Individual Electric Mobility:
Pioneering concepts, first experiences, future challenges

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1 Introduction

1.1 Current mobility challenges

During the last decades, economic growth, globalization and modernization of our society have been severely increasing our demand for mobility. This ongoing trend asks for new mobility solutions that create a modern and moreover sustainable society. Solutions that meet increasing desire for freedom of the individual are longed for. While the mobility of both junior and especially senior citizens shall be enhanced, increasing demand for transport faces major challenges though.

Transport systems are often already facing the limits of their capacity. Increasing demand lowers their efficiency and hereby harms efficient economic development in general. Also environmental concerns have arisen due to increasing demand of mobility. Especially individual motorized traffic, being one of the most flexible and therefore also highly demanded modes of transportation, contributes to a substantial part to our worldwide emissions. Also energy security has become an important issue to which the transport sector shall and can actively contribute. More energy efficient transport modes and rising awareness among travellers has the potential to increase energy efficiency of the transport sector and to hereby also alleviate oil dependency, which reduces the economy’s dependence on fluctuating oil prices.

Transport obviously touches many current issues of high importance. New innovative solutions that allow the sustainable development of the transport sector and that meet increasing mobility demands as well as the growing desire for freedom are needed.

1.2 New mobility solutions

Recent years have already shown increased efforts for finding solutions that tackle the current challenges of mobility as described in 1.1 above. New mobility concepts, such as car and ride sharing or also car pooling have been developed and already successfully deployed in many regions and especially urban areas. The central aim is to use resources more efficiently, which positively contributes to energy security, to emission reductions and to the overall effectiveness of transport systems. Private resources are being shared - a concept that also allows for both, cost reductions and flexibility of customers. Inconveniences of private ownership (such as repair and maintenance matters) are reduced. Mobility needs can, however, still be perfectly met – especially with growing customer acceptance and increasing market penetration rates of these new service concepts.

Further, recent years have also been showing growing public interest in and development of electric mobility. In order to provoke more sustainable individual private transport, especially electric vehicles (EVs, here referring to electric cars) have gained much attention. National and regional governments, vehicle manufacturers, mobility and electricity providers, as well as resource providers have been realizing the alleged potential of this new technology. Electric mobility is seen as a mean for enabling a more efficient use of resources, hereby again contributing to the development of sustainable and efficient transport systems. Besides environmental benefits due to a predicted reduction of local and also global emissions (whereas the potential varies with the concerned region´s energy mix), high potential is also seen for the recovery of the automotive sector and all its adjacent industries by contributing to economic growth and public welfare in general. Hence, electric mobility is seen as remedy for many current public issues concerning environmental, industrial, economic and energy challenges. National governments and regional authorities are therefore on the verge of launching EV supportive policies that aim to promote and push both the development and also the introduction of EVs and their necessary infrastructures (Leurent and Windisch, 2011).

1.3 Objectives of this study

Chapter 1.2 sketched promising solutions for individual motorized transport that have the potential to meet existing challenges in transportation, while not hindering the mobility of the individual. Innovative mobility services and electric mobility are seen as remedy for many pressing concerns. This study shall explore these solutions in more detail by introducing and analysing existing deployment examples. Innovative (and often new) companies providing new mobility solutions are presented. Demonstration and test projects of electric vehicles are explored. These analyses shall finally allow deriving conclusions on promising deployment schemes of electric vehicles that meet current transportation challenges and therefore show a high potential of success.

More explicitly, the objectives of this report are to:

- Give an **inventory of new, innovative mobility services**
- **Introduce electric mobility solutions** by
    - giving a synthetic overview of current EV deployment objectives and policy stimulation packages
    - sketching most recent local and regional EV experimentation and pilot projects or testing schemes
- Derive conclusions on likely successful EV deployment schemes and (if necessary) accompanying stimulation packages

1.4 Overview on the structure of this report

In Chapter 2, the report gives first an overview of current innovative mobility services that have the potential to cure many current problems related to the passenger transport sector. The concepts of ride sharing, car sharing and transport on demand are regarded more closely.
Chapter 3 then serves for an insight in current happenings concerning the deployment of electric vehicles. First public policies towards their development are sketched, then an overview of current offers concerning vehicles and infrastructure is given, finally specific deployment projects with focus on Europe are introduced.
Finally, chapter 4 derives a likely EV uptake scenario that could be deployed in a rural area, by combining the findings of chapter 2 and 3.

2 Innovative Mobility Services

Innovative mobility services refer to new service offers that allow higher resource efficiency in individual private transportation. Although the origins of some of the here proposed concepts date partly even back to the initial uptake of privately owned vehicles, many of them have (re)gained attraction only throughout the last years. Business models are being developed that allow for a profit oriented commercialisation of cost and resource efficient mobility concepts that had fallen into oblivion with the arising urge of the detention of privately owned vehicles in the last decades. By now, an increasing share of people seems to become more and more willing to change some of their ‘old-fashioned’ habits. Environmental concerns, but also economic considerations are stimulants to also think of other models than the possession of a private car for meeting demands of mobility. However, still many obstacles have to be overcome in order to make innovative mobility service offers an integral

part of our society's mobility habits. Behavioural changes and moreover stimulating fiscal or directive policy measures are needed in order to make them to a success.
This chapter gives an overview of innovative mobility models promoting resource efficient transport. Some shown services serve for examples of interesting business models. First, the concept of ride sharing is introduced. Traditional and more recent practices are explored. Next, also car sharing services are investigated. Also here attention is given to very recent concepts that are on the verge of being launched. Finally, the idea and the development of demand responsive transport systems (or 'transport on demand' services) will be presented. French examples of services providers will illustrate the functioning of introduced services.

2.1 Ride sharing

Ride sharing is increasingly being discussed as a powerful strategy to reduce congestion, emissions, and fossil fuel dependency. It is the grouping of travelers into common trips by car or van. It is also widely known as **car pooling**, **lift-sharing** or **covoiturage**. Ride sharing differs from for-profit taxis in its financial motivation. When a ride sharing payment is collected, it partially covers the driver's cost. It is not intended to result in a financial gain to the driver. Moreover, the driver has a common origin and/or destination with the passengers. Alternatively at least a common part of the trip is shared. (Chan et al. 2011)
Ride sharing therefore reduces the costs involved in car travel by sharing journey expenses such as fuel, tolls, and car rental between the people travelling. Car owners (drivers) who offer to share their ride reduce their costs, while ride sharers (passengers) can profit from both, reduced travel costs, and/or reduced travel times compared to other mode alternatives they consider to choose from. Ride sharing therefore typically results in a win-win situation for drivers and passengers sharing a ride; it increases the flexibility and enhances freedom of mobility for all participating parties. Simultaneously, above mentioned congestion-, emission- and fuel dependency issues are abated.

2.1.1 Concepts of ride sharing

When participating in ride sharing drivers and passengers traditionally offer and search for journeys through a medium available. After finding a match for their trip they contact each other to arrange any details for the journey(s). Costs, meeting points and other details like space for luggage are discussed and agreed upon. They then meet and carry out their shared car journey(s) as planned.
Ride sharing is commonly implemented for commuting, but is also popular for longer one-off journeys. Not always the whole length of a trip is shared. Especially on long journeys, it is common for passengers to only join for parts of the journey, and give a contribution based on the distance they travelled. This gives car sharing extra flexibility.

However, the exact functioning of ride sharing depends very much on the specific concept of ride sharing system that is deployed. With the technological advancements in communication services, several mediums have become available that allow drivers and passengers to match their desired rides. This circumstance allows a classification of ride sharing concepts by communication medium. However, also a differentiation by the lapsed time period between matching a ride and taking the actual ride can be established: Regarding this aspect, concepts that range from *in advance-ride matching* (weeks or even months pass before the actual ride is carried out) to *dynamic ride matching* (rides are matched the same day or a couple of hours before the ride) and finally to *ad-hoc ride matching* (spontaneous share of rides) can be found. Chan et al. (2011) proposes a classification that is based on the relationship among its participants. The classification is then expanded by the other criteria discussed.

The following figure is based on Chan et al. (2011) and gives the proposed first level of classification of ride sharing concepts (see the full classification table in the annex of this report

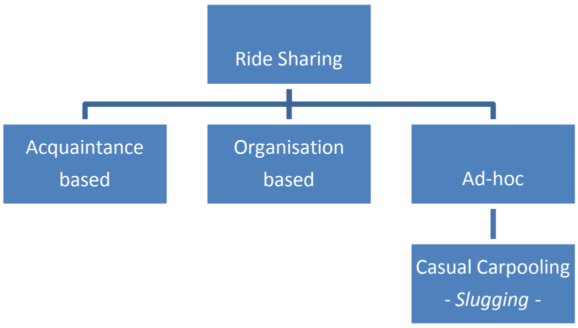


Figure 1: Classification of ride sharing concepts (based on Chan et al., 2011)

Acquaintance-based ride sharing is typically formed among families and friends, often called “fampools,” as well as among coworkers. Companies often stimulate and kick off ride sharing initiatives and provide platforms (e.g. via (intranet) notice boards) on which rides among coworkers can be matched. Often this is done a weekly or also daily basis. Commuting is typically the main purpose of these ride sharing concepts. Companies often promote ride sharing in order to profit from reduced needs of parking facilities, reduced travel expenses for their employees and, above all, increased ‘socializing’ and communication among their staff. Acquaintance-based ride sharing is self-organized.

Organization-based ride sharing refers to carpools that require participants to join a service whether through formal membership or simply visiting the organization’s website. The term does not necessarily refer to consistent participation in the same carpool every day, as some schemes allow for varying carpool participants.

(Large companies have partly already started offering more advanced ride matching platforms by offering organization-based platforms to their employees. These concepts can then be regarded as a hybrid form between acquaintance based and organization based ride sharing.)

Organization-based ride sharing relies on the use of communication media, such as the internet, the telephone or most recently also on smart-phones in order to match rides. (See chapter 2.1.2 for a further specification of the different concepts of ride matching of organization-based ride sharing concepts.)

Finally, “***ad-hoc***” ride sharing requires little relationship between participants and does not include membership. Ad-hoc ride sharing is realized through ‘casual carpooling’, also called **slugging**, which is the ad hoc, informal forming of carpools for purposes of *commuting.*

This practice has its origin mainly in the U.S. (mainly Virginia), where high-occupancy vehicle (HOV) lanes were built in many major cities to encourage carpooling and greater use of public transport, especially in order to reduce congestion during morning and evening rush hours. The practice dates back to the 1970ies. By slugging, drivers are able to use HOV lanes for a quicker trip, and passengers are able to travel for free (or cheaper/quicker

Slugging Etiquette

- First come, first served, though slugs may decline ride if they are uncertain of the driver or so as not to leave a woman alone in the queue
- Drivers may "call out" if they see a friend in the queue
- No talking - unless initiated by driver
- Slugs should not adjust heat or air conditioning, open or close window or ask to change radio
- "Thank yous" should be said by both parties at start and finish
- No money is offered, requested or accepted

than via other modes of travel). No arrangements are made beforehand, and no money exchanged. During rush hour, "sluggers" (passengers) simply either drive to park and ride-like facilities or free parking lots for carpoolers with lines of sluggers (such locations can be found on internet platforms). Drivers then pull up to the queue (the slug line) for the route they will follow and call out the designated drop-off point they are willing to drive to and how many passengers they can take. Enough riders step forward to fill the car and the driver departs. There are a number of unofficial rules to the arrangement (see the box). (BBC, 2003 and Slug-Lines, 2010) Ad-hoc ride sharing is self-organized.

2.1.2 Ways of matching shared rides

As mentioned, organizational based ride sharing services rely on different kinds of media in order to optimally match rides that want to be shared. In the following different ride matching techniques are described more closely.

Internet based matching:

Online ride matching programs and platforms allow users (mostly after a subscription procedure and after becoming a member) to either match their rides themselves or to get their desired rides matched with drivers' or passengers' offers.

In the first, simpler, case, infrequent trips are often matched well in advance by the platform users. They can, however, also do so on short notice. After an often (free of charge) subscription to the platform, and after entering some profile details (e.g. smoker/non smoker, driving habits), the platform user can either put his ride offer or ride demand online and wait for an other user's reply, or he searches for an offered ride or a ride demand that matches his desire (e.g. concerning date of trip, departure time of trip, location of pick-up, user profiles etc.). Also more frequent trips (e.g. for commuting) can be matched.

The second option is that rides matches are carried automatically by the online based tool and suggested to the users. GIS technology that matches potential users traveling to and from similar places is employed. Some companies have developed ride matching platforms — a suite of services that a public agency or employer could purchase for a monthly fee.

Telephone based matching:

This is the earliest form of "dynamic ride sharing" (see also smart-phone based ride matching). This approach allows users to request rides, offer rides, and receive ride matching information in real-time over the telephone. Either human operators or an automated interface communicates with users. "Enhanced" telephone-based ride matching includes capabilities such as: Internet, e-mail, mobile phone, personal digital assistants (PDAs), and geographic information systems (GIS). (Chan et al., 2011)

Smart-phone based matching:

Smart-phone based ride matching enables **"real-time"** or also called **"dynamic ride sharing"** concepts, which facilitate the ability of drivers and passengers to make one-time ride matches close to their departure time, with sufficient convenience and flexibility to be used on a daily basis. The arrangements are of occasional nature. Little advanced notice is needed when attempting to establish a shared trip. These systems only recently developed since traditional ride share arrangements have been relatively inflexible, long-term arrangements. The increasing complexity of work and social schedules is assumed to have made this type of commuting arrangement less desirable. Real-time ride sharing therefore attempts to provide added flexibility to ride sharing arrangements. (Amey et al., 2011)

Real-time ridesharing uses Internet-enabled smart-phones and automated ride matching software to organize rides in real time. This enables participants to be organized either minutes before the trip takes place or while the trip is occurring, with passengers picked up

and dropped off along the way. As in most ride sharing services, a high subscriber base is required. (Chan et al., 2011) The number of "real-time" rideshare providers has increased noticeably in recent years, as has the number of organizations/employers agreeing to use these providers' services. (Amey et al., 2011).
The Avego system (http://www.avego.com) and the NuRide system (http://www.nuride.com) in the U.S. are two examples of what users may expect in terms of functionality from a "real-time" service. In France the operator Villefluide provides a real-time car sharing system. (see chapter 2.1.4)
In the Annex of this report a list of technological requirement of real-time car sharing can be found.

2.1.3 Most recent developments in ride sharing

Especially in the U.S. the following innovative developments could be observed during recent years concerning ride sharing (Chan et al. 2011):

Development of partnerships
From 2004 onwards a new generation of ride matching platforms has been developed for regions and employers to use. Partnerships between ride matching software companies and its large-scale clients take advantage of existing common destinations and large numbers of potential members. These firms sell their ride matching software "platforms" to public agencies and employers, which are sometimes used as standalone websites for each group. While this partnership strategy has gained more users than previous ridesharing phases, it is most suited for commuters with regular schedules.

Financial incentives
Many public agencies and companies promote ridesharing by providing its members with incentives. One example is NuRide, an online ridesharing club with over 48,000 members in seven U.S. metropolitan areas (www.nuride.com). NuRide rewards points when members carpool, vanpool, take public transit, bike, walk, or telecommute for both work and personal trips. These points can be used for restaurant coupons, shopping discounts, and attraction tickets. NuRide partners with public agencies, employers, and businesses to sponsor the incentives.

Social networking platforms
The rise of social networking platforms, such as Facebook, has enabled ridesharing companies to use this interface to match potential rides between friends or acquaintances more easily. These companies hope that social networking will build trust among participants, addressing safety considerations. One example is Zimride, which has partnered with 50 U.S. colleges, universities, and companies that each has their own "network" of members (www.zimride.com). In addition to each network's website, Zimride also uses the Facebook platform to attract public users. Another service is PickupPal, with over 148,000 members in 116 countries (www.pickuppal.com). It allows members to create their own groups based on common area, company, school, and shared interests.

