicles in expected to remain relatively small at least till 2020. A relatively optimistic scenario of 5 million vehicles in 2020 would require 11.25 TWh, which is about the production of a (large) nuclear power plant.

Rather, there are three types of issues related to the electricity demand of electric vehicles: its **timing**, its **spatial distribution** and its **impact on grid power quality**. The following paragraphs will each explain what these three types of issues are and propose possible solutions for them. It should be noted that one of these solutions (smart charging) actually helps to combat all three issues, but is most relevant for the timing issue, which is why it will be detailed there (the discussion on other issues focuses on solutions that are more specific to these issues).

Issue **Demand timing: A sharp peak EV electricity demand coinciding with the existing electricity peak demand would make the cost of delivering this electricity significantly higher than for an average electricity consumer**

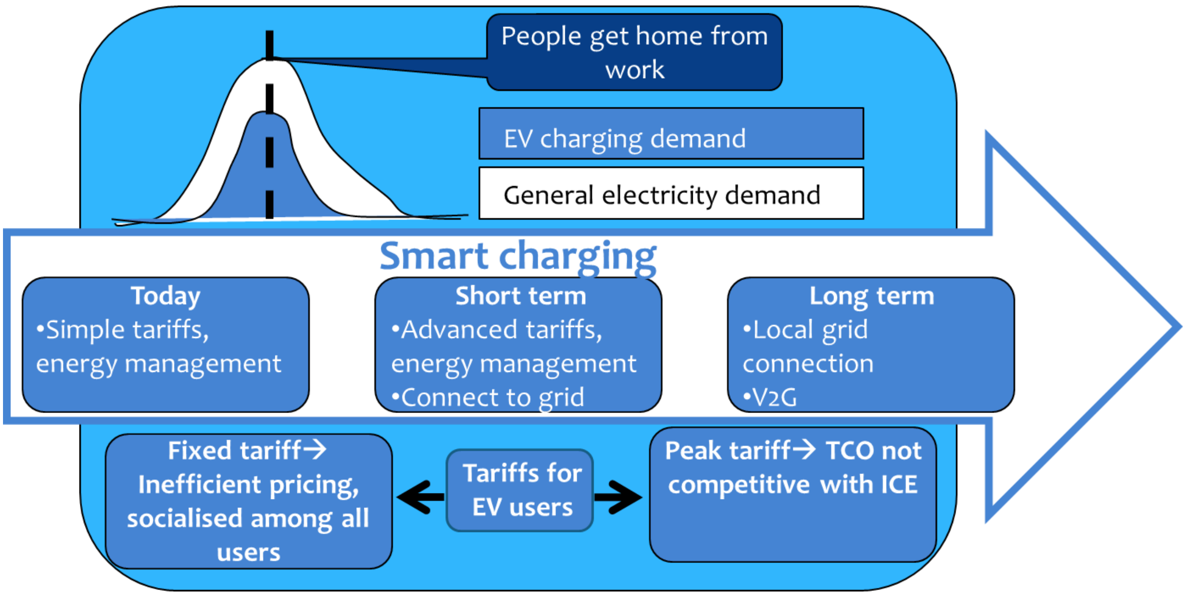

Figure 6.1 Solving excessive peak demand

The distribution of times at which users park their cars (and therefore are able to start charging) is highly non-uniform. It has peaks starting in the evening and at times when people get to work. The start of the evening peak and to a lesser extent the peak at work, coincide with general electricity demand peaks.

Peak demand electricity is much more expensive than baseline electricity because it uses plants that are used only at peak (thus get longer payback times) and plants that are less efficient (thus consume more fuel per unit of electricity output). Also, supplying additional electricity at peak times may require that additional infrastructure (i.e. generation and network capacity) is put in place in order to deliver a secure electricity supply.

The combination of these two facts means that if cars start charging immediately as they are parked, their demand will increase the "height" of the demand peak, thus increasing the cost and market prices to even higher levels than those currently seen during high peak conditions. If the EV users are exposed to temporal variations in electricity prices, this would potentially make the TCO of e-mobility too high to compete with that of ICEs, as shown in D9.2. If on the other hand the EV users only pay a fixed price per kWh (as is typically the case today), the additional cost would become socialised among all electricity system users, which would fail to send efficient pricing signals reflecting the actual cost of delivering electricity, as elaborated in D9.6.

Solution Introduce smart charging to spread demand

The solution to alleviate this problem is to use smart charging, which will allow spreading the charging demand of vehicles, bringing the demand to moments when the electricity is cheaper. Smart charging is also a way of helping with the spatial distribution and the impact of EV charging on grid power quality issues (discussed below). The timing of the introduction of smart charging and which actions need to be taken by various stakeholders are discussed below.

Smart charging needs smart components (that is elements that can produce data, communicate it and act upon received information) in all parts of the e-mobility system, namely the grid, the vehicles and the charging infrastructure. These elements can be hardware equipment (such as communication devices or computers integrated in cars), software or capabilities/knowledge by stakeholders. Only some of these elements are currently available. Others still have to be developed and implemented. Three horizons can be defined: **today** , the **short term** (until 2020) and the **long term** (post 2020).

Today: New tariff mechanisms and local energy management

In the short term, elements that can be implemented without the need for technical advances and mainly require adapting existing regulations that hinder/hamper their implementation can be adopted. They include:

- New tariff mechanisms, such as tariffs based on time of use (with more granularity than just a day/night differentiation) or real-time pricing can be used to incentivise customers to shift their charging events towards times that are more favourable from the grid point of view (i.e. to avoid peak demand hours).
- Basic local energy management strategies, such as scheduling car charging by turning charging of a given car on and off to produce a more system-friendly and cost-efficient charging regime.

Short term: Advanced pricing strategies and energy management, connection to the electricity market

Short-term elements are both advanced versions of the "today" elements and new ones that require relatively advanced techniques and knowledge, and require considerable preparatory work.

- Advanced versions of the "today" pricing strategies in the short term include critical peak pricing, which draw on the advanced knowledge of the requirements of the electricity network.
- Advanced versions of the "today" local energy management are things such as providing modulated power (i.e. not just turning charging on and off), which necessitate advanced communication and control capabilities of the vehicles and the chargers. Providers can also make their decisions whether to charge or not (and how much) based on price, weather, or demand and

supply forecasts. Data, forecasting capabilities and connecting that knowledge to decisions (both from a process and technical point of view) are the elements providers need to implement these advanced energy management strategies.

- The first new element is aggregation: If electric vehicles are allowed to participate in the day-ahead electricity market (i.e. purchase electricity for their charging in bulk), then DSOs can manage their network more easily, as they have more information on the coming demand. As an indication, an aggregation of 10,000 cars each drawing 3 kW would represent a total draw of 30MW, which the DSO could spread out by sending charge patterns to EVSE operators . This would require some simple communication between EVSE operators and DSOs. DSOs would also need the right to access to that data, which is not currently the case. However, it is more likely that this would happen indirectly, through pricing.
- The second new element would be the provision of primary frequency regulation (react to generation fluctuations by drawing more or less power, thereby helping TSOs to manage the system). This would require local controllers in the chargers implementing drop control functions.
- The third new element would be the provision of secondary frequency regulation, which is the combination of the above two elements. This would require advanced communication capabilities between the TSOs and the EVSE operators , as the lead time necessary for a reaction to a given request is much shorter than for aggregation only. This also means that the benefits are higher, since the range of solutions provided by flexible EVs is wider. This would deliver considerable additional benefits, as they would combine the scale effects of aggregation and the important grid-relief effects of frequency regulation.

Long term: Connection to the local grid and V2G

Long-term elements require significant advances either in terms of infrastructure deployment or in terms of technological advances.

- The measures previously described (frequency regulation and aggregation) for the global grid can be extended to services required by local distribution grids (e.g. peak management, investment deferral, outage management etc.). They require a considerably denser communication infrastructure than for the global grid, which explains why it is only expected to happen in the long term.
- Enabling Vehicle to Grid (V2G) schemes requires two-way flows of both information and electricity. This needs the development of supporting technology, as well as the adoption of appropriate standards, such as ISO 15118. These standards need support and to be put into regulation/requirements. For more details, see D7.3[35].

Actions **Policymakers allow the necessary changes, regulators develop guidelines, operators develop and implement systems, electricity suppliers provider financial incentives**

Because smart charging requires different elements of the e-mobility value chain to work together (for example cars need to communicate their status and needs to the electricity network through the charging infrastructure and vice versa), all e-mobility stakeholders have a role to play in the deployment of smart charging. These roles are described below. It should be noted that there are situations where one entity fulfils several of these roles (depending on the country).

35 Not available as of publication of this report, but will appear at the page linked.

Stakeholders	Smart charging actions
Policymakers	Allow the necessary policy and regulatory changes to happen and provide support and coordination
Regulators	Develop guidelines, propose advanced commercial and regulatory mechanisms and enforce standards
DSOs	Set up their network to accommodate smart charging
Electricity suppliers	Provide financial incentives to customers so that they participate in smart charging
EVSE operators	Implement and operate energy management systems, provide benefits to customers
Equipment manufacturers	Develop and implement standards

Table 6.1 Demand timing actions

(1) Policymakers allow the necessary changes to happen and provide support and coordination

The actions of policymakers are concentrated at the beginning of the process. Mostly, they can ensure that smart charging is possible by allowing the establishment of various tariffs, car demand control and electricity reselling (from cars to the network), and by requiring that standards (such as ISO 15118) are used. They can also offer some support, either through subsidies and tax breaks, or through exchange platforms, where the other actors can exchange experiences and ideas.

(2) Regulators write guidelines and enforce standards

Building on the efforts from policymakers, regulators of making the rules around allowed tariffs, car demand control, electricity reselling (for example, who can do it and what transaction fees should be levied), and which standards should be used. This should happen in consultation with all the main stakeholders below.

(3) DSOs set up their network for smart charging

DSOs have a central role in smart charging, as they interact with the charging side (either EVSEs or home charging) in all cases. They need to setup and operate their networks so that smart charging schemes can be implemented. Mostly, this is about setting up and operating communications (within the electricity network and with the charging infrastructure and electricity producers). They validate the scheduling of charging processes, looking for security and reliability through power flow analyses.

(4) Electricity providers provide discounts to customers so that they participate in smart charging

For home charging, there is no EVSE operator, but smart charging can still happen and would be a source of benefits (lower electricity prices through spreading demand). In order for this to happen, these benefits have to be made visible to vehicle owners, who have to give their approval for schemes that either shift the charging time or use power modulation. The simplest way to do this is for electricity providers to give discounts to their customers to participate in smart charging. In some countries, the electricity producer and/or the DSO (who get the actual cost reductions from smart charging) are a separate entity from electricity providers, but in that case, costs can simply be passed through. This also involves explaining to car owners why such schemes are necessary, what they involve and what their benefits are. This would help overcome resistance to the implementation of smart charging by car owners (on privacy grounds or on worries about vehicle performance).