2.1.4 Ride sharing in France

Generally ride sharing is very difficult to quantify since it is often organized on an informal or unofficial basis. However, it appears that ride sharing is especially increasingly dominant in North America, where it represents approximately 8 to 11% of the transportation modal share in Canada and the United States, respectively. There are approximately 613 ride sharing programs in North America. (Chan et al. 2011)

In France 78 online ride sharing service operators have been counted in March 2007 (Cetru, 2007). These operators show different geographic scales of operation. The repartition of the 78 ride sharing operators according to their operational level is given in Figure 2 underneath:

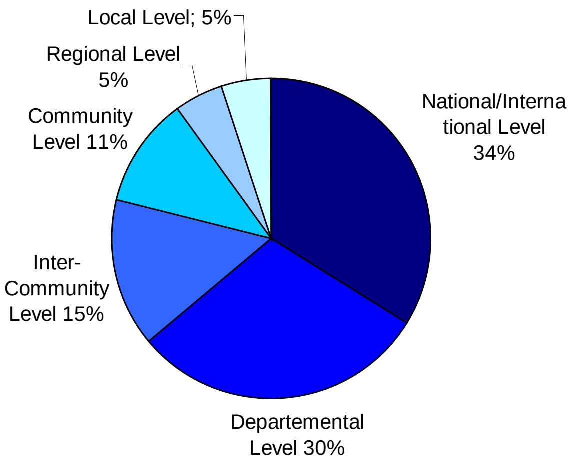


Figure 2: Repartition of French ride sharing operators according to the level of operation (Certu, 2007)

It can be seen that most ride sharing operators that offer online ride matching platforms work on an (inter)national or departmental scale. Only 5% focus with their services on a local area. According to a more recent study of ADEME (2010), there are already over 200 ‘organized’ ride sharing service operators in France. The term ‘organized’ here refers to the fact that these service providers do not offer dynamic car sharing. However, in the meantime also dynamic car sharing operators have launched their services. Obviously, the number of ride sharing services has increased immensely throughout last years. It is, however, rather questionable if this development is in favor of a functioning ride sharing system. After all, the more subscribers make usage of a single platform, the more efficient rides can be matched, which comes to the profit of all users. Already the study of Certu (2007), which counted ‘only’ 78 ride sharing services, critically observes the development of more and more single service providers and concludes that more governance of all these single services would be advantageous for future successful development of ride sharing.

In the following French examples of ride sharing service operators that have reached a certain level of knowledge throughout the last years are sketched:

Operator	***Greencove***	***Comuto***	***Villefluide***
Ride matching technology	Internet, mobile phone	Internet, mobile phone	Smart phone (*real time ride sharing*!)

Table 1: Ride Sharing (co-voiturage) operators in France

Greencove (Reference: www.greencove.fr)
Greencove provides ride sharing services to organizations that have subscribed for their services. Single users (e.g. employees) are then provided with a registration code with which they can personally subscribe on the operator’s website. They can develop their profile and use all ride sharing services provided. Maps are provided in order to easier find already indicated ride sharing offers and in order to easier obtain specifications of travel routes and times as well as shared costs. Search engines are available in order to easier find offers of shared rides. Public transport services are integrated in maps allowing the user to easily construct their desired trip, which might also entail the usage of public services.

Once a ride sharing offer has been matched, time and location of the meeting point are fixed (if this has not been already indicated in the offer). Both, drivers and passengers get automatic notifications per email or telephone about their shared ride if desired. Both parties can get in direct contact with each other if necessary. At the end of the shared trip the payment, as indicated in the ride sharing offer on the webpage, is carried out instantly. Drivers and passengers can post their opinion about each other onto the other's website profile (e.g. concerning driving style, punctuality etc.).

The website www.123envoiture.com provided by Greencove further unites more than 40 ride sharing websites (e.g. developed on regional/organization level). There are more than 345 000 subscribers in France (and Europe) and more than 100.000 typical routes suggested. 123envoiture constitutes the first large scale ride sharing network in France. Each single private person can subscribe (for free) and search/offer rides.

Greencove also frequently works together with large scale events (e.g. music festivals) that want to promote ride sharing among their participants for accessing their grounds (especially in order to reduce needs for parking space). Event participants can register for the car sharing service and search for/offer rides going to/from the event.

Comuto: (Reference: www.comuto.com, www.covoiturage.fr)

Communto offers a platform similar to 123envoiture. Single users can easily (and for free) subscribe to the service, create his/her profile and post or search for offered rides. Costs for passengers are fixed in advance based on Comuto´s guidelines and distance/cost calculations (a maximum charge is fixed by the platform in order to avoid excess charging).

A specification of Comuto is that it offers the service MERCI. MERCI provides a mean with which drivers and passangers can get in contact with each other by phone, without having to reveal their phone numbers.

Villefluide: (Reference: www.villefluide.fr)

Villefluide offers **real time ride sharing** for companies having a certain size and therefore the potential to successfully implement dynamic ride sharing for their employees. Employees of the company register to the service and profit from real time ride sharing by posting and searching for a ride via their phone. Rides are matched within a couple of seconds and confirmed by automatic phone messages. Pre-settings allow users to automatically demand same rides every day, but also to change them in the last minute if needed (by (non) confirmation of a text message). Shared rides are stored in a database. Payments take place automatically at the end of each month according to rides consumed or offered. Drivers and passengers are connected automatically do not have to get in contact with each other by any other means than sending messages via the villefluide server.

2.1.5 Critical Outlook

Since ride sharing reduces the number of automobiles needed by travelers, numerous societal benefits can be achieved. Increased carpooling stimulates the reduction of energy consumption, emissions, traffic congestion, and parking infrastructure demand. However, the magnitude of such benefits is difficult to assess. On an individual level, the benefits are more tangible. Ride sharing participants experience cost savings due to shared travel costs, travel-time savings, and reduced stress. In addition, possible policies might allow for preferential parking and additional incentives.

Despite its numerous benefits, there are behavioral barriers to increased ride sharing use. Individuals probably often acknowledge the attractiveness of ride sharing but are still hesitant to really sacrifice the flexibility and convenience of the private automobile. Moreover, psychological factors, such as the desire for personal space and time and an aversion to social situations, can impact ride sharing adoption. Personal security is also a concern when sharing a ride with strangers, although this is a perceived risk.

2.2 Car sharing

While ride sharing or car pooling (as described in chapter 2.1) refers to the shared use of a car for a specific journey, in particular very often for commuting purposes, car sharing refers to a model of car rental, where people rent cars for short periods of time, often by the hour. Synonyms for car sharing are also the term “car clubs” (especially used in the U.K.), or the term “autopartage” (the French equivalent). Car sharing is especially attractive to customers who make only occasional use of a vehicle, as well as to others who would like occasional access to a vehicle of a different type than they use day-to-day (e.g. for the purpose of transportation of a certain good). The organization renting the cars may be a commercial business, a public agency, a cooperative or they may be forms of *ad hoc* grouping for the purpose of car sharing. Today there are more than one thousand cities in the world where people can share their cars. (Ecoplan, 2009)

As with ride sharing, there are several societal benefits of car sharing. Car sharing reduces the environmental impact of driving and reduces private transportation costs for some drivers with only intermittent need for vehicle transportation (Martin et al., 2010). Studies have demonstrated that each new shared car added to an existing car sharing fleet removes 4.6 to 20 private vehicles from the road. (Martin et al.,2010). This reduction is because members of car sharing services are much less likely to purchase their own cars, and may even sell a car after joining a car sharing service (Shaheen et al., 2006). Car sharing changes the economics of driving by converting vehicle transportation from a fixed cost into a variable cost. Car sharing has been shown to reduce vehicle miles traveled among members by 67% since the modes of public transport, cycling and walking are used more frequently in combination with car sharing (Cervero et al., 2007).

2.2.1 Delimitation to car rental

Car sharing differs from traditional car rentals in several ways. Basically, car sharing offers an alternative to car rental that is usually much more flexible. Since reservation, pick up and return of cars is all done by *self-service*, car sharing is usually offered *all day round, 7 days a week*. Further, the renting period leaves much more flexibility to the user, since vehicles can be *rented by hour (or even by minute)* or as well by the day. Often cars do not need to be returned at the same place where they were picked up. They can be returned at any other shared vehicle renting location offered by the service operator. Sometimes also specific parking spaces throughout the city are only dedicated to the cars of a shared vehicle operator (which can significantly reduce the time for searching a parking space). Customers therefore enjoy the freedom of *one-way trips*. Vehicle locations are mostly strategically located – e.g. next to public transport nodes. This way *easy access* is assured to shared vehicle users. Further, also *no* tedious *extra fees* e.g. for insurance or fuel are charged. A subscription and usage fee (usually based on rental time and/or kms driven) cover all expenses related to the service.

The following table summarizes the features of most shared vehicle services, which guarantee a much higher flexibility to users than what traditional car rental services do:

Flexibility of car sharing is guaranteed by:
▪ Self-service → 24/7 operation of services ▪ Flexible renting periods ▪ Flexible usage (often one way trips possible) ▪ Easily accessible (located close to public

transport services)
- Simple and comprehensive usage fees

2.2.2 Functioning

The functioning of car sharing systems varies enormously from operator to operator. Simplest (smallest) operators have only one or two vehicle pick-up points to which vehicles also have to be returned. Most advanced operators allow cars to be picked up and dropped off at any available public parking space within a designated operating area.
The technology behind retrieving/returning a vehicle can vary from simple manual systems using key boxes and log books to increasingly complex computer based systems with supporting software that allow the interface with mobile/smart phones or via internet.

Reservation process
Usually, to make a reservation, one can either make a reservation online, by phone, or by text messages depending on the company's flexibility. The trip then usually has to be specified: Pick up time and location, rental period, vehicle preferences etc. are to be specified by the user. Obviously, the early a reservation is made, the higher the chance of availability of the desired vehicle at the desired time/date/location.

Retrieving the vehicle
Once the reservation has been made successfully, the desired vehicle can be picked up the indicated location and at the predefined time instant. Often, a small card reader on the windshield allows the customer - equipped with his membership card - to unlock the car (and to activate a timer). Only if the car has been reserved beforehand, the unlocking process will be successful. Often, car keys can then be found somewhere inside the car.

Maintenance of the vehicle
Although members are often responsible for cleaning the car and filling up the tank when low, the car sharing company is generally responsible for the long-term maintenance of the vehicles. Members have to make sure that when they are finished, the car is ready for the next user.
(see www.carsharing.net)

2.2.3 Most recent developments in car sharing

Today, despite the enormous potential environmental benefits, and despite considerable consumer demand, adoption rates for car sharing are currently 12 to 30 times lower than projected by market research (Millard-Ball et al., 2005), regarding the U.S. market. Hampshire et al. (2011) argues that the current car sharing business model is not flexible enough to capture the entire car sharing demand. The traditional car sharing business model is difficult to scale geographically. Financial profitability for a car sharing provider is achievable in high population density areas with many potential members that guarantee high vehicle utilization and offsetting of initial investment costs. In order for the fleet operator to realize a profit on its initial investment, about 25 active members must live within a ¼ mile of each vehicle to ensure sufficient utilization of the share car (Sullivan et al., 2007).

In order to be able to offer car sharing also in lower density areas, a new concept called **Peer-to-Peer car sharing** has been very recently developed (the so far extremely few existing operations mostly only started in 2010). Peer-to-Peer car sharing allows car owners to convert their personal vehicles into share cars, which can be rented to other drivers on a short term basis. The business model is closely aligned to traditional car sharing, but replaces a typical fleet with a 'virtual' fleet made up of vehicles from participating owners. With peer-to-peer

car rental, participating car owners are able to make money by renting out their vehicle when they are not using it. Participating renters can access nearby and affordable vehicles and pay only for the time they need to use them.
Service operators typically apply some form of screening of participants (both owners and renters) and a technical solution, usually in the form of a website, that brings these parties together, manages rental bookings and collects payment. Increasingly, an automated form of insurance and breakdown coverage will be applied to rentals that take place through the service in order to protect an owner's existing insurance coverage.
Current issues with peer-to-peer car sharing mainly concern the insurance and liability questions. (Sullivan et al., 2007)

2.2.4 Car sharing operators in France

In April 2008 CERTU counted 21 cities that profited from car sharing services. Altogether 19 different operators were counted, of which 10 were grouped together to 'le réseau France Autopartage'. (ADEME, 2009) The following map gives an overview of where the French car sharing operators run their services. Also indications of the size of each deployed network are shown. However, due to the age of the study and rapid recent developments in the transport sector, it has to be noted that the shown census is likely to be already somewhat outdated. The importance of the Paris region for car sharing becomes apparent.
On average, a shared vehicle in France runs a yearly mileage of 12 500 km (ADEME, 2009).

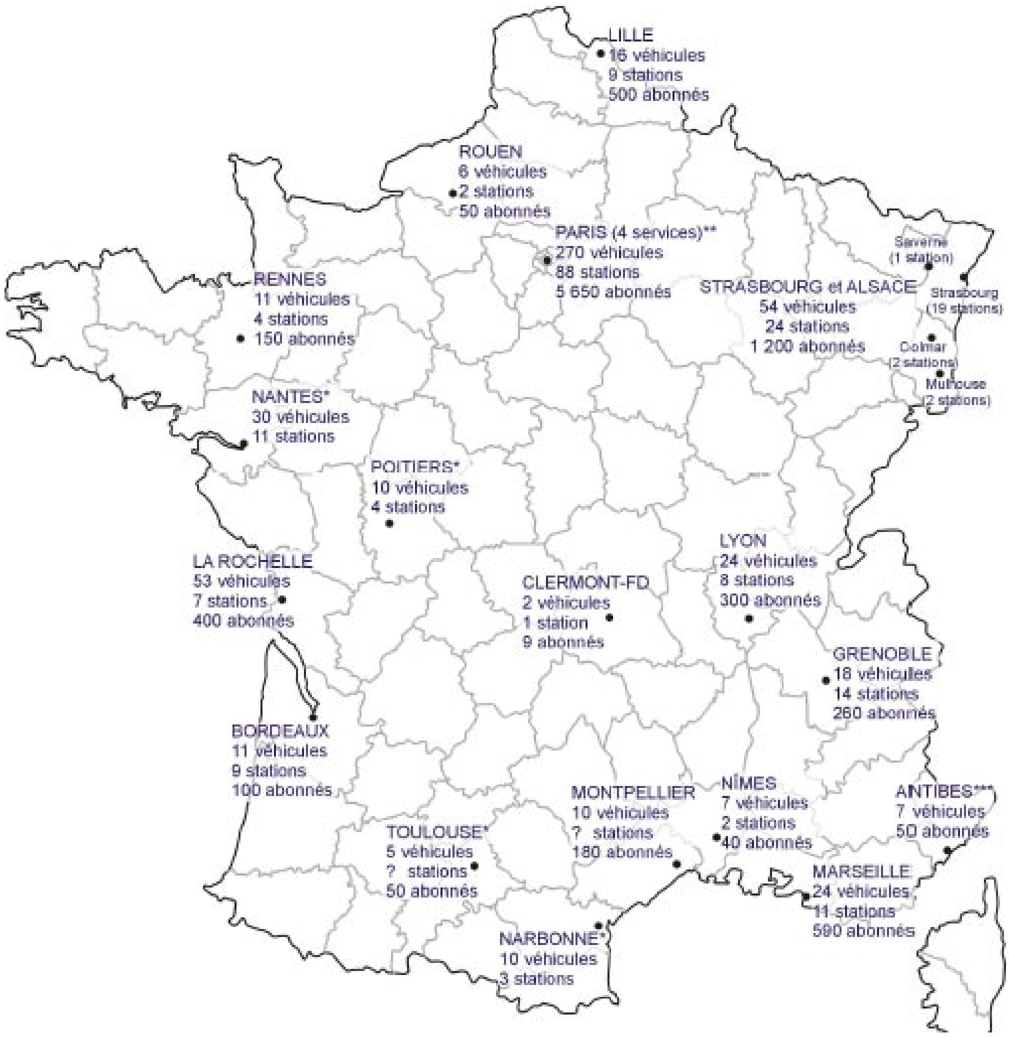


Figure 3: Car sharing operators in France (ADEME 2009, based on data of 2008)

In the following the main characteristics of three well known car sharers in France are shown.

Mobizen (mobizen.fr)
Mobizen (by Veolia Transport) is a French car share operator in Paris, where a dense net of car share locations has been installed. Mobizen offers 3 types of vehicles to different tariffs (Mercedes Classe A (9 Euro/hour), Mercedes Vito (18 Euro/hour), Fiat 500 (9 Euro/hour)). After paying a subscription free, customers are further charged an annual fee, a monthly fee and the vehicle-based fees according to the hours of usage (including petrol and right of usage up until 200km). Different tariffs are available for different usage types (occasional users, frequent users etc.). Generally, the more frequent users pay higher monthly fees (e.g. 100 Euro/month), but get then a reduction on hourly fees.
After the subscription process (via telephone), the client gets sent an electronic card allowing him to access a pre-reserved vehicle. Reservations can be carried out until 5min before departure, either via internet or phone. Once haven accessed the vehicle, the car keys can be found in the car. After usage, the car has to be returned to the same place where the car has been taken from. Each Mobizen car has its reserved parking place in Paris. In case reservation periods are not adhered to, supplementary fees are charged. In case cars are returned in advance, the hourly based reservation fee is reduced.
Mobizen also offers its services to companies. In such cases Mobizen cars are specifically located in the vicinity/on the grounds of the company.

Okigo (www.okigo.fr)
Okigo is a French car sharer operated by Avis and Vinci Park. Deployed vehicles are the Fiat 500 and the C3 Picasso. Okigo operates in Paris. The main difference to Mobizen is the tariff system: Okigo offers much lower rates per hour, per month and per year; however, fees per driven km have to be paid (0.35/km). Other features of this operator function in a very similar way to Mobizen.

Alpes Autopartage (www.alpes-autopartage.fr/)
Alpes Autopartage is a car sharing operator offering his services in Grenoble. 7 different vehicle types are offered (of Renault, Peugeot and Toyota). Alpes Autopartage charges a subscription fee and then only supplementary fees according to the usage of the vehicles. (there are no monthly or yearly rates). Usage fees imply charges per km, per h and per reservation. Fixed rates are therefore held to a very minimum.

Livop (www.livop.fr)
Livop is the only operator in France that offers peer-to-peer car sharing so far. Livop launched its internet platform in September 2010. People wanting to offer or people who want to rent an offered car can subscribe for free on the online platform. The platform offers a mean to match offers and demands of cars.

2.2.5 Critical Outlook

Car sharing offers great potential for improvements in resource efficiency of our transport system. The advantages of shared vehicles can be summarized to the following points (ADEME, 2009):

Shared vehicles
- can greatly reduce the number of privately owned vehicles
- are a mean of provoking intermodal chains in passenger transport, which, in turn, are likely to evoke a reduction of vehicle-kilometres driven

- allow offering the possibility of car use to the entire population
- offer a simple and flexible transport mode
- offer an economic advantage to the possession of a private vehicle
- initiate the altering of transport behaviour and habits

However, the success of car sharing requires already a behavioural change among travellers. While offering certain advantages to drivers (e.g. reduced fixed costs, no parking difficulties), car sharing obviously also bears some detriments that users have to be willing to adapt to. The sole fact of having to make reservations before vehicle usage is a circumstance that users have to be willing to get used to.
French car sharing operators could consider offering one-way trips (as to our knowledge such a service is not yet existent). This would greatly increase flexibility of trips and could increase acceptance of this service among travellers. An even further step would be to offer more flexible parking schemes: The user can park the vehicle on any public parking area free of charge within a designated geographic area. This approach would offer users the highest possible usage flexibility. (An example of a car sharing operator, who offers one-way trips is Car2Go – a German company operating in Ulm and Hamburg (Germany) and Austin, Texas (U.S.). Since April 2009 car2go is also testing the flexible parking system with 200 easily recognizable white Minis in and around the city of Ulm.)

2.3 Transport on-demand (DRT)

Transport on demand (also called demand-responsive transport services, DRTs) are "an advanced, user-oriented form of public transport characterized by flexible routing and scheduling of small/medium vehicles operating in shared-ride mode between pick-up and drop-off locations according to passengers needs". (European Commission, 2011)
DRT systems often provide a public transport service in rural areas or areas of low passenger demand (e.g. low density housing in or around urban areas), where a regular bus service is not viable (European Commission, 2011). In recent years DRT services have also become increasingly popular with the ageing of the population and the ongoing trend to provide them with door-to-door transportation services (e.g. for health care services). In transportation service terms, DRTs therefore fill the gap between bus and taxi services. It is a mean of preventing social exclusion (whether due to young or old age, or physical or mental handicap).
DRTs are often provided by local authorities, who see DRTs as socially necessary transport services. However, DRTs are sometimes also provided by private companies for commercial reasons (e.g. DRT-style airport bus services). (Cordeau et al., 2004)
DRTs are therefore flexible public transport services. Their flexibility can be defined along the following dimensions: route choice, vehicle allocation, vehicle operator, type of payment and passenger category. The flexibility of each element can vary from services where all variables are fixed a considerable time before operation (e.g. a conventional public transport bus route) to services where all elements are determined close to the time of operation (e.g. fully demand responsive services). (Brake et al., 2006) Figure 4 depicts the possible variations of demand responsiveness of public transport according to all mentioned dimensions. Moving from left to right, the demand responsiveness of each dimension increases.

Figure 4: Possible variations of demand responsiveness of public transport (Brake et al., 2006)

2.3.1 Functioning

Process

Usually, DRTs are offered within a given geographic zone. A customer communicates with the DRT service operator (e.g. via telephone or the internet) in a travel dispatch centre (TDC) in order to request a single or return trip with a specific origin and destination. Depending on the flexibility of the service, the service operator schedules the demanded trip statically (the trip is booked well in advance and the routes of vehicles is still to be fully defined) or dynamically (the trip is booked shortly before departure and vehicles already on route have to be scheduled and (re)routed real time in order to fulfil the incoming request). Routes (and/or time schedules) are either fixed beforehand, which 'only' allows customers to demand a stop of a touring vehicle on the predefined route, or they are set up entirely according to incoming demand. For example, ‘semi-fixed corridor’ services run from a fixed starting to a fixed end point. Several intermediate points are fixed, while other defined stops are only served in case a vehicle is demanded. ‘Flexible area’ services have one fixed start and destination point. On their route they only serve those stops that have been demanded or, alternatively, also non-predefined stop points, such as doorsteps. Further, service offers can also have multiple destination points.[1] Agreed pick-up points and times are communicated to the customer once the reservation has been processed. Usually time windows (of e.g. 10 minutes) are defined. The vehicle is often shared with other passengers having had similar requests. (Brake et al., 2006)

Due to the immense flexibility of services and broad range of possible service offers, DRT services have to ability to operate successfully in varying environments. (Mageean and Nelson, 2003)

The following figure gives a summarizing overview of how a DRT system deploying advanced technologies can work (booking over internet has by now become a frequent alternative to telephone booking).

[1] See the annex for an overview of possible vehicle routing concepts of DRT services.

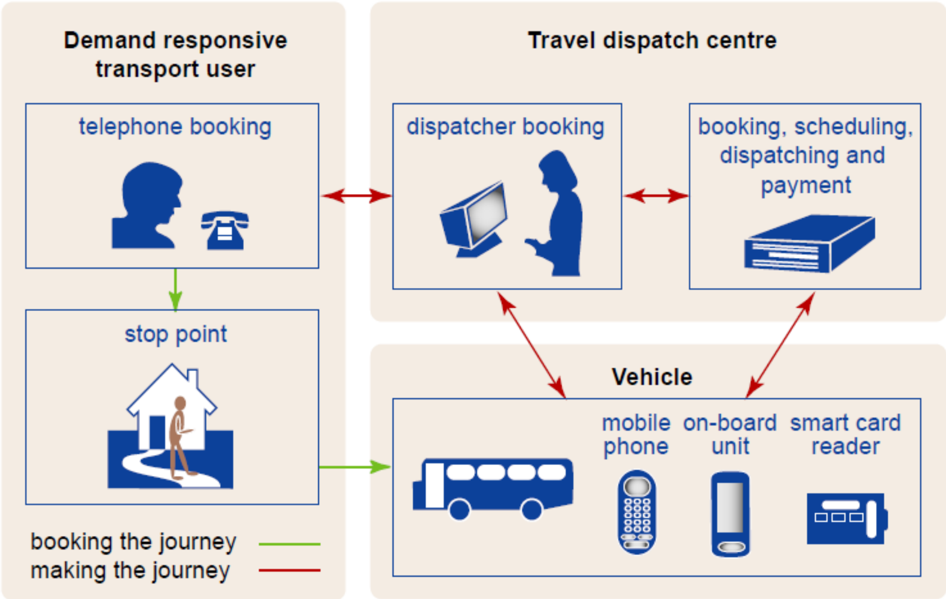


Figure 5: Schematic representation of a DRT system (Brake et al., 2006)

Optimization of requests

Obviously, DRT operators face challenging optimization tasks, especially when wanting to offer high flexibility and quality of their services. Usually three conflicting objectives have to be taken into account:

(1) Maximizing the number of requests served
(2) Minimizing operation costs
(3) Minimizing user inconvenience

A typical way of finding a balance between these objectives is to first maximize the number of requests that can be accepted by given capacity constraints, to then minimize operation costs, while imposing service quality constraints. The latter ones usually refer to deviations from desired pickup and delivery times and to excess ride time (the difference between the actual ride time and the minimum possible ride time between origin and destination of a request). The issue of excess ride time becomes especially important in case emergency services are offered. Operation costs are mostly related to the number of vehicles used, to the total route duration and to total distances traveled by the deployed vehicles.
DRT service operators usually work with mathematical optimization programs that decide on clustering of requests (grouping of requests to be served by the same vehicle due to their spatial and temporal proximity), on vehicle routing (the order in which the cluster-associated origins and destinations should be visited by each vehicle) and on vehicle scheduling (the specification of the exact time at which each location should be visited). These optimization procedures are usually carried out simultaneously and iteratively. (Cordeau et al., 2004)

Pricing

Fare setting is an important issue since the number of passengers multiplied by the fare will provide the revenue of a DRT system. Local authorities usually set a DRT fare as a distance-based fare, (either as a fixed mileage rate or by a zonal fare system). However, there are also some DRT services that use a flat fare. Higher prices especially for door-to-door services could be defendable. However, where implemented, a premium charge needs careful explanation as users usually perceive DRT services as a mean of public transport where 'normal' fares should be charged. (Brake et al., 2006)

2.3.2 Filling the gap

DRT Services fill the gap between individual transport and scheduled conventional public transport. Especially in many suburban or rural areas conventional public transport is facing severe challenges though. Due to the increase of individual mobility (the increase of private vehicle detention), occupation rates are steadily decreasing, often turning public transport lines unprofitable. A traditional answer is (was) to limit the frequency of services, which in turn results in even lower number of customers. As already mentioned, customers experience, however, an ever increasing need (and/or desire) for mobility. Limiting their degree of freedom by restricting their mobility (especially referring here to children, elderly or socially disadvantaged) can have severe effects on rural areas, the persistency of small rural villages and generally on the quality of life.

DRT services have the potential to reduce operational costs of public transport services and to provide customers with a mean of public transportation that offers even higher flexibility than traditional modes.

The figure below summarizes the evolution towards new innovative transport concepts starting from the taxi and the conventional transport concept. Based upon the initial demand of customers for flexible transport services, transport operators and authorities strive to offer services that are cost efficient and financially profitable. Authorities further also look for efficient offers that meet the need of basic mobility for all groups of the population in all possible areas – service offers for which financial profitability is often not evident, but also not the main objective for offering the service. The evolution of scheduled conventional public transport services and flexible but expensive taxi services has been the consequence. DRT services have become a mean to bridge the two 'extremes', by offering flexible services for reasonable costs.

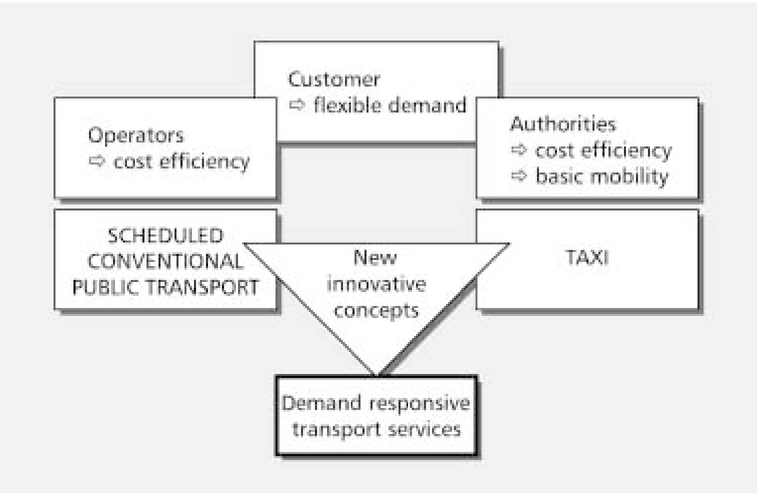


Figure 6: From traditional public transport and taxis to DRT services (Ambrosino et al., 2003)

2.3.3 DRT services in France

In France, there are 615 DRT services (level of 2005, according to Castex, 2007). 73% of these services are open to the public, 16% are dedicated to physically handicapped people (TPMR - Transport de Personnes à Mobilité Réduite) and 5% of the services are run privately. (as can be seen in the following figure).

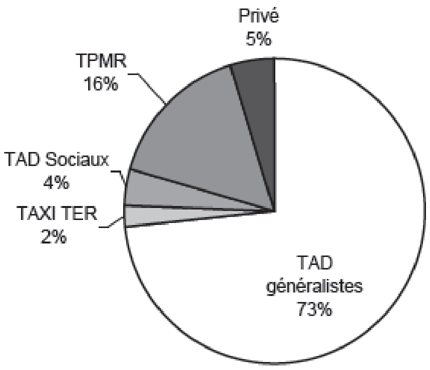


Figure 7: DRT services in France by type of service (Castex, 2007)

There are 7341 communities that are served by at least one DRT service (being 20% of French communities). The majority of services is deployed in rural and pre-urbain areas, with the main objective of connecting city centers with public transport nodes (as e.g. train stations). Also urbain areas show high DRT service levels. Here, the main focus lies on the provision of services for physically handicapped people. (Castex, 2007)
The following figure gives an overview of the distribution of DRT services in France (again, the numbers are based on 2005 data)

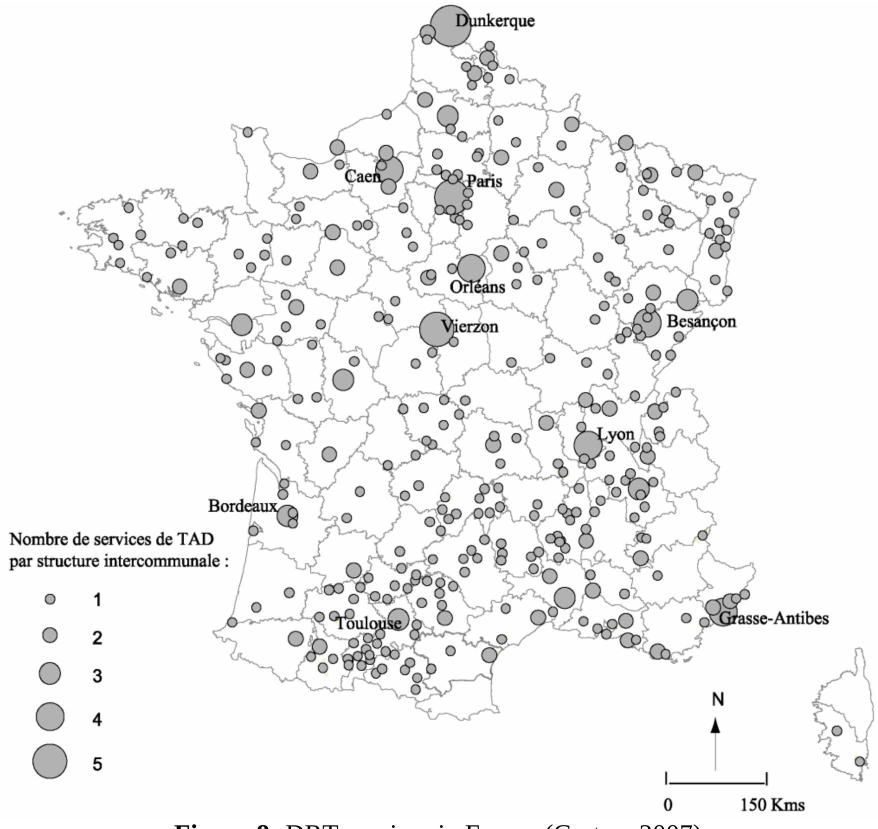


Figure 8: DRT services in France (Castex, 2007)

2.3.4 Critical Review

As described above, a DRT service may have very various characteristics and capabilities, allowing public transport companies to tune their offer and meet users demand under specific mobility conditions. Before deploying a DRT service, the wide variety of possible services and their configurations should be analyzed in view of the regional requirements concerning a new transport service offer. Design decisions and operational choices should be based upon:

- the typology/geography of the region

- the (economic) objectives of the operator or the implementing authority
- the specific characteristics of the potential/prospective user groups
- the type of existing mobility demands.

A careful analysis of all these aspects is needed to define the service and to select the supporting technical system to manage service operations. (Ambrosino et al., 2003)

DRT services offer an excellent opportunity for providing transport services to physically or financially handicapped people, who can not (or do not want to) rely on individual transport. Also rural areas, which often lack of accessibility by public transport means, can be made more accessible and viable via DRT services. Further, attractive and flexible DRT service offers also have the potential to reduce individual private transport and to hereby contribute to sustainable, resource efficient transport behaviour and transport systems. DRT services therefore seem to be a remedy for many current challenges in the passenger transport sector.
Depending on the conditions of the regarded region as well as on the prospective service, economic viability of a DRT offer may be achievable. From a social perspective, the engagement of authorities for subsidizing these kinds of service is, however, justifiable. More expensive ‘traditional’ public transport services can be cut down, while simultaneously offering often even more flexible and convenient transport options to customers.