As an illustrative example of possible incentives and their magnitude, a Dutch electricity provider (Nuon) offers a 25% discount to its customers on the electricity they use to charge electric vehicles (at least for the first three years). It should be noted that this particular discount does not require smart charging participation (or, in fact even a specific meter for the vehicle), but it indicates the order of magnitude of the discounts that should be provided to the customers. Discounts for actual participation in smart charging might be even larger than these 25%.

(5) EVSE operators implement and operate energy management systems, provide benefits to customers

EVSE operators have a central role in the implementation of smart charging at their facilities (i.e. all charging facilities except home charging), since they are the ones operating the charging devices and in charge of the vehicle. They will have to execute the energy management systems described above on the charging infrastructure (and vehicle side).

This requires them to purchase, install and operate all the necessary equipment, to develop the required capabilities (analysis of needs, development and use of best algorithms, and interactions with DSOs). They need to provide information about their needs and their insights about possible and probable charging behaviours to DSOs, equipment manufacturers and marketplace operators so that best standards are developed and implemented. Sharing best practices with each other would be beneficial for all the EVSE operators . They also need to convince vehicle owners and DSOs (and possibly electricity manufacturers) to participate in smart charging scheme. Their role there would be as an intermediary that translates the benefits DSOs (and possibly electricity manufacturers) obtain into incentives to car owners. Similarly to electricity providers, they not only should provide their customers with benefits, but should also inform them about smart charging and its consequences.

(6) Equipment manufacturers develop and implement standards

Manufacturers of equipment (vehicles, charging devices, communication devices) need to ensure that their devices are equipped with the proper elements (communication and processing, mostly) and that these elements follow established standards (such as ISO 15118).

Issue **Demand spatial distribution: Some low-voltage grids may become congested due to pockets of high EV uptake**

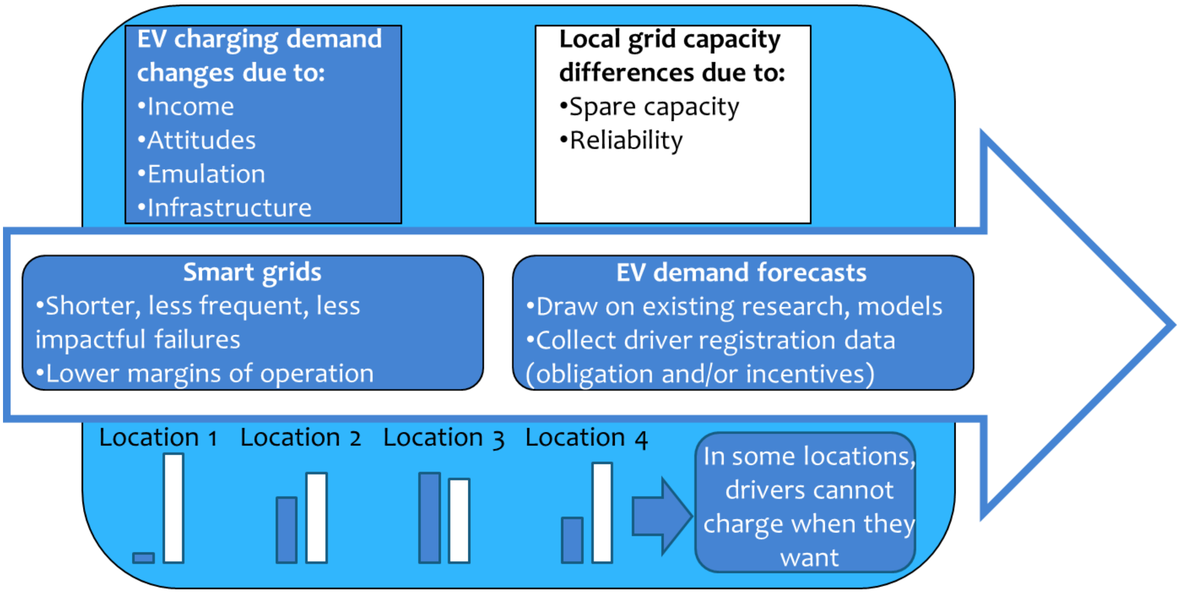

Figure 6.2 Solving local grid congestion

Even if enough electricity is available for acceptable prices (by using smart charging, as discussed above), it does not mean that vehicle owners will be able to get it. In order to reach the charging point location, the electricity has to be distributed through local low-voltage grids. These grids have constraints that are imposed by a combination of the physical or electrical capacities of the lines in the grid and of operational directives that restrict power flows (through a piece of equipment) in order to protect the reliability of the grid (i.e. to avoid failures). Congestion occurs when the **demand** (or the supply) of electricity in a given local low-voltage grid exceeds these **network constraints**. If congestion happens, vehicle owners may not be able to charge their vehicles when they want (and/or at a reasonable price, if time- and location-specific electricity prices are in place that reflect the scarcity of network capacity).

Both the network constraints and the charging demand profile will depend on the locally specific situation, and there may be significant variations from one location to another. These variations may arise from the fact that some low-voltage grids have more spare capacity and/or less reliability issues than others, but also because the EV uptake level is not uniform, resulting in variations in **local demand**. Ownership of an electric vehicle may be much more attractive in some neighbourhoods than in others due to factors such as income levels, infrastructure availability, usage patterns or attitudes towards the environment. Another important effect is emulation/contagion, which refers to the fact that once a certain number of inhabitants of a given neighbourhood acquire an electric vehicle and are satisfied with it, their neighbours will be more likely to get one as well.

Another aspect of this issue is the capacity to deliver the power required by the chargers. This would be especially of concern when adding fast chargers, which require high power (22-50 kW, or even 120 kW for Tesla's superchargers) in a busy area. In some countries, however, even home charging (3-6 kW) might be a problem, as this might exceed power limits on the grid.

To solve these issues, DSOs should **make their grids smarter** and use **forecasts of e-mobility demand** to identify where network congestion may occur due to high local EV uptake and take appropriate action. While smartening their grids, they can also ensure that power requirements are satisfied.

Solution Reducing network constraints: DSOs make their grids smarter

As discussed in the previous section, smart charging helps spread out the demand for charging, alleviating the pressure of peak production, thereby reducing costs to the consumer. This demand spreading also alleviates low-voltage grid congestion issues. Network congestion issues can also be alleviated with smart devices and procedures, potentially avoiding the need to reinforce the local network. As discussed above, network constraints are caused by two types of elements: physical/electrical capacity (which can be upgraded by installing new hardware such as cables or transformers), and operational practices. A smart grid can potentially support more flexible operational practices in two ways: by reducing the **impact of failures** and by reducing the needed **margins of operation**.

Smart grids reduce the **impact of failures** by:

- Making them happen less often: They make failures more predictable through analytics and offer ways to better distribute flows according to capacity.
- Reducing their impact: Operators can redirect flow faster and more accurately, thereby creating smaller isolation perimeters.
- Reducing their length: Information about their cause and location is more precise.

The reduction of the **margins of operation** is made possible by the extra information smart grids provide to their operators. This comes from the fact that these margins of operation are essentially the physical capacity level of the grid minus the level of uncertainty (so that the operator is certain to be within its physical capacity levels). By providing more and better information, smart grids reduce the uncertainty.

The main stakeholders to take action here are the local DSOs that have to deploy and operate smart grids. Regulators can help by easing the constraints they impose on margins (if there are any) and by increasing smart grid requirements (level of “smartness” required, imposing standards to reduce costs and accelerate implementation). Policymakers can also provide some level of support by providing subsidies for smart grid deployment, support smart grid R&D, standardisation and knowledge sharing efforts.

Solution — Adapting to demand fluctuations: DSOs use forecasts of e-mobility demand

As discussed above, the main solution to congestion issues is to make local, low-voltage grids smarter. This will not happen at once in all grids. Given this and the fact that some grids will encounter congestion issues earlier than others (due to the fact that some locations will have higher levels of vehicle ownership), DSOs will need to prioritise their smart grid deployment. In order to do this, they will need to produce plausible demand forecasts, including the demand for EVs.

To produce reliable forecasts, DSOs can use the insightful work carried out in various research projects such as Green eMotion, G4V, MERGE or PlanGridEV (running from June 2013 to February 2016). They can also adapt models used by other industries, such as supermarkets or beer suppliers, who have a great expertise on matching supply and demand on a daily basis, based on elements such as the weather, (sporting) events Another possibility is to look at more detailed, local information that will tell them how many vehicles (and of which type) will come to a given neighbourhood. This information would need to come from their customers. There are different ways to ensure that this happens. It can be implemented through an obligation to inform the DSO (such as is the case in Switzerland), or through information sharing through the car registration authority. These solutions might however face customer backlash due to privacy concerns. A possibility to avoid this backlash is for DSOs to provide their customers with an incentive to do so. This can be a one-time discount, or a permanent one. This discount will be managed by a consumer-facing entity, namely the electricity supplier. An example of such a discount is the 25% discount Dutch electricity supplier Nuon offers its customers on the electricity for their cars (at least for the first three years). This discount was already discussed when incentivising smart charging. It is interesting to note that the discount proposed by Nuon is also valid for customers that do not have a way of communicating the charge used by their vehicle (through a smart meter). In that case, the discount is applied to an estimated use.

Actions — Policymakers and regulators provide support, DSOs deploy and operate smart grids, better forecasts and incentives

Stakeholders	Grid congestion actions
DSOs	Deploy and operate smart grids; produce more accurate forecasts; give incentives to customers to go smart
Regulators	Recognise the contribution of smart grids in potentially reducing network margins and increase the uptake of smart grid technologies
Policymakers	Provide subsidies for smart grid deployment, support smart grid R&D, standardisation and knowledge sharing efforts

Table 6.2 Demand spatial distribution actions

Issue **Grid power quality: Harmonic distortions might impact the grid**

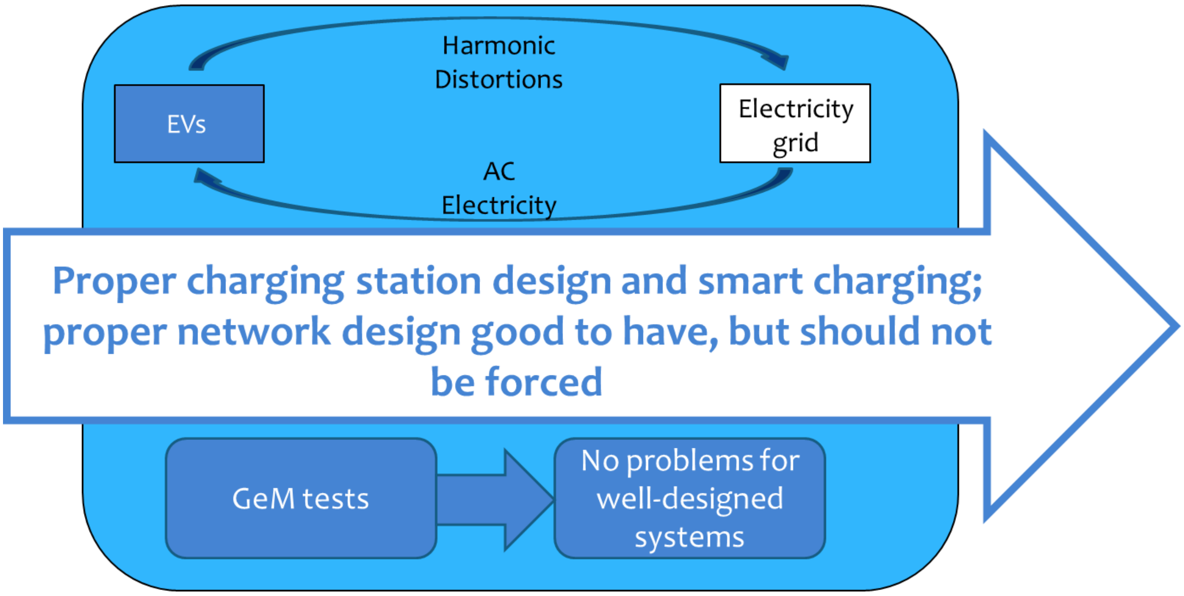

Figure 6.3 Solving harmonic distortion

Power quality issues are related to the fact that electric vehicles can potentially inject harmonic distortions into the grid from which they receive electricity (in the form of an alternative current signal). Such distortions are typical for any connected device that represents a non-linear electric load (this generally includes all devices that contain power electronic components such as e.g. inverters). The level of distortion depends on the nature and design of the devices, as well as on the way they are operated. For example, varying the power at which vehicles are charged (i.e. going beyond an on/off scheme) can potentially increase the level of distortions that come back to the grid. These distortions can lead to unsatisfactory grid operations and even to failures and damages to the grid.

Grids are normally built to accommodate a certain level of harmonic distortions, provided that the devices are designed and operated in such a way that these distortions are not too high. Indeed, tests performed in D8.2, D4.2, and D8.5[36]indicate that harmonic distortions should not be a problem for well-designed grids serving well-operated charging stations, though there might be some problems in communication systems. This might not be true for every situation, so checking if networks and charging stations are properly designed and operated is recommendable.

Solution **Network design: Networks should be less susceptible to distortions, but this should not be forced**

There are a number of desirable characteristics that local grids can have so that they are more resilient to harmonic distortions. These characteristics include low distortions per customer (by having them use a limited amount of power) or enough short-circuit power available (i.e. fluctuating power without excessive flicker levels). A detailed discussion of these elements is available in D8.5[37].and D4.3-A1. The important point that policymakers should take from this is that those are elements that are good to have, but are only one of the factors for designing networks. They should therefore not be imposed by legislation, to

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36 Not available as of publication of this report, but will appear at the page linked.
37 Not available as of publication of this report, but will appear at the page linked.

avoid unintended negative consequences. One example would be a requirement to limit the power available per customer. This would help with harmonic distortions, but would prevent EVSE operators from reaching a meaningful scale. It would also prevent industrial customers from performing their activities. Moreover, as mentioned above, harmonic distortions are not likely to be a huge hurdle, so actions with negative side-effects should be avoided.

Solution **Charging stations design and operations: Charging station design and smart charging are key**

For the design and operation of charging stations, a number of actions can be taken to properly design how the various elements are put together and smart charging is a great help as well. Both the design recommendation and smart charging should be developed and implemented by EVSE operators (including through collaboration platforms) and supported and enforced (through mandated/required standards) by EU, national and local regulators and policymakers. For smart charging, the same steps apply as those described for demand timing. These include elements such as separate circuits for slow and fast charging, how the station loading should be distributed and how to integrate communication to the grid (through the ISO 15118 standard, for example)[38].

Actions **Regulators and policymakers enforce design recommendations, EVSEs develop and implement them**

Stakeholders	Grid power quality actions
EVSE operators	Develop and implement recommendations for charging stations design and smart charging
Regulators	Support and enforce (through standards) recommendations for charging stations design and smart charging
Policymakers	Support and enforce (through standards) recommendations for charging stations design and smart charging

Table 6.3 Power quality actions

[38] Private communication with Endesa

7 Interoperable networks: The various players in the charging infrastructure grid need standards in order to offer discrimination-free access to their services

For public charging infrastructure, interoperability is the possibility for customers from one EVSE operator to use another EVSE operator's facilities. This use includes finding and accessing these facilities, charging the vehicle, and paying for the services. Interoperability is desirable both for customers and providers (EVSE operators and EVSPs that connect drivers and EVSE operators).

EV drivers (i.e. customers of EVSE operators through an EVSP) are interested in interoperability because:

- They might need to charge while being in an **area where their usual EVSE operator has no operations**. This can happen when customers travel to another area, as would be the case during holidays abroad.
- They might **have no EVSE operator** because they mostly charge at home and/or work. These customers might be on a trip away from home/work and need charging.
- Need to charge at a location where their **EVSE operator has no available chargers**. This can happen if a larger than usual number of customers want to charge at a given moment because of a special event such as a sports game or a shopping night, resulting in a full occupancy of the charger capacity. Scheduled or unscheduled maintenance can lower the amount of available chargers.

Providers are interested in interoperability because:

- It would **simplify the work of EVSPs**. EVSPs need to ensure their customers can charge at any location they will be in. This is usually done by having a contract/arrangement with an EVSE operator. This requires some work: Contracts need to be signed and rates negotiated. In cases of very infrequent charging (such as charging abroad during summer holidays), the effort might not be worth it.
- They would generate **extra revenue for EVSE operators**, as they could serve drivers that lack a contract/arrangement with the EVSE operator in question. This can be because the driver's EVSP has not made such a contract/arrangement, or because they don't have one (as they charge home/at work).
- Some locations, such as crowded city centres, might have **space constraints** and would not allow the possibility for several charging stations at one location.

To achieve this, a certain number of elements is needed. They should ideally be standardised, to ensure all the associated processes are possible and cheaper:

- **Hardware to charge cars:** In order to be able to charge, cars should be physically able to connect to the charging station. For wired charging, this means having the right cables and connectors, and implies that standardisation is a help, since it reduces the number of connectors and cables an EVSE operator must support. Inductive charging or battery swapping require specific hardware to be present both on vehicles and charging stations.
- **Software to manage the charging process:** In addition to physical abilities, there is a need for software to manage the charging process. The car should tell what it needs (amount of charge

and time) and can accept (charging modes and speed). The charging station can then take this information, and combine it with its own capabilities and current status. This will serve as an input for its energy management systems.

- **Communications to identify and enable transactions:** The charging interactions are only part of what is needed. Examples of the extra interactions are: finding and booking charging spots, interacting with the electricity networks, managing a network of charging spots, or authorising a transaction. Green eMotion has defined four categories of services for the marketplace (see D3.2): **core services** that are required to run the marketplace, such as user identification and authorisation (see D7.8[39] for details), **basic end user service** like search for charging points, **clearing house services** which enable roaming processes for charging EVs by multiple EVSE operators, and **value added services** that play around (like charging point reservation) but are not limited to electric mobility. This needs a physical communications infrastructure, its management and IDs for all its actors: vehicles, charging devices, electricity network devices, etc.
- **Payment systems to pay for services:** The payment itself can be done through a roaming/clearing house system, or simply by using payment systems used in other commercial transactions: credit/debit cards, cash, mobile phones, etc.

There are essentially three categories of barriers that need to be lifted in order to achieve the desired levels of interoperability: **missing (unique) hardware and software standards**, **lack of adherence to standards** and **unwillingness from EVSE operators to open their networks**. The former is the biggest issue at the moment and asks for an active involvement of a wide range of stakeholders. The second element warrants some degree of attention (it mostly stems from competing standards), while the latter only seems to require a small number of preventive actions from a limited amount of stakeholders.

Issue **Gaps in standards prevent interoperability**

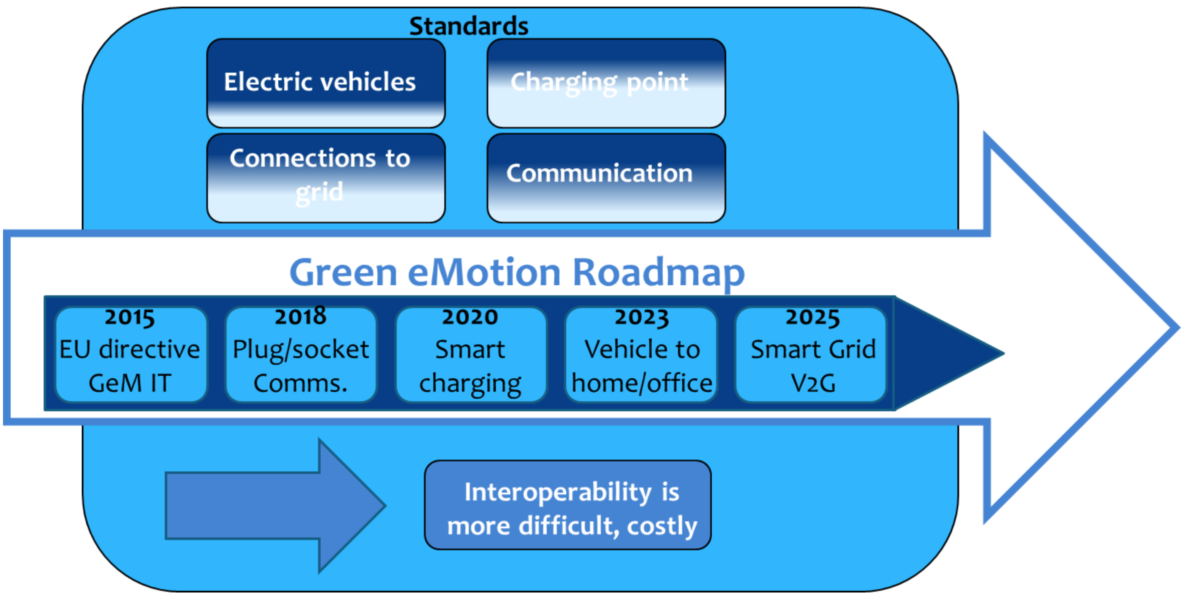

Figure 7.1 Solving gaps in standards

[39] Not available as of publication of this report, but will appear at the page linked.