2.4 Synthesis and Conclusion

Innovative mobility services, such as car sharing and ride sharing, bear great potential to reduce congestion, to cut emissions and to improve overall energy efficiency of our transport system, while simultaneously contributing to energy independency of the transport sector and of our economy in general. Demand responsive transport systems bear the same potential, while specifically guaranteeing accessibility of rural areas and freedom of mobility for economically or financially handicapped.
Recent years have been showing growing interest in such innovative mobility services, both, from demand and supply side. Demand has been increasing due to deteriorating transport efficiency, due to environmental sensibility of travellers and also due to economic considerations of transport customers. Public policies provoking the demand of more environmentally friendly modes and systems have partly already been put in place in order to ‘artificially’ push demand even further.
On the supply side, business models have been developed that allow the commercialization of such new mobility offers. After having forecasted rising demand, suppliers are speculating with steadily increasing profit margins in upcoming years, and are therefore more and more willing to invest and to develop new offers. New service offers distinguish themselves especially by continuously increasing flexibility thanks to the application of recent developments in the IT sector (e.g. smartphones, telematics). These new services are likely to even accelerate interest from the demand side.
However, recent tendencies have to be regarded critically. Real success and financial profitability of innovative mobility services can only be achieved with a critical mass of customers. This requires a very broad acceptance among travellers that have to be willing to change habits, their attitude towards mobility and their perception of transport. As long as people are attached to their own cars, a paradigm change will be difficult to achieve. Certainly, future trends in demographics bear the potential of an increasing share of non-motorised people. However, a critical mass will be difficult to attain by demographic changes or by counting only on environmental sensible or financially handicapped groups of the population.
Governmental steering mechanisms that further support the development and uptake of new mobility services will therefore be a stringent requirement for the success of such services -

especially then, when regions other than dense urban areas want to provide and profit from these new mobility services. Here, financial feasibility is much more difficult to attain; a critical mass of users is even harder to obtain.

3 The take-off of electric vehicles

Recent years have been showing growing public interest in electric vehicles. National and regional governments, vehicle manufacturers, mobility and electricity providers, as well as resource providers have been realizing the alleged potential of electric mobility. Electric mobility is seen as a mean for enabling a more efficient use of resources in the transport sector, hereby contributing to the development of sustainable and efficient transport systems. Besides environmental benefits due to a predicted reduction of local and global emissions, high potential is also seen for the recovery of the automotive sector and all its adjacent industries, by contributing to economic growth and public welfare in general. Hence, electric mobility is seen as remedy for many current public concerns. National governments are therefore on the verge of launching electric vehicle supportive policies that aim to promote and push both the development and also the introduction of electric vehicles and their necessary infrastructures.

This chapter shall give an overview of current developments concerning the electric vehicle landscape. First, a brief overview of various public policy objectives and measures will be given. Then the current market development on the supply side will be sketched. The third and main part of this chapter will serve for an overview of ongoing deployment and experimentation projects concerning electric vehicles.

Note on scope of this study:
The term 'electric vehicle' has recently become quite ambiguous. Often the scope of certain studies has therefore become vague and confusing. In order to avoid such a deficiency the scope of this report is clearly defined to be the following:
Electric vehicles (in the following abbreviated as 'EV') refer to fully battery electric vehicles (often abbreviated as BEVs) and to plug-in hybrid electric vehicles (often abbreviated as PHEVs), both necessitating the deployment of (public) recharge infrastructure in order to charge the vehicle's battery. The term 'vehicle' is here further understood as passenger car. Electric bicycles or scooters as well as electric trucks (e.g. for freight transport) therefore fall out of the scope of this study.

3.1 Public policies on the deployment of EVs

Numerous countries have already stipulated definite measures and policies in line with defined EV strategies and deployment objectives. Governments hereby play a key role by actively influencing market developments. They are (together with other public authorities) responsible for the framework in which a market for EVs must succeed. In order to understand market potential of EVs, it is therefore also important to obtain an understanding of governmental objectives and stimulation measures. Many countries have released official understandings and agreements in which deployment objectives and stimulation packages together with available financial means are defined. Analyzing all of these measures lies out of the scope of this report. However, the following two sections give a comprehensive overview of numbered deployment objectives and supportive demand-side measures.

3.1.1 Deployment objectives per nation

The importance of EVs varies from country to country. Main motives may lie in supporting the recovery of the automobile industry, in increasing energy independence, in reducing emissions from the transport sector or in the general development of efficient transport systems. Due to varying motives and objectives, also different importance has been given to the subject of EVs in various countries. However, many nations, having been conservative in their estimations of future EV potential (e.g. the Netherlands, Italy), have recently also started to actively support their development, in order to catch up with nations that have already longer been following this path (e.g. France, Denmark). Many European countries have stated they wanted to become 'leading' nations concerning EVs. They seek to take a leading role in technology developments as well as in market development, in order to boost their own industry and to attract global industry players to their countries. Even nations without their own major automobile industry, see a big potential to become a major player in the sector (e.g. UK, Portugal). (Leurent and Windisch, 2011; Michaux; 2010)

As a measure to prove and show their dedication to obtaining a leading role in the developing market, many countries have stated official and precise EV deployment objectives. In order to achieve these, partly substantial financial means have been dedicated to research activities, to experimentation projects and even directly to the automobile (or battery manufacturing) industry. Deployment objectives seem to have mainly been based on very vague groundings though. Profound demand analyses seem to have been hardly carried out – in a certain way quite understandable due to the many still existing ambiguities concerning definite, future EV offers available to the customers. Deployment objectives therefore rather give an impression of the willingness and motivation of a government to support the market development. Especially the upcoming years, when first major EV models arrive on the market, will show if the objectives prove to be realistic. Defined objectives, however, very often go in line with the amount of public money dedicated to EV research. They therefore give an impression of the 'devotion' of a country to the support of EV development.

The following graph gives an overview of EV deployment objectives per country for the year 2020 (most countries have defined this timeframe for first definite objectives; the exceptions of the US and Spain are indicated by (*) – here specific deployment objectives were defined for the year 2015).

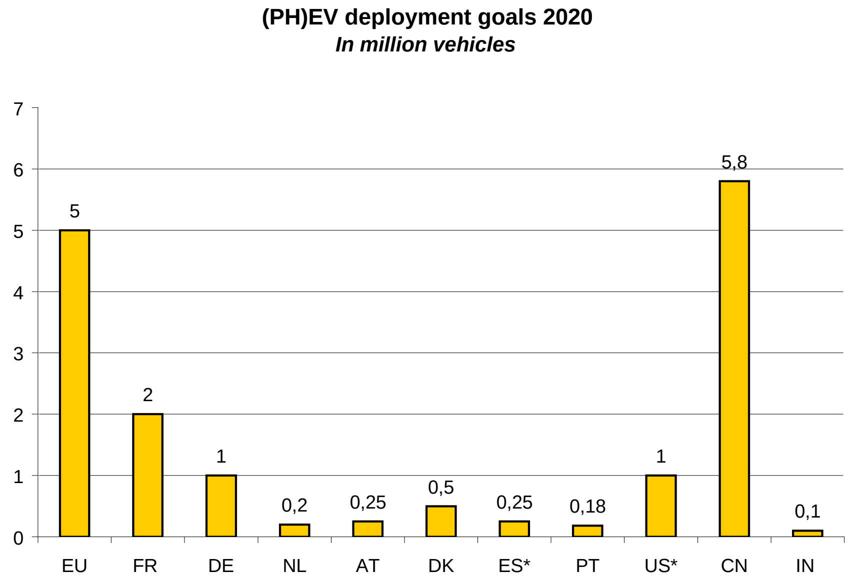


Figure 9: EV deployment goals for the year 2020 per country (Leurent and Windisch, 2011)

Figure 9 clearly shows that especially France, but also Germany have most ambitious deployment goals among European countries when regarding the explicit numbers of vehicles to be deployed. Given the size of the country, the US have a comparably poor target, whereas China is on the contrary surprising with its objective of deploying 5.8 million vehicles. However, these deployment targets are difficult to compare, keeping in mind the different market sizes and populations of the regarded countries. A more meaningful way to compare the targets is therefore to compare the deployment goals in terms of their percentages of the current car fleet. (Numbers of current car fleets were obtained from Eurostat 2010 and give number of the vehicle fleet in use in 2008.)

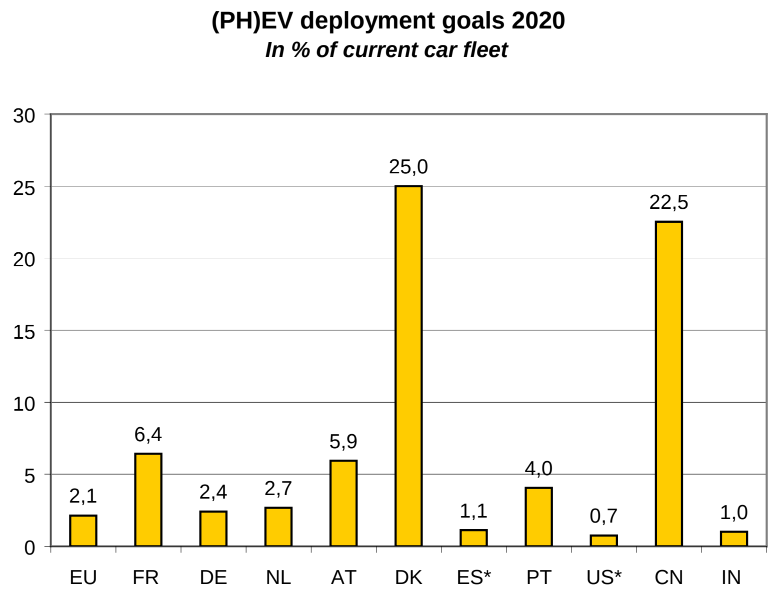


Figure 10: EV deployment goals in percent of the current car fleet (Leurent and Windisch, 2011)

Figure 10 gives a much clearer picture on actual deployment goals for the year 2020. Considering that current penetration rates of passenger EVs or PHEVs are close to 0% in most countires, these objectives show remarkable aspirations for the upcoming years. Denmark's goal is striking. Until 2020 25% of the auto market shall be penetrated by EVs (taking the current car fleet as constant until then). The upcoming years will show if the goal is really realistic or if it has to be revised. The shown percentage for China has to be regarded with attention. Whereas in all European countries (and also in the US) the shown percentage might remain similar over the years (since the size of the car fleet is not expected to change significantly), China's objective measured in percentage of the current car fleet could change immensely. Assuming an increasing vehicle demand (studies preview a growth of China's vehicle fleet by a factor of 10 between 2005 and 2030 (McKinsey, 2009)), the deployment objective of 5.8 million vehicles could signify a much smaller percentage of the total vehicle fleet by 2020 (namely approximately 4% if assuming a constant growth over the years). However, McKinsey (2009) states that if massive EV deployment starts in 2016, already 30% of the total vehicle market could be penetrated with EVs by 2030. Obviously, there is a lot of ambiguity concerning the Chinese market and various scenarios will become clearer throughout the upcoming years when Chinese policy strategies have become more evident.

The shown deployment objectives of various countries (certainly the study is not exhaustive), reveals the interest and general support of many countries concerning the deployment of EVs. Upcoming years will clarify if set objectives have been realistic. However, objectives give an impression of national governmental support that is dedicated to the deployment of EVs. The following chapter reveals in more detail which policy have already been put in place in order to specifically support the demand side of the developing EV market.

3.1.2 National market stimulation measures

In order to support above stated deployment objectives, most nations have been putting policy measures in place that support the development of an EV market. Measures are directed versus research activities, versus the supply side of a future market (the development of vehicles and necessary recharge infrastructure), and versus demand stimulating leverages (such as purchase subsidies or tax reductions).

The following table gives a synthesized, qualitative overview of policy measures that have been introduced per country on a national level. Specifically the encouragement of EV demand and of infrastructure deployment is regarded. Measures indicated with (*) refer to specific deployment projects and do not apply to the whole country.

Measures		F	D	UK	NL	AT	DK	IT	ES	PT	US	J	CN
Encouraging EV purchase	Purchase Subsidies	++		++				++	+	+	++	+	++
	Taxation incentives		+	++	++	++	+++		+	++		++	
	Less insurance costs					+		+					
	Reduced/No parking fees			++*				+***					
	Free public transport pass					++**							
	Public procurement	++	+	++	+		+			++	++		++
Encouraging Infrastructure deployment	Subsidies for infra uptake			++							++	+	
	Public funding for infra development	++		++	+					++			
	Tax deductions for infra uptake	++			++								

Table 2: Measures encouraging EV demand/infrastructure development per country (Leurent and Windisch, 2011)

Table 2 shows that taxation incentives and purchase subsidies are currently most common means for incentivising EV purchase. Many of these measures where introduced with recent EU guidelines that oblige member states to base vehicle taxation on emission levels. Measures that support the deployment of infrastructure are still less frequent. Obviously, these two types of measures should go hand and hand though. Increasing measures on the infrastructure side are therefore likely to be taken up shortly.

The following table gives a more specific (quantified) overview of deployed measures concerning the encouragement of EV purchase. Financial support for the single EV user is shown per country. Only measures provided at a national level are shown. Regional or local measures are therefore not included in the table.

Measure	FR	D	UK	NL	AT	DK
Purchase Subsidies	EUR 5,000/veh (under the 'bonus/malus' system)		up to EUR 6000/veh (discout of 25% of list price)			
Vehicle Taxation incentives		no circulation tax for 5 years (emission + motor based, worth up to ~ max. EUR 250/year)	no circulation tax (emission based, worth up to ~ max. EUR 500/year), 5 year exemption of company car tax	no registration tax (fixed percentage of purchase price + emission based part), favourable tax deductions for employers	no registration tax (e.g. petrol cars: 2% of purchase price * (fuel consumption in litres-3))	no registration tax (105% * vehicle price up to ~ EUR 10.600 + 180% * vehicle price above 10.600)
Reduction of insurance costs					no insurance tax (motor based, max. EUR 60/month)	
Other (quantifiable examples)			London: free parking worth up to EUR 7.000/year		Vlotte project: free transport pass worth up to max. ~ EUR 600/year	

Measure	IT	ES	PT	US	JP	CH
Purchase Subsidies	refunding of up to 65% of extra EV costs	up to EUR 6.000/veh (discout of 20% of list price)	EUR 5000/vehicle (+1500 possible) for the first 5000 vehicles till 2012	tax credit up to max EUR ~6.000 ($7.500)/veh (based on battery capacity and vehicle weight)	max. ~ EUR 900/veh. (YEN 100,000)	up to EUR 6,000/veh
Vehicle Taxation incentives	no circulation tax (emission based)	no registration tax (emission based, max. 14,75% of purchase price)	no vehicle tax, no circulation tax, personal income tax allowance		no weight tax, no acquisition tax (emission based)	
Less insurance costs	50% reduction on insurance cost					

Table 3: Overview of financial measures per country supporting EV demand (Leurent and Windisch, 2011)

Quite striking is again the case of Denmark, where 'only' taxation measures are deployed. However, due to extremely high taxation levels in Denmark, this measure is likely to have remarkable impact on the purchase behaviour of the Danes.

3.1.3 Conclusion

National interest in the deployment of EVs has become remarkable within the last years. Clear objectives have been defined, deployment strategies have been designed and economic measures have already been put in place. Besides the presented economic measures many countries have also been implementing command and control instruments (as e.g. standards for quality and safety of cars, emission regulations or mandates), procurement instruments (as e.g. EV deployment in public fleets), collaborative instruments (e.g the development of public-private partnerships for infrastructure deployment), or communication instruments (as e.g. education and marketing activities) that focus on the uptake of EVs. Experimentation projects have been launched in order to test various policy measures, customer behaviour, new technology, and innovative collaborative approaches among stakeholders and to assess possible future energy demands. (An overview of such experimentations projects is given in chapter 3.3.) It becomes evident that EVs currently profit immensely from the good-will of national and regional governments. The question if these measures are justified from a social perspective remains to be explored.

3.2 The current and future EV supply

3.2.1 Vehicle Supply

In the following an overview of EVs that either have already been launched or that are planned to be launched on the market is given. In the short descriptions it was tried to give especially information on release dates, retail prices and vehicle autonomy (as far as this kind of information was already assessable). The given list of vehicles is by no means exhaustive. However, a broad range of envisaged models of most engaged vehicle producers is covered. The vehicles are presented in alphabetic order.