The first and most important barrier to interoperability is the fact that some standards are missing in the e-mobility value chain illustrated in Figure 7.2, thereby preventing even the possibility of interoperability (or making it harder and more expensive). Considerable efforts towards the establishment of standards have been made, such as eMI^3[40], OCA[41], or M/490 WGI[42], but there are still considerable gaps. These areas of lack of standardisation, shown in Figure 7.3, cover elements in electric vehicles, charging points, connections to the grid and communications. They have a quite wide range of criticality and they involve either missing elements in the standards or competing standards (or a combination of both).

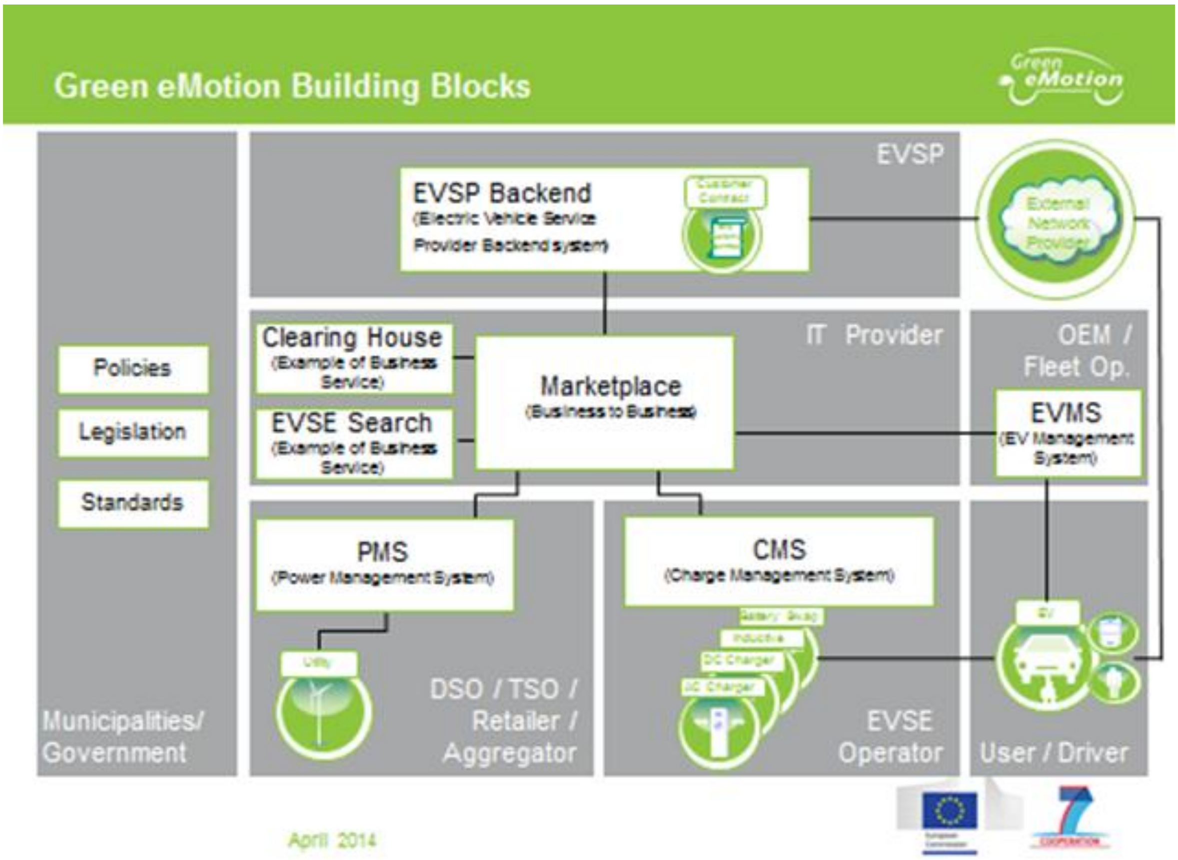

Figure 7.2 Green eMotion building blocks

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[40] eMI^3 (http://emi3group.com/) is an open group of significant actors from the global Electric Vehicles market who joined forces to harmonize the ICT data definitions, formats, interfaces, and exchange mechanisms in order to enable a common language among all ICT platforms for Electric Vehicles.

[41] The Open Charger Alliance (http://www.openchargealliance.org/) is a global consortium of public and private electric vehicle (EV) infrastructure leaders that have come together to promote open standards like the adoptance of the Open Charge Point Protocol (OCPP).

[42] The M/490 Working Group Interoperability provides a common understanding of all the terms and definitions used in our discussions regarding the state of inter-operability between Smart Grid devices, Systems and Subsystems (see this presentation for details).

Electric vehicles	Charging point	Connections to grid	Communication
• ***Battery*** • **Range prediction and state of charge** • **Regenerative braking** • ***Charging modes*** • *Connectors* • *Cables* • *Communication* • **Inductive charging**	• **Identification** • **Communication** • **Safety** • **Electromagnetic compatibility**	• **Power quality** • **DC metering** • ***Smart Charging-Load Management*** • **Power level**	• **Data exchange** • **Marketplace platform** • **Security- data protection** • ***Privacy*** • *Payment*

Criticality level				
Low	Low/Medium	Medium	Medium/High	High
Missing elements (bold)		*Competing standards (italic)*		

Figure 7.3 Areas of lack of standardisation (from **D7.5**[43]*)*

Note that the marketplace platform issue in Figure 7.3 is about the interface and communication with various IT infrastructure components, such as Clearing House, EVSE search, Management Systems for Power, Charge, and EV, and EVSP Backend, as illustrated in Figure 7.2. For more details, see D3.9 and D7.2.

Solution Follow the Green eMotion Standardisation Roadmap

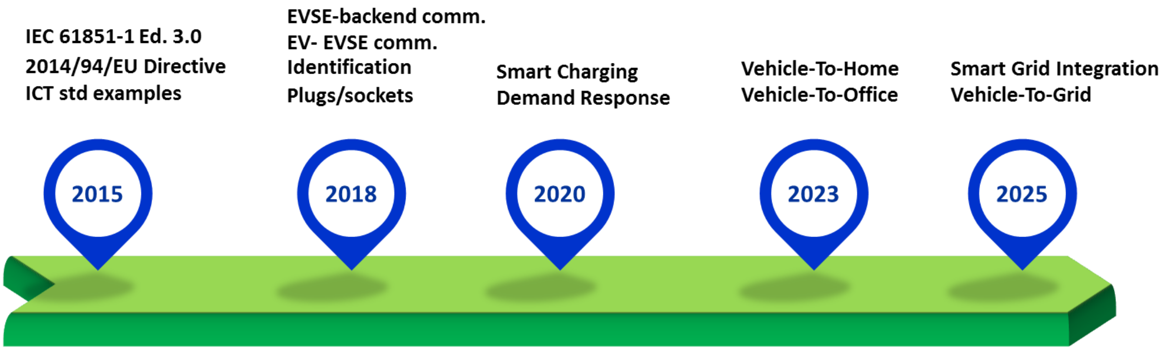

Figure 7.4 Green eMotion Standardisation Roadmap, targets (from D7.844)

While considerable efforts are being made by providers (EVSE operators, EVSPs, DSOs, marketplace) and manufacturers (of vehicles, chargers, communication equipment), there is a need for a step up in

[43] Not available as of publication of this report, but will appear at the page linked.
[44] Not available as of publication of this report, but will appear at the page linked.

action, especially for a number of critical standards, both physical and related to communications. The physical standards that need priority focus are: battery safety after crash, cables, Electro Magnetic Compatibility (EMC)[45] pollution and DC metering. However, these standards affect interoperability less than communication standards do. Additionally, communication standards are at a lower development stage. The burden of action and effort lies by the industry, both for providers and manufacturers, with policymakers in a support role through financing programmes such as Green eMotion. The key elements that need improvement are:

- Speeding up the processes to obtain common standards
- Using precise methodologies that consider different layers and steps, namely the definition of use cases and business cases
- Cooperation both within and between standardisation groups is key, as no single entity would be able to fill all the standard gaps.
- Some kind of central control/coordination is also needed, both from regulators (the European Commission in particular) and industry stakeholders.

In order to deliver these improvements, D7.8[46] established a standardisation roadmap (a high-level version of it is in Figure 7.4 , more details are in D7.8[47]). This roadmap defines a series of five time horizons (from 2015 to 2025).Quoting from D7.8[48]: "The effort is to start ensuring an easy and "universal" charging to drivers, thanks to a definitive physical interoperability (plugs/sockets) and to concrete choices towards roaming features (identification, authorization, IT interfaces), and then work to progressively include e-mobility in the wider concepts of smart grids, through smart charging and reverse flow solutions." (for details see D7.8[49]).

This roadmap has the following advantages:

- It presents an European point of view, which was missing from previous roadmaps that were US- or German- specific.
- It is based on the inputs of a large number of stakeholders (44), covering the whole electromobility spectrum (from OEMs to municipalities).
- It draws on direct experiences from the 10 Green eMotion demonstration regions.
- It is based on a high level of expertise and from direct participation in standardisation bodies.
- It benefits from direct contacts and feedback from the European Commission, a key actor for standardisation.
- It is based on a four-year experience dealing with standards for electromobility
- It was established by one of the most active actors in the field of electromobility standards, ensuring that it can spread through a wide network of contacts.

[45] 'electromagnetic compatibility' means the ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to other equipment in that environment; (source: Directive 2014/30/EU)
[46] Not available as of publication of this report, but will appear at the page linked.
[47] Not available as of publication of this report, but will appear at the page linked.
[48] Not available as of publication of this report, but will appear at the page linked.
[49] Not available as of publication of this report, but will appear at the page linked.

Actions **Providers and equipment manufacturers implement Green eMotion standardisation roadmap, with some support from policymakers; both regulators and the industry have a coordinating role**

Stakeholders	Actions
Policymakers	Provide support through programmes such as Green eMotion
Regulators	Coordinate processes
Providers	Implement Green eMotion standardisation roadmap
Equipment manufacturers	Implement Green eMotion standardisation roadmap

Table 7.1 Gaps in standards actions

Issue **In some cases, there is a need to support competing standards**

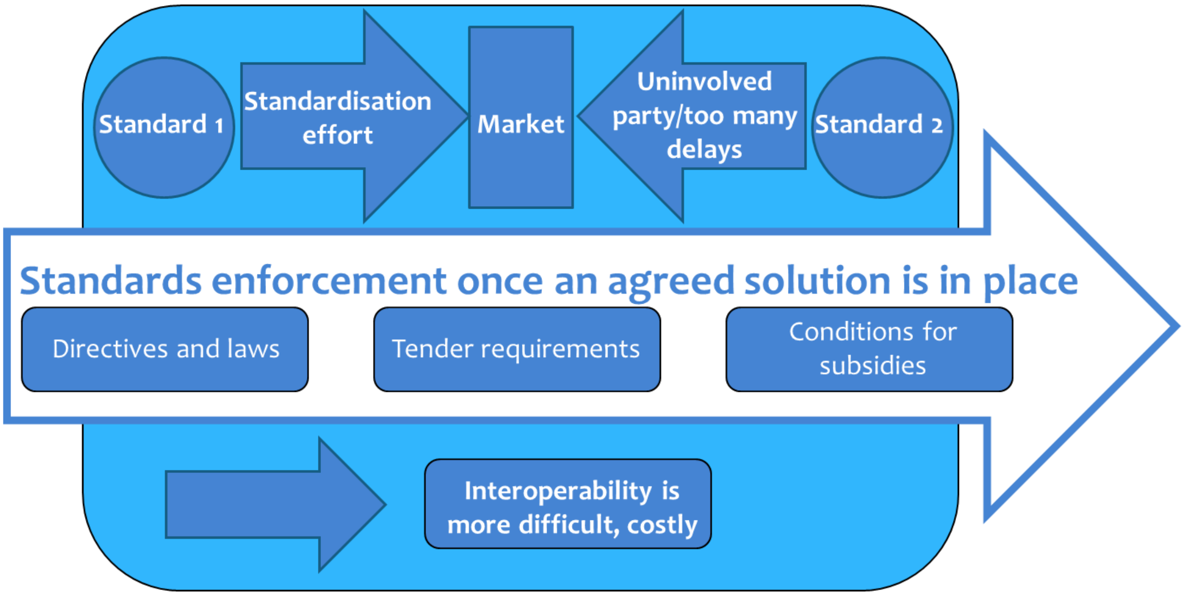

Figure 7.5 Solving competing standards

There are cases where multiple standards need to be supported. This can occur if a successful solution comes to the market from a party not involved in the establishment of standards and/or if establishing a standard takes too much time. This was for example the case in the CHAdeMO/CCS situation. The CHAdeMO fast-charging protocol, developed by Japanese manufacturers has become a de facto standard, due to the high number of Japanese vehicles in Europe: as of December 2014, there are 1’327 stations in Europe[50]. Despite this, European and US automakers have thrown their support behind another standard, CCS (see D7.5[51]).

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[50] http://www.chademo.com/wp/

[51] Not available as of publication of this report, but will appear at the page linked.

Solution

Enforcement of standards needs to come once an agreed solution is in place

Regulators can intervene here by enforcing a chosen standard through legislation. This can take the form of a European Directive and its national translations, requirements in tenders, or conditions to obtain subsidies (including only subsidising vehicles that conform to standards). This enforcement mostly holds for hardware and software standards, but can also apply to testing and certifying processes. This should however only occur at the latter stages of standardisation, once a widely agreed upon solution is in place.

It is very risky for regulators to intervene, as it can hold up or even stop further development and research for better options. Regulators should state **what** they want (not **how**). If necessary, they can bring parties together and indirectly drive the process.

An example would be smart charging: Regulators could make legislation requiring can require that that flexible electricity loads (such as EVs or heat pumps) brought on the market from 2017 onwards need to have smart capacities, i.e. that they can be controlled (by software). Deciding which protocols and standards should be used before these protocols and standards exist would create issues, as these might not be optimal. The market (i.e. manufacturers of equipment) are the ones that should develop and implement such standards and protocols.

Actions

Regulators set requirements

Stakeholders	Actions
Regulators	Regulators to set system requirements and facilitate the process for standards through (European Directive, national laws, tender requirements, conditions for subsidies)

Table 7.2 Competing standards actions

Issue **Operators might not be willing to open their networks**

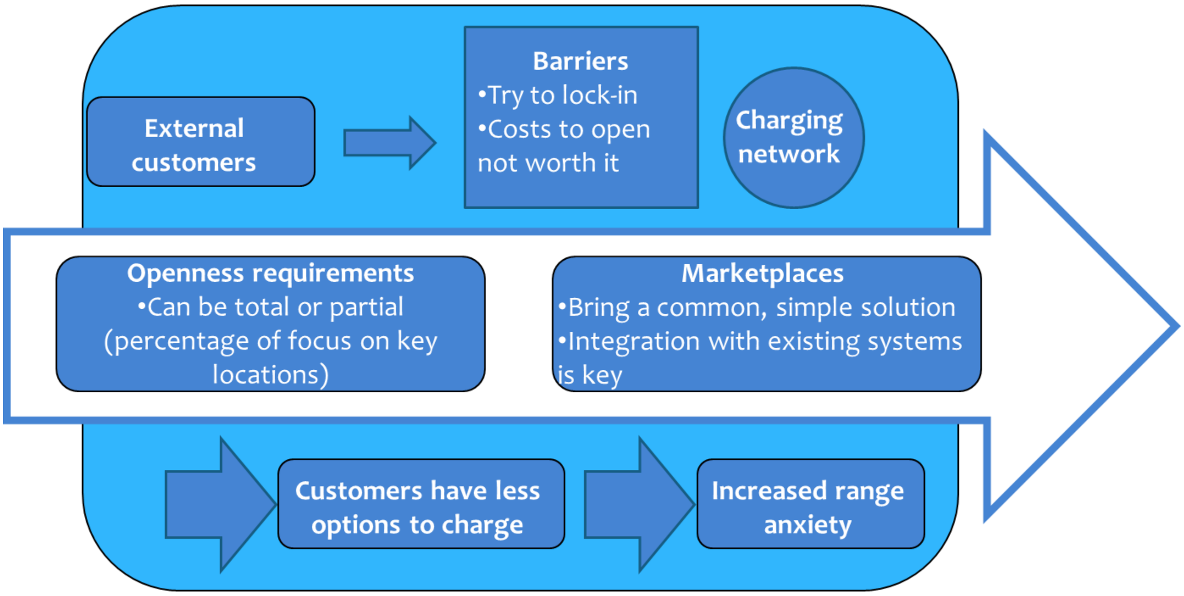

Figure 7.6 Solving lack of network openness

EVSE operators that are also EVSPs may be reluctant to open their networks to customers from other EVSPs for two reasons: to increase their market share, or because it might be too complex to be financially interesting. The former would be operators trying to force a monopoly situation in a given geographical market. This is less likely to happen if EVSE operators are independent entities from EVSPs. Independent EVSE operators have an increased utilisation rate as their main objective, whereas having EVSP activities might push them to try and lock-in customers. This is because a customer that wants to charge at a given location has to be a customer of the EVSE operator managing this location, but could be the customer of any EVSP. This same issue can apply for clearing house activities. The former reason is because EVSE operators might be in a situation where the extra revenue from outside their customer base does not cover the expense of implementing and running the necessary software and communications systems.

Evidence for this lack of willingness can be found in Tesla's superchargers. This network of fast chargers will only be accessible to Tesla vehicles (see D7.5[52]).

Solution **Requirements in authorisation processes ensure that networks will be interoperable; this can be facilitated by developing marketplaces**

The unwillingness of EVSE operators to open their networks to increase their market share can be addressed by regulators, who can impose openness requirements into authorisation processes. These requirements can be of total openness, or can involve a given percentage of charging locations, with a focus on key locations. These key locations would typically be locations where several EVSE operators would want to serve their customers. Imposing such requirements should ideally occur at an early stage, before authorisations are even requested. This effort should involve regulators at all levels: a European Directive, together with its national translations, could be the basis upon which local regulators would put such requirements in their authorisation processes. Openness could also be a requirement for subsidies.

The reluctance of EVSE operators to open their networks due to a negative effort/reward balance can be solved by the introduction of a common, simple solution. This solution can be a marketplace (i.e., a

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[52] Not available as of publication of this report, but will appear at the page linked.

roaming platform), such as the one developed within Green eMotion (see D3.8). There are actually a number of such marketplaces being developed, so interoperability between them is also important to ensure the interoperability of the electromobility system as a whole, as shown in Green eMotion, see D8.5[53]. EVSE operators need to support further development of marketplaces, with a possible extra support from policymakers. They also need to integrate it within their systems, and make their customers aware of the possibility they have of accessing other EVSE operators' installations without having to sign up for a new contract or use another identification system than the one they are already using. This would alleviate their concerns about access in locations not covered by their usual EVSE operator and their desire for a simple, unified system.

Actions **Regulators put openness requirments in authorisation processes; EVSE operators and DSOs develop interoperable marketplaces, with policymaker support**

Stakeholders	Actions
Policymakers	Support marketplace development
Regulators	Put openness requirements in authorisation processes, laws/directives and as a condition for subsidies
EVSE operators and DSOs	Develop and implement marketplaces that are interoperable

Table 7.3 Network openness actions

53 Not available as of publication of this report, but will appear at the page linked.

8 Appropriate governmental actions: plans, laws and procedures need to be aligned to support e-mobility

Providers, such as EVSE operators for charging stations and EVSPs for e-car sharing fleet, need to get authorisations to start their activities. Typically, these authorisations occur at the municipal/local level, but are often part of a national and European legal system. Providers strive for simple, consistent and efficient processes, so that they can focus their efforts on developing their business.