BMW - Project i
BMW's "Project i" is a program aimed to develop lightweight eco-friendly low emission urban electric cars that go on the market under the sub-brand BMW i. The project has three phases: The Mini E demonstration was the first phase of this project, which will be followed around mid 2011 by a similar field testing with the BMW **Active E** all -electric vehicle (based on BMW 1 series coupe). The last phase of is the development of the Mega City Vehicle urban electric car.
The **Mini E** was first launched on the market as a field test in June 2009 and available through leasing to private users in Los Angeles and the New York/New Jersey area. (Green Car Congress, 2009a) Another field test was launched in the U.K. in December 2009, where more than forty Mini E cars were handed to private users for two consecutive six-month field trial periods. (Green Car Congress, 2009b) Field testing in Paris began in 2010. (EDF, 2010) A total of 100 trial vehicles were also assigned to Germany. Field testing in Munich began in September 2010, for a leasing fee of €400 per month. The **Mega City** is expected to go into mass production in 2013 as the BMW i3. (BMWi, 2011)

Bolloré Blue Car (also Pininfarina Bluecar, B0 or B Zero)
The Bolloré Blue Car is a small electric car designed by the battery manufacturer group Bolloré from Quimper, France. Its commercialization was foreseen for 2010, but was delayed. Production will be carried out in Turin, Italy, operated by Véhicules Electriques Pininfarina Bolloré, a joint venture between Pininfarina and Bolloré. (see www.bluecar.fr)

BYD E6
Unlike the small city-oriented electric vehicles, the E6 of the Chinese company BYD is a five-passenger wagon. It has a range of 200 to 250 miles (320-400km). Field testing began in China in May 2010 with 40 units operating as taxis in the city of Shenzhen. Currently over two years behind schedule (the original release date has changed from 2009 to September 2011), BYD has released little information on its E6. BYD plans to sell the E6 in the U.S. for $35.000 before any government incentives. (Hybridcars, 2011; PlugInCars, 2011a)

Chevrolet Volt
The Chevrolet Volt is a PHEV manufactured by the Chevrolet division of General Motors. The Volt has been on sale in the U.S. market since mid-December 2010, and displaced the Toyota Prius as the most fuel-efficient car sold in the United States (Bailey and Krolicki, 2010). According to General Motors the Volt can travel 25 to 50 miles (40 to 80 km) on a 16 kWh (10.4 kWh usable) lithium-ion battery (Carpenter, 2010). The suggested retail price for the 2011 Chevrolet Volt starts at $40.280 excluding any charges, taxes or any incentives. The Volt is also available through a lease program with a monthly payment of $ 350 for 36 months, with $2.500 due at lease signing, and with an option to buy at the end of the lease. Nationwide availability in the U.S. and Canada is scheduled to begin with the 2012 model year commencing in late summer 2011. (Green Car Congress, 2010)

CODA Sedan

CODA Automotive Inc. is a privately held American company headquartered in Santa Monica, California that designs, manufactures and sells electric vehicles (EVs) and lithium ion battery systems built for automotive and power storage utility applications. CODA's first vehicle, the CODA Sedan, is a four-door, five passenger battery electric vehicle (BEV) powered by a 34kWh battery system and a stated range of 120 miles (190 km) per charge. The vehicle is scheduled for delivery in the second half of 2011. (PlugInCars, 2011b)

Ford Focus Electric

The all-electric version of the Ford Focus is set to be launched in 19 markets in late 2011. The five door hatchback Ford will last for a 100 mile (160km) range. Ford expects to launch production versions, under the name Focus Electric, to the U.S. market by late 2011 and in Europe by 2012. (PlugInCars, 2011c)

Mitsubishi i MiEV

The Mitsubishi i MiEV is a five-door hatchback EV. It has an all-electric range of 120 km to 160km (depending on the test cycle applied). The i MiEV was launched for fleet customers in Japan in July 2009, and on April 1, 2010 for the wider public. Retail sales began in the Japanese market at a price of ¥3.980.000 (~€45.000) before subsidies or tax reductions. Sales to the public in Hong Kong began in May 2010 at a price of HK $ 395.000 (~€37.000) and sales in Australia began in July 2010 via leasing. The i MiEV is here available at a price of A$1.740/month (GoAuto, 2010). Sales in Europe began in January 2011, when Mitsubishi announced that about 2,500 vehicles (sold as **Peugeot iOn** and **Citroën C-ZERO**) have been shipped for sales in 15 European countries. The price of the European version varies by country but will be set to around €33.000 to €35.000. (Mitsubishi, 2011) A new battery manufacturing plant is scheduled to go online in April 2012, which Mitsubishi expects will bring the price down 30%. (Reuters, 2010)

Nissan Leaf

The Nissan Leaf is a five-door mid-size hatchback EV, introduced in Japan and the U.S. in December 2010. Sales are scheduled to begin in Portugal in January 2011, in Ireland in February 2011, in the United Kingdom in March 2011, and the Netherlands in June 2011, with global market availability planned for 2012. Initial availability is limited in quantities and to select markets and only for customers who made online reservations. The Leaf's retail price starts at $32.780 in the U.S. The price is announced to be around €35,000 in the European countries where it will be launched first. These prices include the price of the battery. (Nissan, 2010)

Renault Z.E.

The Renault Z.E. (Z.E. stands for Zero Emission) is a program of all-electric cars from Renault. Four models have been presented so far: The **Fluence Z.E**. is a five-seat saloon which implements the "Quickdrop" rapid battery exchange system that is compatible with Better Place's electric vehicle network. The **Kangoo Z.E**. is a van, the **Twizy Z.E.** comes as a ultra-compact city car and the **Zoe Z.E**. is a supermini. Since the Fluence Z.E. is the first model that will appear on the market more information is already assessable: The price of the Fluence Z.E is announced to be at €21.300, significantly lower than other EV models, as batteries will be rented to the customers. The Fluence Z.E carries a 22 kWh lithium-ion battery which allows a total all-electric range of 160 km. Sales of the Fluence Z.E. are scheduled for 2011 in Israel, Denmark and the rest of Europe. (Renault, 2011)

In March 2011 Renault also announced prices for the Twizy Z.E. model at the Motorshow in Geneva. The Twizy will be sold for (at least) €6.990 in Europe before any possible purchase subvention. The battery is rented for a price of €45/month. The autonomy of the vehicle is advertised as 100km. (Trader-Finance, 2011)

REVA

The REVAi (or only REVA), known as **G-Wiz** in the UK, is a small micro EV, made by the Indian manufacturer REVA Electric Car Company since 2001. The REVAi have sold more than 4.000 vehicles worldwide by mid 2010 and is available in 24 countries. (In many countries, the REVAi does not meet the criteria to qualify as a car, and fits into other classes.) The REVAi is a small 3-door hatchback with a range of approximately 80km. In January 2009, a new model was launched, the **REVA L-ion**. It is powered by lithium-ion batteries. (EcoWorld, 2011) The REVAi is available in the Republic of Ireland at a retail price of €11.500, the REVA Li-Ion has is sold for €17.500. (Greenaer, 2011)

Smart ED

The Smart ED of Daimler is a BEV version of the Smart Fortwo micro car. Field testing began in London with 100 units in 2007 (where it was available only for lease to corporate clients for £375/month), followed by Berlin in late 2009, and then the U.S. in January 2011 with 250 units, which are part of 1,500 cars that will be tested in several European cities, Canada and selected markets in Asia. Mass production is scheduled to begin in 2012. It runs on 13.2 kWh of sodium-nickel chloride Zebra batteries and has a range of 135km. (Smart, 2011)

Tesla

The **Tesla Model S** is a full-sized BEV in development by Tesla Motors. Production for the retail market is expected to begin in early 2012, with a base price of $57.400 (~€42.000). The base model will have a range of 260 km when fully charged. There will also be larger battery packs available with ranges of 370 and 480 km.

The **Tesla Roadster** is a battery electric sports car. The Roadster was the first highway-capable EV in serial production available in the U.S. Tesla has produced more than 1,200 Roadsters sold in at least 28 countries as of July 2010. The Roadster runs on lithium-ion battery cells and has autonomy of 320 km. It has a base price of €84.000 in continental Europe. (Tesla, 2011)

Th!nk City

The Th!nk City is a small two-seater highway capable electric car produced by Think Global (an electric car company located in Oslo, Norway) and production partner Valmet Automotive, with a top speed of 110 kilometers per hour and an all-electric range of 160 kilometers on a full charge. The Th!nk City is currently sold in Norway, the Netherlands, U.S., France, Austria, Switzerland and Finland. (Think, 2011) In Austria the Think City is sold for €35.760 including a lithium ion battery, or for €44.400 including a ZEBRA (natrium-nickelchlorid) battery. There are also leasing options available for €395 per month for private customers or for €470 per month for business fleets. (all prices include 20% VAT). (Think Austria, 2011)

Volkswagen E-Up

The **E-Up!** is an all-electric concept car of the ‚new small family‘ of Volkswagen, which was presented in 2009. It is powered by a 40kW battery and a lithium ion battery of 18kWh for a range of 130km. Volkswagen plans to commercialize the E-Up in 2013. Further, Volkswagen plans to launch an electric version of the Golf model, the **E-Golf**, and also an **E-Jetta**. Both are not expected before 2014 though. (PlugInCars, 2010)

3.2.2 Synthetic Overview

After having given an overview of current and future EV models available on the market, the following table gives now a summary of most important features of the reviewed vehicles. Anticipated market launch dates as well as indications of anticipated retail prices are given, in case these were already published. The autonomy refers in most cases to advertised values. If these autonomy ranges can be hold in real life usage, will be revealed once the vehicles are really in use. Since retail prices vary from country to country, values are given for those countries were the vehicles have been launched (or are envisaged to be launched first).

EV Model	Anticipated Market Launch	Anticipated Retail Price	Autonomy
BMWi - Mini E	June 2009 (field tests)	n.A.	180km
BMWi - Active E	mid 2011 (field tests), 2013	n.A.	160km
BMWi - MegaCity	2013	n.A.	160km
Bolloré Blue Car	end 2010 (retarded)	€ 15-25.000, 330 €/month rent	200-250km
BYD E6	September 2011	$35.000 on US market	320-400km
Chevrolet Volt (PHEV)	mid December 2010 (US)	$ 40.280, or $ 350/month lease (incl. $ 2.500 down payment)	40-80km (electric range)
CODA Sedan	second half 2011 (US)	$ 45,000	190 km
Ford Focus Electric	late 2011 (US) 2012 (Europe)	n.A.	160 km
Mitsubishi i MiEV (Peugeot iOn or Citroën C-ZERO)	2009 (Japan) 2010 (Australia) Jan 2011 (Europe)	¥ 3.980.000 (~€ 45.000) (Japan), AUS $ 1.740/month (~€ 1.270) lease (Austrialia), €33.000 to €35.000 (Europe)	120-160 km
Nissan Leaf	Dec. 2010 (Japan, US), Jan 2011 (Portugal), Feb 2011 (Ireland), March 2011 (UK), 2012 (global)	€ 35,000 (Europe)	160 km
Renault Fluence Z.E.	2011 (Israel, Europe)	€ 21.300 + € 79/month battery lease	160km
Renault Twizy Z.E.	fin 2011	€ 6.990 + € 45/month battery lease	100km
Renault Kangoo Z.E.	fin 2011	€ 20.000 (excluding VAT) + €72/month battery lease	160km
Renault Zoe Z.E.	fin 2011	n.A.	160km
REVAi (G-Wiz)	2001	€ 11.500	80km
REVA L-ion	2009	€ 17.500	120km
Smart ED	early 2012	~ € 20.000	135km
Tesla Model S	early 2012 (US)	$ 57.400 (US)	260km
Tesla Roadster	2008 (US) May 2009 (Europe)	$ 84.000	320km
Th!ink City	end 2009	€ 35.760 (l-ion battery) € 44.400 (Zebra battery) € 395/month (private) €470/month (business) lease	160km
Volkwagen E-Up	2013	n.A.	130km

Table 4: Overview of (anticipated) EV models and their main features

3.2.3 Infrastructure Supply

As far as EV recharging infrastructure is concerned, numerous companies have already developed and designed various installations (such as Schneider Electric or Coulomb Technologies – to name two famous examples). Offered products cover appliances for public or private use, for on-street or off-street installations, shared or non-shared use (only one specific vehicle has access) and restricted or open access. Market launch of these new products is currently happening. Prices are therefore often difficult to obtain, and would, however, vary with the specific needs and type of usage of the infrastructure. In order to obtain an idea of possible costs, table 6 gives an indicative overview of expected retail prices of *normal* charging stations (charging time, depending on the battery, 6-8 hours). Costs for the equipment and for installation are stated separately. Table 5 explains beforehand the terminology used. (Indications for prices of fast charging and battery swap stations are given underneath.)

Terminology for charging point types/locations	
Public	For use by the general public. On-street or off-street in municipal or other publicly accessible car parks (e.g. supermarkets)
Restricted Access (RA)	Use of charging points restricted to subscribers
Open Access (OA)	For use by any EV owner (also non-subscribers)
Shared	For open access, for use by subscribers (e.g. to a neighbourhoods network) or for shared use in workplaces or residential developments

Table 5: Definition of infrastructure terminology (TfL, 2010)

Item	COST £ (approx)					
	Restricted/open access		Charging point type			
	Restricted	Open	A On-street Public Shared RA	B Off-street Public Shared RA/OA	C Off-street Private Shared RA/OA	D Off-street Private Not-shared OA
Charging point equipment	3,500	500	3,500	3,500/500	3,500/500	0-500
Charging point installation	1,000-1,500	500	1,500	1,000/500	1,000/500	0-500
Feeder pillar equipment	500	0	500	500/0	500/0	0
Feeder pillar installation	300-500	0	500	300/0	300/0	0
Connection mains – feeder pillar	1,000-1,500	0	1,500	1,000/0	1,000/0	0
Connection/commissioning feeder pillar – EVCP	500	0	500	500/0	500/0	0
Road signs	100-200	100	200	200/100	100	0
Bay road markings	200-500	200	500	200	200	0
EVCP branding and logos	0-200	0	200	200/0	0	0
Traffic management order	0-500	0-500	500	500	0	0
Total Cost £ (approx)	**7,100-9,400**	**1,300-1,800**	**9,400**	**1,800-7,900**	**1,300-7,100**	**0-1,000**

Table 6: Indicative cost breakdown of equipment and installation costs of EV infrastructure (TfL, 2010)

Fast charging stations that can reduce the charging time of a battery significantly (down to only 20min) are more cost intensive. They necessitate more power. New installations will therefore often be coupled with an upgrade of the existing electricity net. Lidicker et al. (2011) assume in their study average costs of home charging units to be around US $2.650 and for public and fleet charging stations to be around US $7.500. The costs of rapid charging stations are not estimated, but are expected to lie around US $30.000 – 35.000.

Further, also **battery swap stations** that allow exchanging depleted batteries with fully charged ones in an automated process have been developing. Lidicker et al (2011) estimated the costs of such a charging station to lie around US $800.000. However, it is recognizes that, depending on the area, the costs of such a swap station could vary between $500.000 and $1 million. Costs of swap stations are likely to decrease with time and experience. Maintenance costs for each swap station have been assumed to be around $30.000.

Obviously, stated values can only give indications on future prices though. Especially battery swap stations have not been commercialized yet.

3.3 Electric Vehicle Deployment projects and experiments

This chapter gives an overview of a selection of currently ongoing demonstration projects deploying EVs. In certain areas these projects shall already clearly help reduce environmental impact of the transportation sector, in other regions these projects rather have the goal to test and try out how courses of action for a successful EV implementation could look like. Customer behaviour and vehicle acceptance is analysed, demand forecasts try to be established on projects results, technologies are tested and assessed, and finally, deployment projects also serve as mean for marketing EVs.

In the following an overview of several interesting projects and experiments that all have a different character is given. Also here, the shown examples are by no means exhaustive. Especially in 2009 and 2010 numerous deployment projects have been launched, mostly in cooperation with vehicle producers in order to test their new developments.

3.3.1 Israel's EV uptake with Better Place[2]

In January 2008 Israel announced its partnership with Better Place (an EV infrastructure provider and operator) and the Renault-Nissan alliance, making it to the first entire nation to commit to an all-electric car infrastructure. Israel is seen as an ideal early adopter of electric vehicles since it is geographically small, with all major urban centres less than 150 kilometres apart, where 90 per cent of car owners drive less than 70 kilometres per day. Israel has high taxes on gasoline coupled with economic policy encouraging consumers to buy zero-emission vehicles. Further, it has a growing solar power sector that stands to gain an important new market. With the introduction of EVs Israel follows its goal to be independent of oil by 2020.

The infrastructure network deployment started with several municipalities including Tel Aviv, Haifa, Kefar Sava, Holon, and Jerusalem. Charging spot infrastructure has been planned and implemented in every parking lot. Also, in July 2009, Israel Malls, the leading shopping centre group, signed an agreement with BetterPlace to deploy EV charge points in shopping centre parking lots. (Israel Malls owns 17 of these shopping centres). In August 2009 an agreement with Israel Railways was signed, which allows charging infrastructure to be installed in train station parking lots. An agreement with the city of Jerusalem foresees the installation of a total of 100 charge sports on major city streets and public sites in an initial stage (from October 2009).

Altogether more than 50 leading companies have signed as partners. They agreed to let BetterPlace install charging infrastructure on their premises while simultaneously becoming first corporate EV fleet customers.

So far more than 1000 charge spots have been installed. Altogether approximately 50.000-70.000 recharge spots and 70 battery swap stations shall be deployed. The costs are estimated to be around $150-200 million for the complete infrastructure provision. Until 2016 approximately 100.000 EVs (of the Renault model) should be sold.

Functioning of the BetterPlace system

[2] All information obtained from BetterPlace (2011)

In order to understand the envisaged functioning of a nation-wide EV roll-out and up-take, the service offers of the infrastructure provider BetterPlace has to be understood. In the following the main services of BetterPlace are therefore sketched.