There are four main issues that make these processes more complex, less consistent and less efficient than desired:

- The introduction of e-mobility is complex since it requires involvement of various policy departments which may have conflicting interest
- Processes to obtain authorisations to deploy charging and car-sharing networks are unclear and require too much work
- Processes to obtain authorisations to deploy charging and car-sharing networks are not harmonised
- Legal frameworks regulating the provision of e-mobility services are not adapted to their needs

Issue **The introduction of e-mobility is complex since it requires involvement of various policy departments which may have conflicting interest**

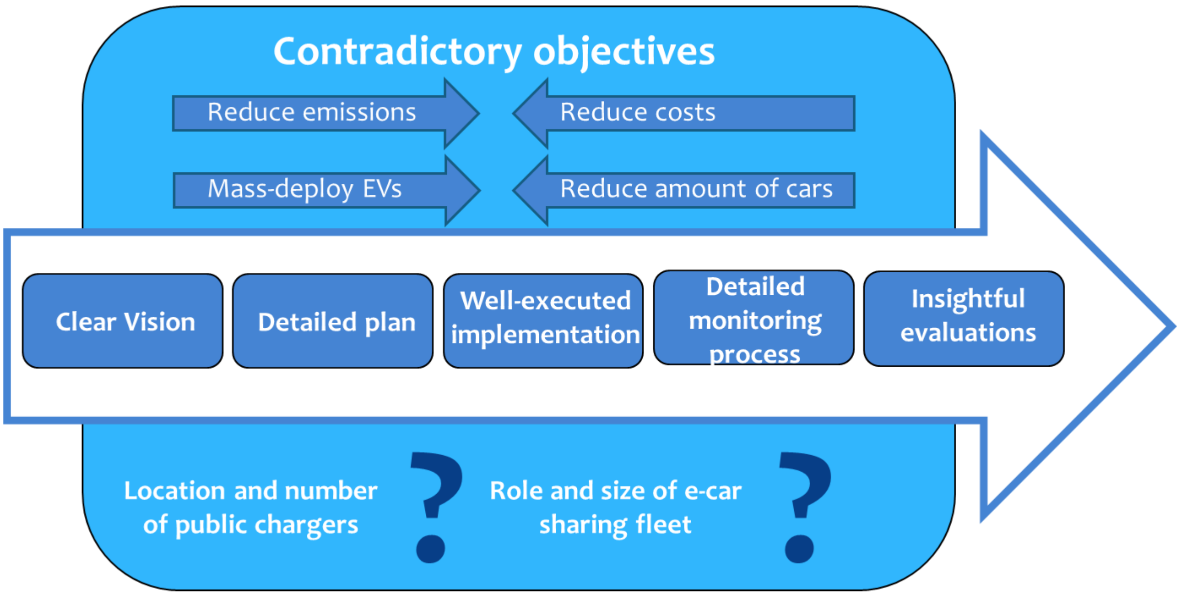

Figure 8.1 Solving conflicting interests

Cities generally have a positive attitude towards electric mobility, given its local environmental benefits in terms of noise and pollution. However, its implementation is complex. It involves many stakeholders that need to work together to achieve a common goal of sustainable transport as part of a healthy urban environment. The different stakeholders, however, sometimes have objectives or interest conflicting with e-mobility. Even within a given municipality, these interests might be different. For example the large scale roll-out of electric vehicles might be seen as contradictory to the objective of drastically reducing the number of cars in the city. Another source of conflict is the fact that sometimes investments in electric mobility need to be made by departments which have other aims then reducing local emissions. The purchase of electric buses might be seen as a good initiative by the environmental or energy department, but it needs to be paid from the budget of the transport department which objective might be delivering qualitative transport at low as possible costs.

Moreover, without a plan how to come to the common vision it is also not always clear which projects actually contribute to achieving the goal. For example without a vision on how many infrastructure is necessary and where and when it needs to be placed, it is difficult to judge requests for placing charging poles. The same holds for requests for starting e-car sharing initiatives, which require the city to have a vision on the role and size of e-car sharing in the future transport fleet.

Solution — A clear vision and plan on how to integrate and finance EVs/infrastructure in the overall transport system can bring success

To be successful, cities need to go through a continuous process that combines all the important elements of a successful mobility approach. Those elements are the following:

- They need a **clear vision** that sets the city's ambition and help garner support for successful latter phases. This vision should start by identifying what the specific needs of the city and all key stakeholders are in order to set clear, tangible and ambitious, but realistic goals. It should also identify key success factors, potential issues (and ways to overcome them), and benefits all stakeholders will obtain. The key at this stage is to engage with stakeholders from the very start and keep that engagement throughout the process. It also needs to clearly define what the ambitions of the city are and to what extend they come into conflict or work together with other priorities such as congestion reduction or local noise/pollution reduction. To illustrate how differently this can be between cities, the examples of Amsterdam and Malmö are interesting. Politicians in Amsterdam are much more behind the development of electric mobility than those of Malmö. This is essentially because the issues electric mobility can solve (noise and air pollution) are much more acute in Amsterdam than Malmö. A potential of increase of air pollution beyond allowed levels of air quality was the reason for the cancellation of development projects in Amsterdam (offices, housing, and commercial spaces). On the other hand, Malmö is more preoccupied with space constraints, for which electric vehicles do not bring a benefit.[54] The rest of this chapter assumes such an ambition is in place and indicates what should be done to reach them in the most efficient way possible.
- They need a **detailed plan** that defines what the needs are: what is needed (in terms of infrastructure element types, as well as of scale), where and when, and who should deliver them. This plan should identify pitfalls and prepare contingency responses. The key at this stage is to quantify and secure the resources (finances and capabilities) that will be needed. If possible, this plan should use a phased/tiered introduction that allows monitoring and adaptation, see bullets 4 and 5 to happen.
- They need a **well-executed implementation** of measures that engage all actors, raise awareness and ensure the required elements are delivered. The key at this stage is to have clear roles, responsibilities and deliverables.
- They need a **detailed monitoring process** that provide the right data needed to follow the plan's progress and help identify issues and share successes. The key at this stage is to have the right

[54] "Let's go electric! Factors influencing local authorities in promoting the uptake of electric transport" Wies de Jong (2014)

data, obtained with the right methodology. It also needs to be shareable and shared with others. To this end, collaboration platforms and venues to share experiences and data would be of great help.

- They need **insightful evaluations** that produce recommendations for improvements and help identify success factors. The key at this stage is to act on these recommendations and actually adapt transport policies as a consequence. This phase should also be used to plan next steps and future actions.

Cities should try to learn as much as possible from cities that have had successes, such as Amsterdam.

The main result of a properly designed and executed process will be a greater efficiency at all levels and reduce many of the other issues related to achieving compliance, such as unclear, too complex and fragmented authorisation processes.

It will also ensure a higher buy-in level from all stakeholders, through the combination of involving them at all stages and through better, simpler, faster processes.

Actions **Policymakers set a vision; plan, implement, monitor and evaluate the processes**

Stakeholders	Actions
Policymakers	Set vision; plan, implement, monitor and evaluate processes

Table 8.1 Vision actions

Issue **Processes to obtain authorisations to deploy charging and car-sharing networks are unclear and require too much work**

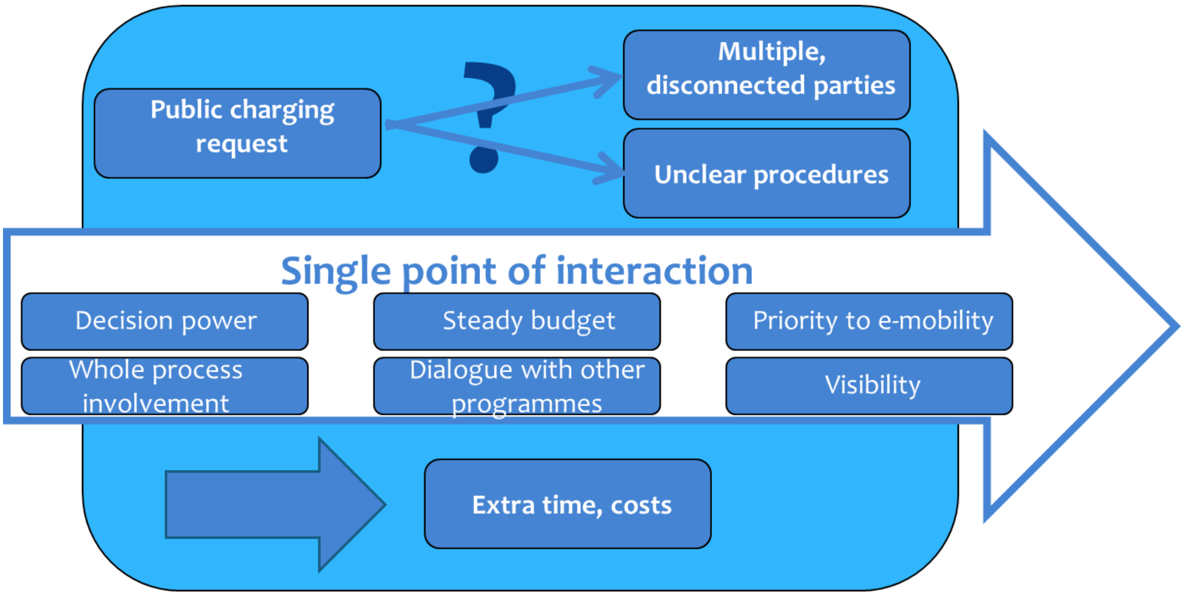

Figure 8.2 Solving unclear authorisation processes

Authorisation procedures are complex, because they often involve many disconnected parties, some of whom might not have a power to make a decision: in some cities, the groups promoting electric mobility do not have the power to deliver authorisations and the departments that have that power might not see electric mobility as a priority. Even in situations where the departments that have power to authorise might be on board, this fragmentation adds a layer of complexity and creates delays and additional costs.

Solution A single point of interaction simplifies processes and makes them more efficient

The main solution to this issue is for cities to centralise the authorisation processes by creating a single point of interaction for authorisation requests. Depending on the situation of the city and the magnitude of its ambitions, this can range from a simple information/coordination desk that redirects requesters to proper places and informs them about best practices to a full-sized department that takes over competencies related to putting in place electric mobility. This will reduce costs and efforts both for the city and the requesters. The Amsterdam/Malmö shows the value of such a structure: Interviewed Malmö stakeholders cite the dependency of the environmental department on collaboration with other departments as the main problem for the uptake of electric mobility, whereas the existence of a central contact point that could help with all processes (and requesting a city-wide parking permits in particular) was cited as a decisive element in the creation of Car2Go (an electric car-sharing programme). Another example is London, where Transport for London was in charge of installing charging points, but not of their promotion, resulting in very low utilization rates (two thirds are used for less than a minute a day). [55]

The key elements for this single point of interaction to succeed are the following:

- **Decision power:** This organisation needs to be able to ensure that the authorisations it delivers actually lead to projects and that no decisions from other organisations stand in the way. For an information/coordination desk, this means having enough knowledge about the processes and connections to decision makers to know if a positive decision will be made. For a full-sized department, this means that all the decisions relevant to the deployment and operation of charging infrastructure should be held by this organisation.
- **A steady budget:** The operating budget of this organisation (i.e. what it needs to perform its tasks: salaries, IT systems, etc.) needs to be steady, for example (partly) based on a national or European fund. This will ensure that the organisation can immediately act on a request. If the budget of this organisation was connected to requesting projects, then there would be a delay. It also ensures that the organisation can build capabilities and acquire and share knowledge and that these elements are retained within the organisation from one project to the other. Amsterdam and Malmö show[56] both sides of this aspect: In Malmö, the environmental department is fully dependent on external sources of funding and relies on EU projects. In contrast, Amsterdam, because of its air quality problem, gets 50% of its funding from a national fund. The other 50% are paid by parking fees collected by the municipality. The high political support of electric mobility ensures that this should continue to be so.
- **Priority to e-mobility:** This will ensure that this organisation will fully support the efforts of providers of e-mobility services and avoids having other issues getting in the way, thereby speeding and improving processes. It also ensures that this organisation develops capabilities and knowledge that support the deployment of e-mobility and that it shares such capabilities and knowledge with similar organizations in other cities (and that it draws from theirs). This priority refers to the priority of the single point of interaction, not to the city's priorities, which are set at the vision stage (see above).