Better Place, found in 2007 (headquarters in Palo Alto, CA), builds and operates EV infrastructure and systems that optimise the energy access and use for EVs in a defined region. Subscription packages give drivers access to a network of charge spots, battery switch stations and systems that allow an efficient use of EVs while minimising environmental impact and customer's costs. Better Place does not rely on any public funding but finances its infrastructure development by the means of private investors. Together with its partners BetterPlace provides the following products and services:

- *EVs and Batteries*
  Better Place is currently mainly working with the Renault-Nissan Alliance in order to provide EVs to its customers. The Renault model Fluence ZE is the first model that is to be deployed.
  Further, Better Place works with battery and vehicle manufacturers (e.g. Renault, A123Systems, AESC) to develop lithium-ion batteries for EVs. The business model approach foresees that not the customers but Better Place (or the battery manufacturer/vehicle manufacturer/a coalition of these) is in possession of the vehicle batteries. This allows EV drivers to change their batteries in the so-called 'battery swap stations' (see underneath).

- *Recharge Infrastructure + Maintenance*
  Better Place develops, installs and manages networks of charging points for EVs. Customers are provided with a personal charge spot for their homes/in their garages (if not already available), where EV drivers are supposed to primarily charge their vehicles. Further, Better Place installs charge spots at workplaces, in public parking lots, and along urban streets.
  In order to quickly and reliably extend the range provided by an EV battery, Better Place also provides the recharging network with battery switch stations that use an ingenious robotic system to switch new batteries for depleted ones, cool and charge the batteries in inventory, and manage the logistics to ensure that each EV gets a fully-charged battery each time the vehicle arrives at a station. Better Place works in this field with automakers to ensure that EVs and battery switch stations are compatible.
  Better Place also engages in the management and maintenance of the charging infrastructure. All charging points are continuously monitored and maintained.

- *Communication infrastructure*
  All charge spots are equipped with communication systems that allow data transfer with network operation centres. Customers and utilities are provided with real-time information that enables a number of services: Customers get optimised route planning and navigation assistance to charge spots and battery switch stations, while utilities can manage electricity production by modulating EV charging in order to take advantage of off-peak electricity. An on-board computing platform connects drivers to a network operation centre. This enables the following functions for EV drivers:

  - Energy monitoring (e.g. alert drivers in case of low battery state of charge)
  - Energy planning (e.g. enable drivers to plan a route, understand their range or autonomy and advise when they will need to charge)
  - Service and support (e.g. on the road directions to the nearest switch station or available charge spot and live troubleshooting)

- Charging and battery switch (e.g. provide intelligence to the charging process such as priority charging and managing the battery switch process)

The communication software further allows Better Place to monitor all the batteries in the network (residing inside vehicles and in switch stations) and to aggregate data on each battery's state of charge and anticipated energy demand. The EV network software communicates this data to utility partners in real-time, allowing them to optimise the allocation of energy, based on available supply and EV drivers' demands. Utilities can hereby ensure that EVs also serve as distributed energy storages, while at the same time meeting driver expectations in terms of charging time and pricing.

BetterPlace is also active in various other nations in order to build up an EV infrastructure network. So far there are, besides Israel, further engagements in Denmark, Australia, the US (Hawaii and California), Canada and Japan (where an EV Taxi project has been launched in Tokyo). The following graph gives an overview of envisaged EV deployment plans in the various nations.

	2010	2011	2012	2013	2020
Israel	Commence operation of the Better Place network (charge points and battery switch stations). 10-100s electric cars piloted, testing software, charge points etc.	Commercialisation. 100,000 electric cars pre-ordered. Nationwide network established, inc. 150,000 charge and 100 switch stations. 19 major companies first to operate electric fleets.	Further network expansion. Rapid corporate and public uptake of Better Place compatible electric vehicles, released by manufacturers such as Renault—Nissan.	1 in every 6 car park spaces has charging capacity = 500,000 charging points installed and running. Supply electricity from green sources.	Tax exemption on zero emission car purchases expires. Israel aiming to achieve goal of oil independence.
Denmark	Copenhagen used as blueprint for Better Place role out after demonstration at UN Climate Change Conference (Dec 2009).	Early consumer adoption of electric vehicles. Network set up (100,000 charging points and 100 battery swapping stations), with partners DONG. Renewable energy used to charge car batteries.	Electric car tax exemption expires. Mass adoption of electric vehicles. Further expansion to Better Place network.		
Australia	Early plans for network deployment in Canberra made. Australia selected for development to prove the feasibility of the Better Place model in large nations.	Start Better Place network construction in Canberra, with partners ActewAGL.	Canberra network supporting Better Place customers. Other city networks established and links on major roads.	Nationwide roll out commences with cities such as Melbourne, Canberra, Sydney and Brisbane being linked by highway battery switch stations.	
California	Deployment of the $1bn Better Place network in the Bay Area commences. This includes cities such as San Francisco, Los Angeles, San Diego and San Jose.	Early uptake of Better Place compatible electric vehicles, released by Renault-Nissan, and potentially from firms such as Chevrolet and Toyota.	Mass market uptake of electric vehicles utilising the Better Place network consisting of over 200,000 charge points, 200 switch stations and a driver service centre.		
Hawaii	Network installed, aiming to utilise solar, wind, geothermal and wave energy for electricity.	First stations open to consumers. Tourists are target audience, through rental cars, to maximise global coverage.	50,000-100,000 charge points installed across Hawaii, Oahu, Maui and Kavai ($100 million)	Island cointinues to invest heavily in reenewable for charging better place	Widespread use of electric vehicles helps Hawaii towards its goal of 70 renewable energy use by 2030.

Source: Better Place, Verdantix

Figure 11: Timeline for the BetterPlace roll-out in various nations

System Costs and Profitability

The business case of BetterPlace gives a good overview of how an integrated electric mobility approach can look like. Several countries seem to have adopted similar visions on electric mobility and are trying to develop also well-integrated systems that optimize vehicle usage and energy use. (e.g. Portugal and the mobi.e project, see chapter 3.3.5).

However, costs for customers have not really been officially stated so far. There are studies anticipating a possible price for system subscribers (whether such a system is operated by BetterPlace or a different service provider). A study released in December 2010

(EcoTechnologies, 2010) tries to shed light on a possibly profitable pricing scheme for a business model like Better Place (users are charged costs per km, which cover costs of battery usage, electricity needs, infrastructure supply, IT technology). The resulting price estimates, which make such a business model profitable according to the study, are seen in the figure underneath (values are transferred from $ to € using an exchange rate of 0.7545).

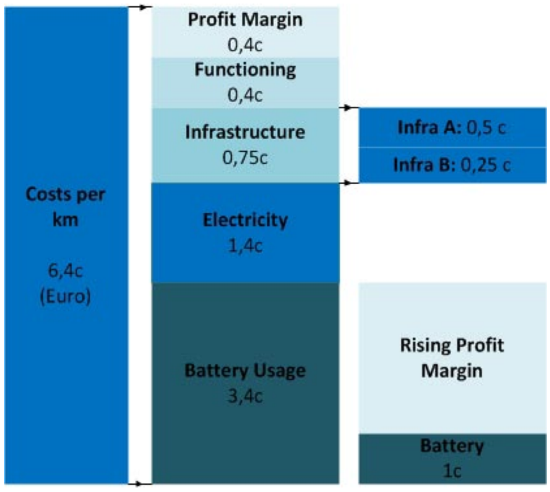


Figure 12: Estimation of possible prices/km (based on EcoTechnologies 2010)

It can be seen that a large part of the costs per kilometer are made up by the costs for the battery, as well as by the costs for electricity. The costs for infrastructure are divided into installation and usage costs of Infrastructure A, being the 'basic' infrastructure (comprising recharge infrastructure at home and 1 recharge spot/vehicle in a regarded area), and of Infrastructure B, being (optional) 'range-extender' infrastructure, meaning battery swap stations. According to the study a price per kilometer of €6,4c allows a profit margin of € 0,4c during the first years. By increasing demand and decreasing costs of the deployed batteries, the profit margin can rise up until €2,8c per 'sold' kilometer (driven kilometer of a system subscriber). Alternatively, the costs for the end customer might be decreased. If such an offer will be profitable from a customer perspective, depends clearly very much on the fuel price that is assumed (on the region that is regarded) and on the EV price without battery.
Lidicker et al. (2011) who analyses the profitability of a business model like BetterPlace (including the deployment of battery swap stations) for the San Francisco Bay Area, concludes that a profitability of the business will only be profitable in case conventional vehicle users are faced with an enormous rise of the fuel price.

3.3.2 Austria's Vlotte Project[3]

VLOTTE is the project title of an EV demonstration and testing programme taking place in the Western part of Austria, Vorarlberg, since August 2009. It belongs to the biggest EV model regions in Europe.
In 2008 the Austrian Climate and Energy Fund selected Vorarlberg to become a model region of electric mobility and appointed €4.7 million to its development. Vorarlberg is the westernmost of Austria's nine provinces. Around 370.000 people live on in area of 2.602 km².
Vorarlberg is clearly geographically separated from the other provinces by a massif in the east. The "backbone" of the region is the Vorarlberg Rhine Valley. Eighty percent of the population lives on 11% of the province's land area.
The Rhine Valley is characterized by a relatively low population density and a simultaneous homogeneity of the settlement structure: an urban-sprawled landscape.

[3] All information stems from Vlotte (2011) and TU Wien (2010).

Despite the comparably high acceptance of public transportation, many people are still dependant on motorised individual mobility.

Functioning

In the year 2009 100 EVs were distributed in order to gain experience in consumption, autonomy, service costs and different battery technologies. The 100 vehicles were assigned to interested parties of an exclusive circle. 40 cars were given to companies, 40 to public institutions, non-profit organisations and associations and 20 to private users. The customer is offered a “mobility card” for approximately €500/month (exact price depends on the vehicle type). The mobility card includes, apart from the leasing of the car, maintenance costs of the electric parts, a railway pass of the Vorarlberg Public Transport System and the free-of-charge refilling at all public energy recharging stations. After four years the car is purchased by the customer for a residual value of 25% of the initial purchase price. In addition, VLOTTE-customers got free ÖAMTC-membership (Austrian Automobile Association) for the years 2009 and 2010.

Project Partners

The Vorarlberg Electric Vehicle Planning and Consulting Corporation is primarily responsible for the implementation and support of the VLOTTE and serves as the platform for all partners that are necessary for a successful and effective execution of the VLOTTE project. The extremely collaborative approach of all stakeholders makes the VLOTTE project unique.

Vorarlberg achieved to build up an unprecedented cooperation of all important partners to accomplish a successful realisation of the project. The following list shows which partners are involved and what their main tasks in the project are:

Institution	Project Contribution
illwerke vkw	provision of the necessary infrastructure (charging stations), ensures the carbon neutral energy supply with additional photovoltaic plants
Federal state government of Vorarlberg	coordination of the mobility management for an optimal networking with the public transport system
Public Transport System Vorarlberg	provision of a year long railway pass for every VLOTTE-customer, enables the construction of recharging stations in park-and-ride complexes, tests the suitability for daily use of electrically operated buses
Energy Institut Vorarlberg	responsible for CO_2-monitoring, conducts campaigns on how to save energy, aims for a sustainable sensitisation of Vorarlberg’s population
Vorarlberger Landesversicherung (Insurance)	cares for extensive insurance coverage (liability, collision and battery insurance)
ÖAMTC (Austrian Automobile Association)	provides all VLOTTE customers with a free membership and accident and breakdown cover, if necessary it provides breakdown service or replacement vehicles
Raiffeisen Leasing GmbH	leasing partner, caters for an optimal handling of the leasing contracts
Technical University Vienna	accompanies the VLOTTE-project within an extensive vehicle- and charging monitoring, develops scenarios for charging logistics and conducts energy management tests
Service Partners	provide all necessary vehicle services
ReffCon GmbH, Think E-vehicle importer for Austria	contact person for e-mobility concepts, provides consultation in finding the appropriate funding, national and international, for sourcing and marketing.

Vehicles

There are different types of vehicles offered to the project participants. The following were made available (and partly reequipped with electric motors):

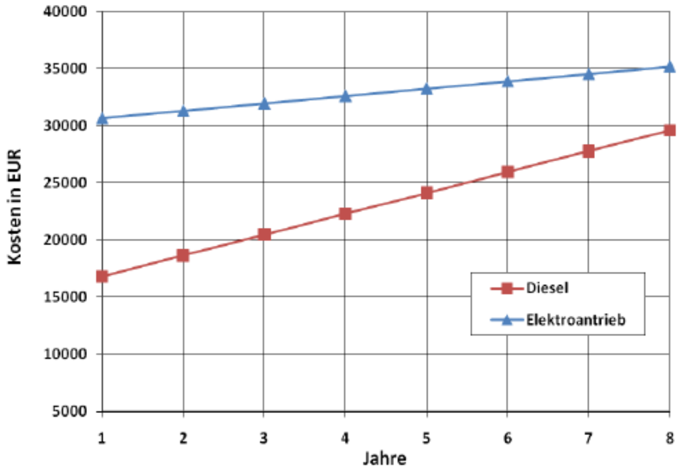
- *TH!NK* using a ZEBRA battery: Driving range: 120-180km, Top speed: 100 km/h (most Flotte vehicles)
- *Renault Twingo*: Driving range: 135km, Top speed: 120 km/h
- *Fiat Panda*: Driving range: 130km, Top speed: 110 km/h
- *Fiat 500:* Driving range: 130km, Top speed: 100 km/h

Energy Source
In the model project VLOTTE, all energy necessary for the operation of the vehicles is supplied by regional, renewable energy sources. The vehicles of the VLOTTE project thus drive carbon neutrally. The energy mainly stems from solar panels specifically installed for the project.

Charging and Charging Infrastructure
The employed EVs can be charged by any ordinary electricity plug. The regional electricity supplier offers special tariffs during the night in order to encourage projects participants to charge their vehicles over night. The duration of charging takes on average 7 to 8 hours of the employed vehicles. If 3 phase-current is available, the charging time is drastically reduced.
Every VLOTTE project participant furthermore has the possibility to charge his vehicle for free on the public charging infrastructure network in Vorarlberg (which is constantly being expanded and currently comprises 57 charging stations), in Germany, Switzerland and Liechtenstein. The existing infrastructure of energy recharging stations was considerably expanded in 2009. In a first step alongside commuter train stations and in a second step at central points in the catchment area of the first 100 electric vehicles new charging stations were built. Just like the cars, all filling stations got equipped with measuring devices in order to analyse the energy demand at the charging point. Based on this data the charging network is going to be expanded stepwise also in 2010. The expansion will take place in order of priority, depending on those locations that recorded high energy demand.

Results and outlook
The VLOTTE project is accompanied by scientific studies lead by the Technical University of Vienna and the Energy Institute Vorarlberg. Customers that use VLOTTE vehicles report periodically their usage behaviour. On a monthly basis data concerning the number of trips, distances, duration of charging processes, consumption, autonomy, service costs and usage of recharge infrastructure is collected. In the following some results stemming from the final study report of the Technical University of Vienna are sketched (see TU Wien, 2010).

Economic Analysis - Vehicles
Results of economic analyses conclude that current high demand for the EVs is mainly due to the fact that purchase prices are still extremely high subsidized. Monthly costs for the single customer are therefore in the range of typical monthly costs for mobility. However, only comparing the running costs of the vehicle, it is concluded that the EVs offer twice the range of a conventional diesel vehicle for the same amount of money. It is expected that this difference will increase even further with climbing prices for diesel and the learning curve of EV usage, which will finally reduce electricity demand. However, due to the high purchase costs of the EVs, the cost advantage due to less running costs loses its importance. The following figure shows cumulated cost curves over time (in years) for the EV (in blue) and a comparable conventional vehicle (in red). The information next to it shows the assumptions on which calculations were based upon. Partly these assumptions take optimistic values with regard to the EV’s advantage over the CV. For example the diesel consumption seems to be too pessimistic for upcoming years (instead of 7L/100km probably a value of 3-4L/100km would be more appropriate), and also the maintenance costs per year seem to be rather high for the CV.



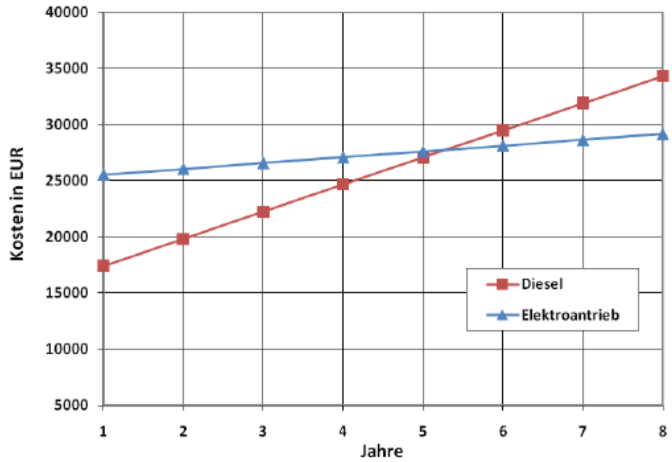
Diesel Vehicle:
Investment Costs: € 15.000
Maintenance Costs: € 900/year
Fuel Costs: € 1,1/Liter
Consumption: 7L/100km

Electric Vehicle:
Investment Costs: € 30.000
Maintenance Costs: € 150/year
Fuel Costs: € 0,18/kWh
Consumption: 23kWh/100km (based on experiences with the Fiat 500)

Yearly Mileage: *12.000 km*

Figure 13: Cummulated total costs for an EV and a CV from today's point of view (TU Wien, 2010)

Figure 13 clearly shows that even after 8 years of vehicle usage, the diesel vehicle remains to be more profitable.
The following Figure now shows a possible future scenario, where diesel prices are higher, investment costs are lower and electricity demand decreases due to learning effects of vehicle usage. It can clearly be seen that a cost-break even point is reached after 5 years.