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[55] "Let's go electric! Factors influencing local authorities in promoting the uptake of electric transport" Wies de Jong (2014)

[56] "Let's go electric! Factors influencing local authorities in promoting the uptake of electric transport" Wies de Jong (2014)

- **Whole process involvement:** The organisation needs to oversee the whole process and needs to conduct the vision, planning, implementation, monitoring and evaluation (see above). This will help make the process of deploying and operating infrastructure more efficient, since it will be proactively driven by an organisation that prioritises e-mobility.
- **Dialogue with other successful programs:** Some cities, such as Amsterdam have created such a centralised organisation and have seen benefits in the deployment of e-mobility services, contrary to cities such as Malmö who have encountered obstacles created by fragmentation. Engagement will be an opportunity for cities to learn from previous successes and avoid pitfalls.
- **Visibility:** The organisation needs to communicate its advantages and successes to all key stakeholders, especially potential providers. This will ensure that the organisation is known and used. It might also convince some reticent providers to apply for projects for which a scattered and complex procedure was an obstacle.

Actions **Policymakers create a single point of interaction**

Stakeholders	Actions
Policymakers	Setup a single point of interaction

Table 8.2 Simplifying processes actions

Issue **Processes to obtain authorisations to deploy charging and car-sharing networks are not harmonised**

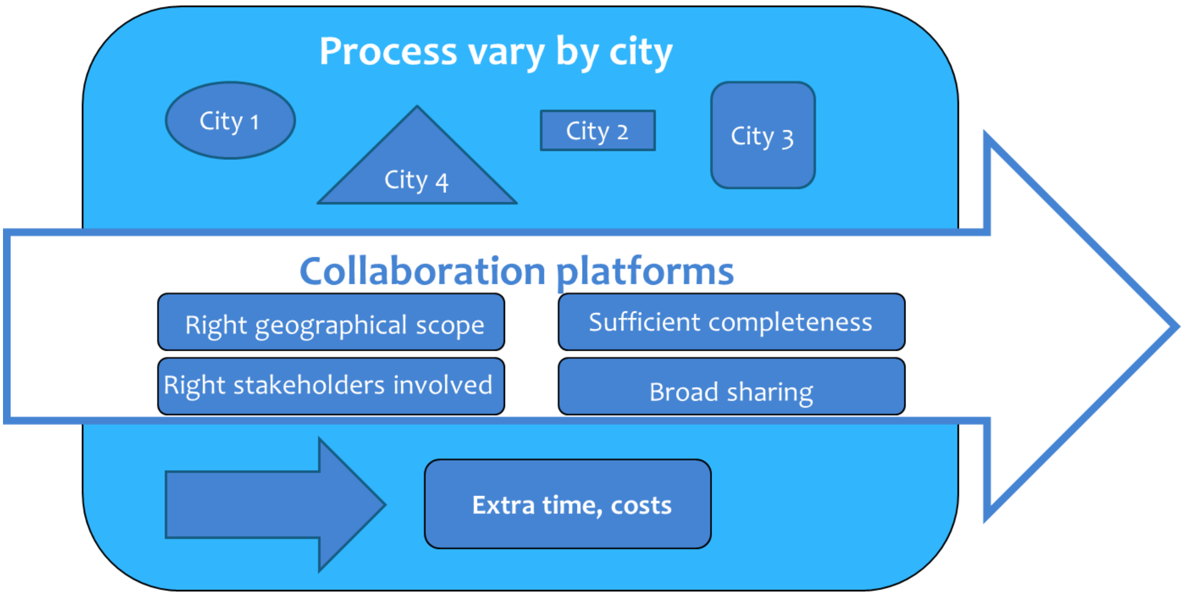

Figure 8.3 Solving not harmonised processes

Having cities that support e-mobility, know what the consequences are and adopt efficient procedures is one part of the effort required. There also needs to be consistency (both in terms of effort/knowledge and in terms of procedures), so that providers avoid a new learning process each time they start a new application in a new city. This will reduce their costs and learning time, making them more eager to start a project.

Solution

Collaboration platforms and the adoption of best practices help harmonisation

The key element here is to develop a coordination effort to harmonise authorisation processes. A good way to do so is through a collaboration platform. This platform should have the following characteristics:

- **The right geographical scope:** The harmonisation effort should at least overlap with the range of cities a provider would want to operate. Typically, this would happen at a national level, but there are cases where users are mobile across national borders (examples are the Maastricht, Geneva, Basel or Bratislava regions). Providers would naturally want to follow their customers (and vice versa), so it is important to assess the particular situation of a region in order for the harmonisation effort to reach its natural target.
- **Right stakeholders involved:** While the involved cities are the obvious stakeholder group that needs to be involved, it should not be forgotten that the groups (namely providers, all actors of the e-mobility ecosystem (including users) and other parts of the administration.) that will be impacted from this effort should be involved as well. This will ensure that their point of view is taken into account, resulting in greater benefits and reduced obstacles.
- **Sufficient completeness:** One potential issue is that cities that are lagging in the development of their procedures (by lack of commitment or knowledge) might not get on board with harmonisation. In that case, national (or provincial) governments should step in and take the lead. Their presence as neutral parties is useful in any case. They can also help from a logistical, financial and knowledge point of view.
- **Broad sharing:** It is also important that the harmonisation efforts are made public and that their contents are shared. This will ensure a higher visibility for e-mobility and will help share knowledge about best practices and elements to avoid. Even if the actual procedures differ from region to region, the harmonisation process should be quite universal.

Actions

Local policymakers (with a possible facilitation from national policymakers) harmonise their processes through a collaboration platform and adopt best practices

Stakeholders	Actions
Local Policymakers	Harmonise their processes through a collaboration platform and adopt best practices(with a possible facilitation from national policymakers)

Table 8.3 Process harmonisation actions

Issue **Legal frameworks regulating the provision of e-mobility services are not adapted to their needs**

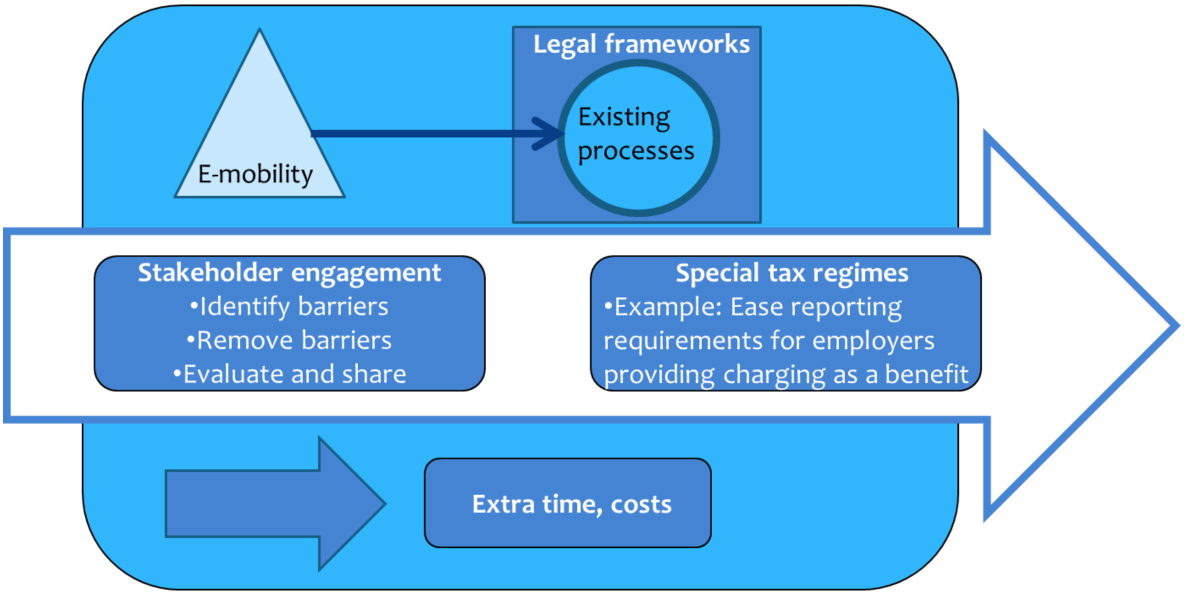

Figure 8.4 Solving non-adapted legal frameworks

The legal frameworks related to the provision of electricity (most notably which parties are allowed to provide it and what is needed to qualify as one) vary quite strongly across Europe. While some countries such as the Netherlands or Germany have attained a large degree of openness and competitiveness, others, such as France are more centralised and directed. This takes place into a more general issue of liberalising the electricity market (and the various degrees countries are implementing it). For e-mobility, this is most relevant because of the resulting lack of clarity and missing frameworks about which parties are allowed to sell energy, build and operate infrastructure and the condition potential providers would need to meet. The main problem is that the current regulations are not necessarily written with the specifics and needs of e-mobility in mind and might discourage some providers from entering the market, especially if they are relatively small and miss some capabilities needed in the electricity market. One example would be employers interested into providing charging to their employees, but not wanting to have to collect and report charging data on an individual user basis.

Solution **Engagement with stakeholders helps understand what kind of laws to get the right policies in place to promote e-mobility**

In order to identify the actual issues at hand and produce appropriate policies to solve them (which will very much depend on the local situation, both in terms of regulation and in terms of market needs), national governments should set up a platform that engages all the important stakeholders, namely potential providers, customers, NGOs, hardware manufacturers and local governments. The activities of this platform should include the following elements:

- **Identify barriers:** The first step is to figure out which regulations (in domains such as energy, transport, building codes, etc.) need to be adapted, and for which purpose (given by business needs).
- **Remove barriers:** Once the barriers are identified, barrier-lifting solutions should be proposed and implemented. Those solutions should be focussed on lifting the barriers discussed above (as opposed to sweeping changes), both to avoid backlash against sweeping measures and to increase their effectiveness.