Diesel Vehicle:
Investment Costs: € 15.000
Maintenance Costs: € 900/year
Fuel Costs: € 1,8/Liter
Consumption: 7L/100km

Electric Vehicle:
Investment Costs: € 25.000
Maintenance Costs: € 150/year
Fuel Costs: € 0,22/kWh
Consumption: 14kWh/100km

Yearly Mileage: *12.000 km*

Figure 14: Cummulated total costs for an EV and a CV for likely future scenario settings (TU Wien, 2010)

Further it is stated that calculations for the future scenario should also take costs for the abatement of C02 emissions and possible EV-advantageous taxing policies into account, which have the potential to significantly increase the attractiveness of EVs. Such future measures are seen as reasonable since the change to sustainable transport entails economic additional benefit for Austria (due to more value adding activities based in Austria when changing to renewable energy sources).

Economic Analysis – Infrastructure
The costs of recharging infrastructure differ immensely due to different design, configuration and accompanying intelligence. Recharging can e.g. be carried out by a simple household socket on private parking facilities at home or at work. Such infrastructure deployment is usually related to no or very little costs. Publicly accessible recharging locations are obviously more expensive. Their exact costs depend on the charging power available, the number of sockets available, the distances to existing transformer stations (with regard to excavation

works), and the necessary communication interfaces for payment and identification. So far only average costs per day of EV usage for charging could be estimated. They amount to € 1,5/day (€ 0.18/kWh * 36,32 km/driving day *23,06 kWh/100km = € 1,5/driving day). At public charging locations an increased price for electricity is likely to be charged in the future in order to cover investment costs. However, full coverage of investment costs for complex infrastructure build-up only by turnover stemming from recharging activities will probably never be feasible.

Results show that longer observation periods and/or a higher number of deployed vehicles would be necessary in order to derive recommendations for locations of recharge infrastructure. This would allow better recording of demand accumulations at certain locations. So far, only 5 public recharging locations (out of almost 60) proved to be reasonable installations. Basically the recharging infrastructure on private premises proved to be easily sufficient for current demand. 90% recharging was carried out at premises at the work place (keeping in mind that most vehicles were distributed among businesses).

Analysis of Usage and Recharging Behaviour

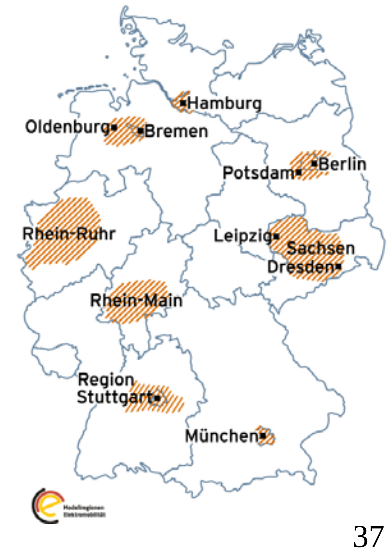
Thanks to recording of GPS data, locations of vehicles and their parking times could be analysed. Altogether a time frame of 1816h could be observed. During these observed hours the vehicles were parked for altogether 1774h. Only during 8% of the parking duration vehicles were *not* connected to electricity supply. These 8% were, however, observed for 64% of all stops. Only at a parking duration of over 30min every second stop of a vehicle serves for a connection to the grid. Stops of over 2h serve in 75% of the cases for vehicle recharging. Stops of over 12h serve for 100% of the cases for recharging activity. Unfortunately it can not be said whether no charging activity is due to lack of infrastructure supply or due to the deliberate behaviour of the customer.

General Results and Outlook

Within almost a year the VLOTTE vehicles made more than 150.000 km. However, a better result could have been achieved if sufficient vehicles had been available. More than 200 interested people had to be short-listed due to insufficient supply of EVs.

The success of the project led to the development of the succeeding project VLOTTE II. Here, the focus is given to the establishment of so-called ‘mobility-hubs’ – car sharing points where besides EVs also electric scooters and electric bikes can be hired. In 2010 and 2011 the mobility hubs called ‘e-stations’ have been being built. A first one was launched in Lech. Here, tariffs for vehicle rental vary from € 10 (for E-bikes / half a day) to € 49 (for E-cars / full day).

By mid 2011 the fleet of the VLOTTE vehicles will be expanded to 250 vehicles; single-lane vehicles will be complemented. The number of charging points shall be augmented, the supplied electricity shall still stem from renewable energy sources deployed in the region.



3.3.3 Germany’s model regions with Berlin

Out of Germany’s funding for the development of EVs of €500 million, €115 million are dedicated to the establishment of model regions. Stakeholders of science, industry and all participating authorities (regions, cities, communities) work closely together in order to build up EV infrastructure and to achieve that electric mobility becomes an integral part of the transport system. Out of 130 applications, 8 regions were selected for the available funding means. The map on the right shows the eight selected model regions, which all focus on different main activities.

Germany’s model regions are therefore by far not only regions were test fleets are employed or EV demonstration projects are carried out. Model regions refer here much more to centres of excellence, where EV related research (mainly in automotive engineering, infrastructure + networks and battery technology) is carried out, were incitation to new research companies in these fields are given, were vehicles and infrastructure are developed and manufactured and were test fleets are employed and evaluated in order to achieve a certain target number of EVs on the roads within a given a time frame. (EnergieAgentur.NRW (2009), NRW.INVEST Gmbh (2009))

The model region of Berlin and Potsdam

A very active model region is Berlin and Potsdam. Here, the *emo*, the Berlin Agency for Electromobility, was founded in 2010. It combines the competencies of science, industry and politics in the German capital region. Thanks to financial contributions from the states of Berlin and Brandenburg, several practical projects with a total volume of around 80 million Euros are currently underway in the region. The projects are (among others) the following:

BeMobility:

BeMobility explores the potential of EVs as shared vehicles. The objective of the project is to operate a public EV fleet as integral part of public transport. Recharge infrastructure, IT interfaces, customer behavior and user friendliness of deployed systems are analyzed. Results shall give information on the implementation of marketable mobility offers.

The project is run collaboratively by transport service providers, energy suppliers, infrastructure operators, vehicle manufacturers and research institutions (participating companies are e.g. Deutsche Bahn, Bosch, TU Berlin, RWE, Vattenfall). It is the first time that involved partners cooperate in this way with each other. Each partner provides his specific knowledge and experience for the project.

In August 2010 the first project phase started. First EV rental stations equipped with recharge infrastructure of the different providers of the consortium were launched; first EVs could be tested by customers. Real operation with up to 40 vehicles (and electric bikes) starts in spring 2011. By then all IT systems and (smartphone) applications shall have been put in place, and all rental stations close to transport nodes (such as train stations) shall have been deployed. Vehicles in use are the Citroen C1 (re-equipped with an electric motor), the Smart ED and the Toyota Prius. (BeMobility, 2011)

e-mobility Berlin:

End of 2009, the project “e-mobility Berlin” started in the German capital. Daimler contributed a fleet of over 100 electric cars. In addition to the latest generation of the smart electric drive, electric cars from Mercedes-Benz were also used. Both vehicles are equipped with the latest lithium-ion battery technology. Project partner RWE provided 500 charging points and was responsible for the operation of the network as well as for handling the power supply and centrally controlling the overall system. The charging stations were set up at the customers’ homes and business locations and in public parking lots. The network incorporates various business-to-business partners, such as shopping centers, parking garages, and fleet customers.

The joint initative is benefiting from the extensive experience that Daimler has gained from its current electro-mobility project in London. Since 2010, more than 100 electric vehicles from smart and Mercedes-Benz are also deployed in test fleets in Rome, Milan and Pisa for the “e-mobility Italy” project. (Daimler, 2011)

Mini E powered by Vattenfall: (Vattenfall, 2011)
Between June 2009 and August 2010 50 MINI E vehicles got tested during two 6-month periods. Mainly private households but also business fleets of Vattenfall, DB Car sharing and Sixti Car club got equipped with the cars. The usage fee of the MINI E was set to be €650/month, which was, however, reduced to €400/month due to the participation in the research project. The monthly fee included the usage of the vehicle, a service package and insurance costs. Recharging costs were to paid extra by the MINI E users.
Vattenfall was responsible for the supply of green energy and for the development of recharge infrastructure on public and private premises. Each of the 50 MINI Es could get charged either at home or at the workplace. The charging process was controlled in such a way that most possible ‘redundant’ wind energy was used (wind-to-vehicle application). Altogether 50 recharge stations on the public street were envisaged. The most important results of the project were:

- The wind-to-vehicle application functioned and was used by the users
- The limited range of EVs does not pose any problems for everyday life
- The longer charging durations do not harm the mobility behavior of EV users
- People who dispose of charging infrastructure at home and at the work place do not need additional public charging infrastructure
- Technology at public parking stations is more prone to maintenance and more cost intensive
- The integration of users that do not dispose of their own private vehicle parking possibility (and who park their car on the public street), is with current charging infrastructure rather cumbersome and cost intensive.

Further, the *WohnMobilE* project test EV car sharing in residential quarters.

3.3.4 London Vehicle Deployment Plan[4]

The Mayor of London launched an Electric Vehicle Delivery Plan in May 2009. It sets out the proposed approach to the deployment of charging infrastructure for privately-owned EVs up to 2015. Altogether 25.000 charging points shall be installed and the target of 100.000 EVs on London’s roads shall be attained. Partnerships between public authorities and industry and a comprehensive incentive package for the use of EVs the goals shall be achieved.
The EV Deliver Plan is grouped around three key themes, being Infrastructure, Vehicles and Incentives, Marketing and Communication. In the following description of the London strategy, this grouping is maintained. Finally some additional information on the functioning of the system is given.

Infrastructure
There are currently over 250 EV charging points in operation, with the greatest concentration in central areas. They are primarily located in publicly accessible car parks. Only 32 charging stations can be found on-street.
The city of London envisages making three main types of charging points in the public access charging network available to arrive at a total number of 25.000 (non residential) charging points:

[4] Greater London Authority (2009a), (2009b)

- Type 1: slow charging points (6-8 hours charging time, unit cost: £0-£3.500), with the priority locations at company car parks, on street parking bays in dense residential areas, public car parks
- Type 2: fast charging points (30min -3 hours charging time, unit cost: £3.500-£5.000), with priority locations at private car parks in shopping and leisure centres, supermarkets, large retail stores, short stay public parks in town centres, on street parking in visible town centres etc.
- Type 3: Rapid charging points (15-20 min charging time, battery swap system, unit cost: £25.000-£50.000), with priority locations at motorway service stations and supermarket car parks

Also the development of private charging network, in residential homes, at workplaces and for new developments will be supported. This will be realised by providing information e.g. through the 'Green Homes service', by developing technical guidance to assist businesses with their installations and by obliging 20 per cent of parking space in new developments to be equipped with charging infrastructure for EVs. Besides residential off-street charging points, installations at private car parks and customer car parks take the biggest share in the network (22.500 installations). The public charging network is envisaged to comprise 500 on street charging points and 2.000 installations in publicly accessible car parks (e.g. car parks owned by the boroughs, Transport for London, Network Rail, retailers and private operators). At least 250 fast points will be publicly accessible, forming a core fast charging network provided in key town centres, as well as at strategic points on the road network and at motorway services.
Great attention has been given to the definition of specific charging point locations. The main goal is to assure that every Londoner will be no more than one mile from the nearest EV charging point by 2015. Studies were carried out in order to project likely early adopters and their motivations to by EVs. This helped explore where future EV owners are likely to live and where charging infrastructure will therefore be installed first and most dense.

The principles guiding the installation of the publicly accessible EV charging network lie on 1) providing an equitable base coverage (any Londoner wishing to buy an EV should have reasonable access to charging facilities) and on 2) targeting infrastructure in key locations.
In order to discover potential EV 'hotspots' and to define where EV charging points should be installed first, it has to be known where likely EV-owners live and drive to. For locating 'likely' innovators and early adopters of EVs, it was analysed where current EV and hybrid vehicle owners live. So called 'mosaic' types of these owners, describing the socio economic features of the person groups were established. It was discovered that five mosaic types make up nearly three quarters of current electric vehicle owners. Hybrid car owners are more diverse; however, the same five mosaic types make up 60 per cent of current hybrid car owners. The mosaic types and their description is shown in the following table:

Mosaic type	**Description**
Global connections	Affluent middle-aged singles living in central London
Cultural leadership	Professionals living in middle ring suburbs and working in Central London
New urban colonist	Ambitious singles or couples living in high density suburbs
City adventurers	Young and single skilled workers living in inner suburbs
Corporate chieftains	Business managers living in detached houses in outer suburbs

Table 7: Mosaic types who currently own electric or hybrid cars

Mapping these five key mosaic types across London provided an understanding of where future EV owners are likely to live (see the figure underneath).

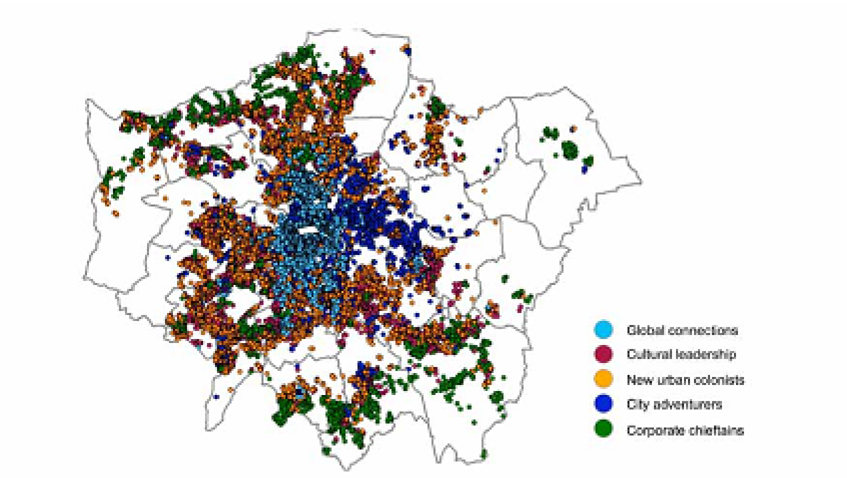


Figure 15: Location of mosaic types

The largest representations were found in central, north-west and south-west parts of the city, with pockets in the southern and eastern suburbs.
In order to maximise the uptake of EVs, it was also important to look at likely EV uptake based on several location-specific features. These include the availability of off-street residential parking (as this facilitates regular charging at home), locations where vehicle owners drive substantial distances (as this helps maximise the environmental benefit of EV usage and its cost-effectiveness) and multi-car ownership households (as the likelihood of switching second cars to EVs is high). The location specific factors, together with the segmentation analysis have been used to for understanding the distribution of likely EV owners over the coming years.
The 'hotspot' analysis is used alongside borough knowledge of local issues to plan the distribution of charging infrastructure. A preliminary analysis is shown for the region of Camden in the figure underneath. Here, three potential hotspots for targeting EV promotional efforts and charging points were identified.

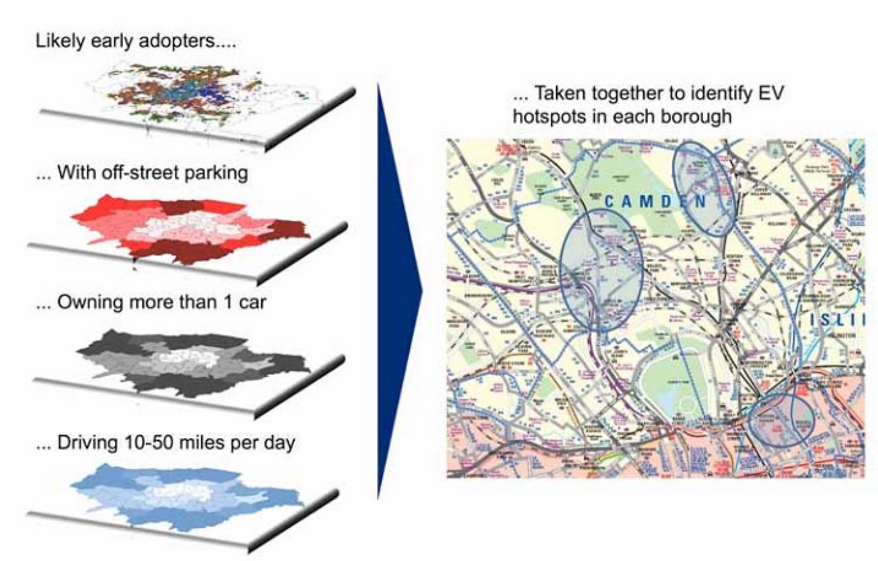


Figure 16: EV 'hotspot' method for the region of Camden

However, possibly even more important is identifying the principal destinations of Londoners living in hotspot areas. Charging points must be deployed in these locations as well. Specific locations based plans will therefore be developed.