- **Evaluate and share:** A continuous evaluation of both the effectiveness of measures to remove barriers and the need for such barriers (for example through technical advances or new business models) should take place. The consequences of this process should be the introduction of new measures that are needed, the removal of ineffective or obsolete measures or the tweaking of existing measures.

Solution **Tax and reporting exemptions for employer charging are needed**

A specific example of a too constraining regulation is the provision of charging by employers as a benefit to their employees. The key benefit resides in tax exemptions on the provision of electricity, as this would be a work benefit (in the same way cars, public transport or biking can be offered as a benefit). The issue there is that employers would need to report the consumption of each user on an individual basis in order for them to benefit from this fiscal advantage and might not have the capabilities/inclination to do so. The solution would be to ease the reporting requirements, at least until technological evolutions make it trivial to do so.

Actions **Policymakers engage with stakeholders to get the right laws in place; regulators create a special regime for employer charging**

Stakeholders	Actions
Policymakers	Engage with stakeholders to get the right policies in place to promote e-mobility
Regulators	Create special regime for employer charging

Table 8.4 Legal frameworks adaptation actions

9 Conclusion: Prioritised Issues and actions

Not all the issues discussed in the previous chapters are of equal importance or urgency. Based on the discussions of each issues in the previous chapters, we have prioritised these issues according to their importance and to their urgency. A high importance means that failure to address this issue will result in large, negative consequences for the uptake of electric vehicles. A low importance issue is an issue that is either expected to have a low impact on the uptake of electric vehicles, or are likely to be solved on their own. High urgency issues need to be solved at early stages of EV deployment because they will manifest themselves then, or because they require early action for latter effects. Low urgency issues can be addressed at a later stage of EV deployment. This prioritisation is shown in Figure 9.1and explained in Table 9.1.

9.1 High-importance actions

The issues with high importance are the following:

I) Drivers will typically park their cars at similar times, which coincide with a **peak** in the general **demand for electricity**. If those cars also all charge at the same time, they would require a large amount of peak production, which is more costly. If these extra costs are attributed to EV drivers only, the economics of EV ownership would become much less favourable. If these costs were spread among all users, pricing signals would not be efficient. To avoid this outcome, policymakers, regulators and infrastructure operators can introduce smart charging (i.e. use devices and software to control the moment when charging occurs) by providing support, enforcing standards, setting up networks for smart charging, providing drivers with the right incentives to use smart charging.

II) An increase in EV ownership in a certain region can create **congestions** in the **local**, low-voltage **grid**. To overcome these, policymakers and regulators can setup the right frameworks for the introduction of smart grids, which DSOs will deploy. DSOs should also develop demand forecasts to identify grids that might be congested.

III) **Incomplete or competing standards** can be an **obstacle to interoperability**, i.e. the possibility for drivers to charge their car at installations operated by other providers than their usual one. To prevent this, policymakers, regulators, providers and equipment manufacturers should get together to further develop and implement standards.

IV) **Installing charging hardware is costly**, especially in existing buildings and structures. Regulators can help by putting requirements in building codes and tenders that require buildings and structures to have some degree of preparedness for charging infrastructure.

V) For public charging infrastructure, finding the **right matching services** (shops, restaurants, parking, etc.) can make or break a business case, and is difficult to do. EVSE operators and partners should work together to identify the right matches, according to the characteristics of services they offer.

VI) The **utilisation of public charging infrastructure** will often be **low**, especially in initial phases. This would not attract investors, as they would face a long payback time (or no possibility to get their investment back). Policymakers can help by subsidising vehicle adoption and the deployment of unprofitable charging infrastructure.

VII) Electric vehicles have a **purchase price** that is considerably **higher** than their combustion engine counterparts. Policymakers can use a variety of tax incentives to reduce this gap, but they can also introduce information requirements at dealerships. These requirements would be to display total costs of ownership, which would be more favourable for EVs than a purchase price comparison. They can also use other channels (such as websites and apps) to provide customers with such information.

VIII) Drivers have **range anxiety**, namely that they are worried that they won't be able to perform their usual activities with an electric car. Such issues are mostly issues of information on charging possibilities and optimal charging/driving behaviour, rather than actual extra range needs. Policymakers, EVSE operators, EVSPs and manufacturers should work together to provide drivers with information on charging possibilities and optimal behaviour. This can happen through the development of training/information materials (websites and apps), as well as proper signage of charging stations. The latter not only provides drivers with information about charging possibilities, it also shows them that charging is available.

9.2 Prioritisation of actions

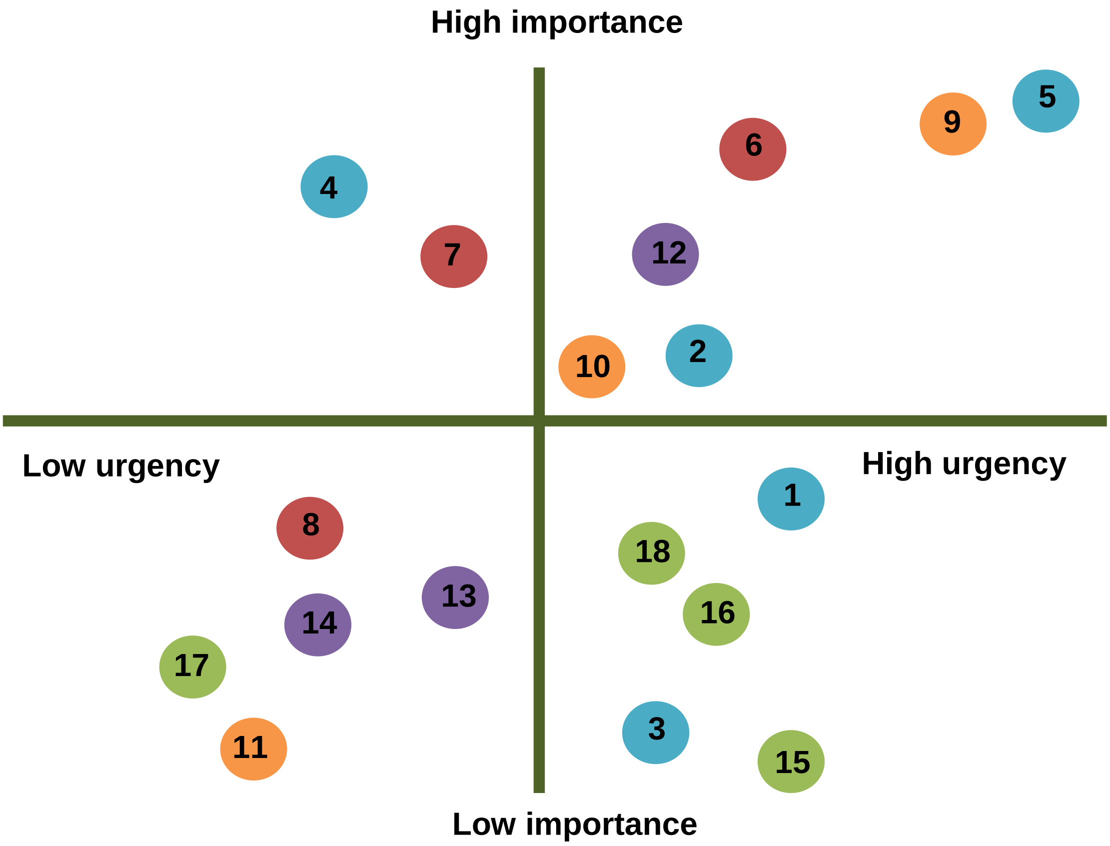

Figure 9.1 Prioritised issues

Issue	Importance	Urgency
1) The hardware used by charging points is expensive	Pays itself back over time, economies of scale are expected to occur	This is more of an issue at early stages, since economies of scale have not been reached yet
2) Installing hardware at charging points is expensive	Is a labour cost issue and not expected to go down in time	Occurs before charging points are in operation
3) Operating EVSEs does not scale down easily	Can be integrated with existing operations, service providers offer outsourcing	Is more important at early stages, with small numbers of customers
4) Combining charging with other services is not always an easy sell	Is very important for the business case of public infrastructure	Is more important for infrastructure types that come later to the market (such as malls)
5) The utilisation levels of public infrastructure are expected to be low	It makes or breaks the business case for public infrastructure	This is especially an issue at low levels of EV adoption
6)The purchase price of EVs is considerably higher than for comparable ICEVs	Most important issue from surveys, impacts TCO in a big way, looks like a fundamental issue that cannot be solved on its own	This is particularly important at early stages, where the difference in purchase price is the highest (due to small production amounts and lack of knowledge)
7) Consumers have range anxiety issues	Second-most cited issue from surveys, impacts ability of drivers to perform activities they want	OEMs can focus on early target groups with lower range needs
8) Driving habit data privacy issues are more visible for EVs than ICEVs	Has not been prominent is discussions about EVs	Visibility will occur once EVs are deployed on a large scale, protection provisions can easily be "bolted on"
9) Higher electricity costs due to sharp peak demand	Impacts TCO in a big way, also impacts non-EV users	Needs to be integrated in grid and electricity production planning, requires development of smart charging
10) Pockets of high EV uptake may create low-voltage grid congest	Would prevent charging of vehicles, impact non-EV users	Is already occurring in some neighbourhoods, needs to be integrated in grid planning
11) Harmonic distortions might impact the grid	Tests show that this is not a big issue	Impact would only occur with large number of devices
12) Gaps in standards prevent interoperability	Create extra costs, uncertainty about which standards to support	Need to occur soon, so that projects can know what standards to support
13) In some cases, there is a need to support competing standards	Most players are involved in standardisation efforts	Occurs once standards are in place
14) Operators might not be willing to open their networks	They usually comply without too many issues	Occurs at latter stages, when users start going for longer trips

Issue	Importance	Urgency
15) Various policy departments with possibly conflicting interests are involved	Not done on purpose, will to solve exists, EVs generally have support	Should ideally be solved before projects start and authorisations are requested
16) Authorisation processes are unclear and difficult	Vary from place to place, solutions exist and are shared, is a relatively small burden, compared to other issues	Needs to be solved before projects start
17) Authorisation processes are not harmonised	Differences are not that great, not all operators are active in multiple cities	Occurs at latter stages, when providers have national coverage
18) Legal frameworks are not adapted to e-mobility needs	Number of identified issues is small, policymakers/regulators are willing to solve issues	Any existing issues need to be solved before deployment starts

Table 9.1 Importance and Urgency of issues