The EV delivery plan committed to installing charging points in London Underground car parks. In the first phase of installation in London Underground car parks it is envisaged to install 12 charging points in six car parks. These car parks have been chosen based upon where current EV owners and potential early adopters live and work. EV charging points are installed in visible locations within these car parks, close to station main entrances and exits where practical. Further, Transport for London is currently working with the Association of Train Operating Companies to develop a detailed plan to install charging points in appropriate locations. Initial discussions have also taken place with private car park operators, who are keen to support the delivery of EVs in London. Eleven Sainsbury´s car parks are already equipped with two charging points each. Tesco has installed points in three of its London car parks. 30 charging points have been installed at Westfield Shopping Centre in West London. Currently there are 32 on-street charging points across London.

The following figure gives an overview of the envisaged partition concerning type and spatial distribution of the 25.000 charging point developments.

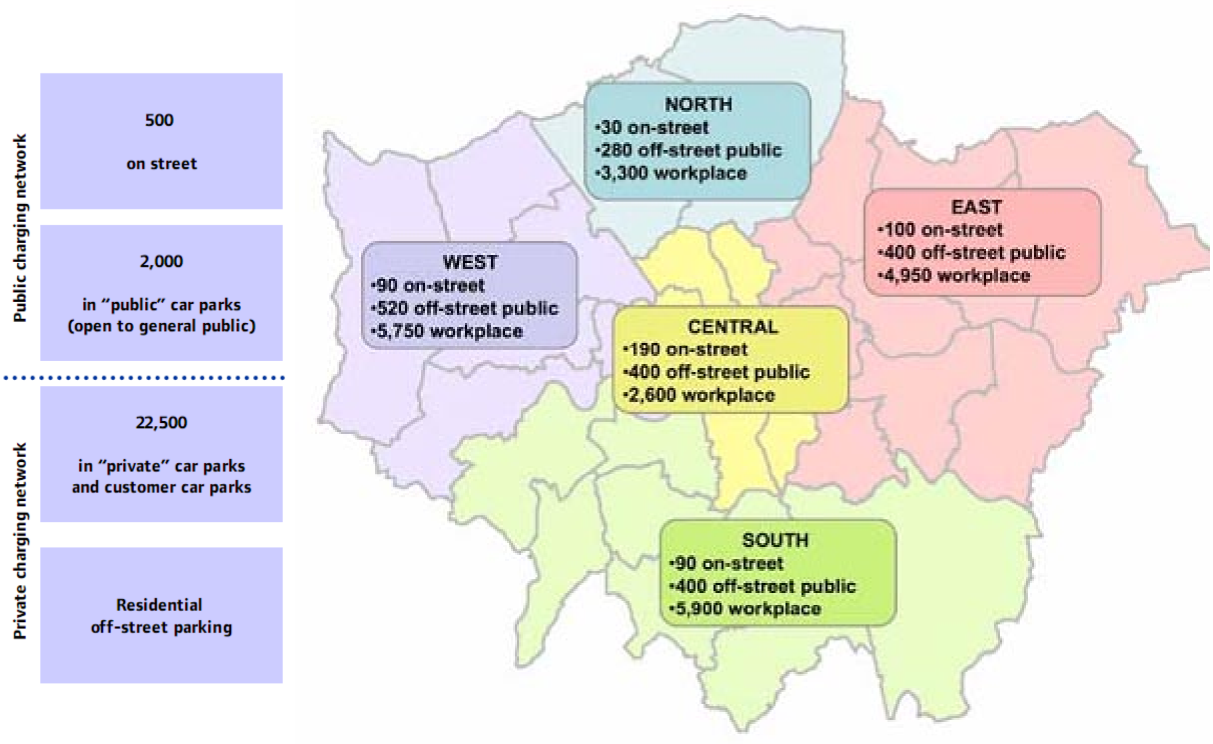


Figure 17: Proposed distribution of charging infrastructure across London's sub regions by 2015 by type

Vehicles

Currently there are around 1.700 EVs in London, representing 0.06 per cent of the total number of vehicles registered. London is committed to increase the number of EVs on the capital's streets as soon as possible to 100.000 vehicles (or 5 per cent of London's fleet). The following actions are proposed:

- Continue with EV trials including the Low Carbon Vehicle Procurement Programme (see national policies UK) to inform research and development in the fields of consumer behaviour, range of vehicle types, drive cycles and infrastructure, fast charging and smart metering.
- Increase the uptake of EVs in the Greater London Area (GLA) group fleet (comprising the fleets of GLA, Transport for London, Metropolitan Police Authority, London Development Agency and the London Fire + Emergency Planning Authority).

Develop a joint procurement plan across the GLA family making use of increased volumes to reduce cost.
- Increase the use of EVs amongst suppliers to the GLA group (review supplier contracts to increase the use of low carbon vehicles)
- Increase uptake of EVs in the borough and other public sector fleets (also work with and support the London Organising Committee for the Olympic Games to include EVs as part of the Olympic fleet)
- Develop EV options for wider public transport, as e.g. for taxis (currently conducting a Low Carbon Taxi trial), private hire vehicles (PHV), buses (from 2012 all new buses will be hybrids)
- Work with business partners to make EVs an integral part of the wider London fleet market for commercial vehicles and cars
- Encourage the private sector to acquire EVs (work with key businesses to encourage the uptake, establish a plan for large scale procurement of EVs)

Incentives, Marketing and Communication
As mentioned already in chapter 2.4 (see Plug-In Car Grant), the Department for Transport announced that up to £230 million would be allocated to incentivise the market uptake of EVs in the UK. EV purchasers receive a rebate of up to £5.000. Further (see Fiscal Measures), EVs are tax free in the UK.

The city of London guarantees aside the national incentives supplementary ones to EV users:

- *Parking:* A number of boroughs offer subsidised parking for EVs. E.g., parking at public car parks in Westminster is free, saving the user up to £6.000 a year. An annual fee of around £200 is charged which also covers the cost of electricity. In addition, a number of London boroughs have emissions based on-street parking permits (free for EVs) in place.
  The city of London will work with boroughs and other parties to investigate the potential for the provision of priority parking for EVs in cars parks and in town centres.
- *Congestion Charging:* There is a 100 per cent congestion charging discount available for EVs (being worth £8 per day and up to £1.700 per year for regular travellers in the congestion charging zone)
- *Car Clubs:* Car clubs are supported and specifically encouraged to employ EVs in their fleet. Installations of dedicated bays and charge points for car club EVs are funded.
- *Bus Lanes:* There are concerns that at peak times many bus lanes are heavily used by buses, taxis, cyclists and motorcyclists and the inclusion of additional vehicles may affect the reliability of these journeys. However, a feasibility study is to be carried out.

For marketing and communication purposes, a strong and easily recognisable brand for EVs in London will be developed. A pan-London interactive web site will be developed that provides exhaustive information on EVs in London and e.g. on the location of vacant charge points. A call centre for help and advice and to report any issues is envisioned.

Functioning and Funding of the system
It is foreseen that the EV scheme will initially operate as a flat fee membership scheme, whereby EV owners pay an annual membership fee to access any of the 2.500 publicly accessible charging pints and are able to access electricity free at the point of use (they will not be billed for electricity usage but will only pay the annual membership fee). The

aspiration is, however, that the scheme moves to a 'pay as you go' model once there is a sufficient number of EVs in London to make it viable.
Transport for London has allocated £20 million to promote the adoption of EVs. Further, funding was made available through the 'Plugged-in Places' programme of the UK government. It is also envisaged to receive funding from the European Commission.

3.3.5 Portugal's Mobi.E Project[5]

In Portugal several factors come together that speak for the introduction of electric mobility. Renewable energy sources account for 40% of electricity production and its share will increase to almost 60% by 2020. Portugal is further also already taking the first steps in the deployment and experimentation of smart grids. Every Portuguese home will have an intelligent meter by the end of 2016. Given these favourable framework conditions, Portugal has developed ambitious plans concerning the introduction of EVs and of the accompanying infrastructure under the frame of the programme for electric mobility Mobi.E.

Mobi.E

The uniqueness of Mobi.E is its integrative approach in order to reduce barriers to market development by assuring an open business model that allows the integration of multiple actors, of diverse vehicle and battery types, and of diverse electricity suppliers all using the same infrastructure. By its open business approach, Mobi.E wants to assure competition and equity on the electric mobility (and infrastructure) market as well as low barriers of entry to all interested parties. Other services concerning parking, public transportation and car sharing that ensure the sustainability of the mobility system shall be integrated in the comprehensive approach. For this purpose Mobi.E provides a platform for transaction management between all involved parties and guarantees the integration of new operators and retailers.

IT Solution

Mobi.E relies on a comprehensive IT management platform that interconnects all stakeholders around a defined value chain, through the integration of all information, energy and financial flows. Main system features include real time visualisation of recharging points (including their status and vacancy), monitoring of the recharging process, web-based multiplatform access (e.g. via cell phone), integrated invoicing with complementary services (e.g. parking, public transport, electricity, creation of personal and business accounts), and roaming between all electricity retailers.

Recharging concept

For each charging station, there is one central station being capable of managing several satellite stations. This way communication with the user is concentrated in one single unit. This concept allows low and easy maintenance. The central station will be capable to control up to 250 charging points, which makes it easy to adapt the size of a charging station to the customers' needs.

Recharging network

Mobi.E is currently deploying a pilot recharging infrastructure. The network comprises 1.300 normal charging points and 50 fast charging points. The entire network will be in place by the end of June 2011.

In order to assure also demand for EVs, Portugal has implemented numerous incentive measures. Next to several tax incentives and a purchase subsidy put in place (see chapter 3.1.2), there is also an agreement for public procurement and many communication and education activities.

[5] Pinto and Neves (2010)

3.3.6 Norway: Deployment plan and experimentation

In the Norwegian "Action Plan for electrification of road transport" the goal that the share of EVs of the total car park increases to 10% by 2020 (meaning a total number of approximately 260 000 vehicles) is stated. In order to achieve this goal, the government of Norway has established a comprehensive fiscal incentive scheme for the purchase and use of EVs. EVs profit from the following measures: no VAT, no import duty, a reduced annual vehicle tax, free access to public fields, free parking in public car parks, exemption of road tolls, free access to domestic ferries and bus lanes. Further, there is a public funding of up to 50% of the purchase price for companies. (Clean Vehicle, 2011)

Ready for electric vehicles? (Solvoll et al., 2010)

In September 2009 the Bodø University College started the EV test project “Ready for electric vehicles?”. The project focuses on both economical and behavioral topics concerning the use of EVs in Northern Norway. The project followed 17 EVs, among which were electric models of the Fiat Fiorino and the Fiat e500. 5 participating companies leased the vehicles from the company Moving City AS. 4 vehicles were deployed in the fleet of Bodø Energi (a local energy supplier), 7 vehicles were deployed within a data firm, 2 within the municipal fleet of Bodø, 2 vehicles each were given to the car rental firm Bodø Avis and to a garbage disposal firm. The main reason for companies to participate in the project (and to generally consider the deployment of EVs in their fleets) was the expectation that EVs would promote an eco-friendly profile of the company. This would make an investment profitable by a positive economic effect on the long run.

Observations showed that the EVs worked quite badly in the beginning, partly due to lack of practical training and partly due to technical problems with the recharging of the battery. The battery problem was mainly due to extreme cold and a resulting reduction of their capacities. After a familiarization process with the vehicles (and after the end of the extreme cold) the usage of EVs worked better. Feedback from users showed that recharging is a crucial point and important issue of the deployment of EVs in the Bodø region (of the rather deserted Northern Norway). The limited range of the EVs implies that flexibility in car use is reduced. Denser charging infrastructure was therefore desired.

3.3.7 French EV deployment projects

France, being on the forefront of EV initiatives, has been launching several projects that test infrastructure and vehicle technologies, as well as customer behaviour and business models. In the following an overview of current projects is given.

Project Kléber

For the project Kléber EDF and Toyota collaborate in order to test a big scale deployment of the Toyota Prius in real life situations in the city of Strasbourg. The project started mid 2010 and deploys approximately 100 PHEVs within a period of 3 years. 170 public and private recharging points have been installed. EDF carries out the supervision and management of the infrastructure. Different operational solutions of infrastructure management are tested. The vehicles offer many supplementary services to the drivers (concerning navigation system and communication with the recharge network). (EDF, 2011)

Project Mini E

The project Mini E started in November 2010 under the collaboration of BMW, EDF and Véolia. The objective is to test around 50 MINI E vehicles in Paris by renting the vehicles to enterprises and private persons, two times for a 6-month period (see MINI E project in Berlin, chapter 3.3.3). EDF manages the infrastructure (only normal charging points are deployed). (EDF, 2011)

Project SAVE

The project SAVE is a large scale deployment project in the region of Yvelines involving various partners. 100 vehicles are to be deployed. The region of Yvelines is characterized by a loose urbanization, with a high degree of social housing.

The project SAVE was established conjointly by Renault-Nissan, EDF, the region of Yvelines, EPAMSA (Etablissement Public d'Aménagement du Mantois Seine Aval), and the Ile-de-France region. Renault and EDF are also allied with Total and Schneider Electric for the purpose of this project.

Renault-Nissan delivers the vehicles, pilots the experimentation and studies user behavior concerning recharging and the use of accompanying services (such as communication services). EDF participates in the deployment of infrastructure, in studies concerning user behavior and possible business models. Schneider Electric contributes in the deployment of infrastructure. BetterPlace was supposed to implement and manage a battery swap station. Its participation has finally not been realized though.

The infrastructure, comprising 300 recharging points on public and private premises, has been made available till the end of 2010. Since 2011 a progressive delivery of EVs has started in order to test the vehicles for a 1-1,5 year period. Tested vehicles are the Renault Fluence Z.E., the Renault Kangoo Express Z.E. and the Nissan LEAF.

The project, having costs of € 23 million, profits from financial means of ADEME (€ 6,5 million Euro) and from support of the region of Yvelines and Ile-de-France. (Mobilité Durable, 2010; Yvelines, 2011; Avem, 2010)

Project Carsharing in Nice

This project is carried out collaboratively by Veolia Transport (70% Veolia Transport Alpes Maritimes) and EDF (30% SODETREL). In April 2011 a car sharing service will start its business by deploying exclusively EVs. In the Côte d'Azur region 210 EVs are going to be distributed between 70 car sharing stations. Different vehicles types are going to be deployed, among which will be the Peugeot iOn. 140 charging points are being constructed. The project duration will be 12 years; yearly costs are estimated to be € 1,4M/year.

Customers have the option of two different subscription models. One is tailored for infrequent users (no fixed monthly costs but higher usage rates/hour (8€) or per day), the other one is designed for more frequent users (monthly rate of 50€ but an hourly rate of only 5€). (EDF, 2011)

Mopeasy

Mopeasy is a car sharing service launched in January 2010 in Neuilly Sur Seine. The company only deploys EVs (so far of the type REVA). After a registration to one of three different possible tariffs (business, professional, à la carte), an EV can be booked via the internet. Via an access code sent by SMS, the customer gets access to the reserved vehicle. The vehicle has to be returned to the same place where it was taken from. (Mopeasy, 2011)

Liselec - Yelomobile

In 1999 the agglomeration of La Rochelle initiated the car sharing service Liselec, which became Yelomobile in 2010. Since 2006 the service is operated by Proxiway, a daughter of Veolia Transport. 50 EVs and approximately 15 recharge and parking facilities are deployed. Apart from a 'pay as you go' scheme for 7€ per hour, there are also 5 other tariffs available that allow lower hourly costs (down to 3€/hour) due to higher monthly costs of (up to 250€/month). The vehicles that are deployed are electric versions of the Citroen Saxo, the Peugeot 106 or the Citroen Berlingo. Vehicles are not reserved beforehand. Users, equipped with a badge, can access the cars instantly. (Yelomobile, 2011)

Autolib[6]

Autolib is an EV car sharing system in the Ile-de-France region currently being in the early stage of its development. Beginning from April 2011 the network of 1120 charging stations will be set up. Charging stations will be predominantly located in Paris, where approximately 700 of them will be installed. The remaining charging stations will be constructed in 45 adjacent communities of Paris (see figure 18 underneath). Out of the 700 stations in Paris, there will be 500 charging stations on the street surface (disposing of 4-6 parking lots each) and 200 charging stations underground (disposing 6-10 parking lots). 80 stations will also comprise a kiosk, where an Autolib staff member will be available for subscription services and other enquiries.

The EV type deployed is going to be the Bolloré Bluecar. More than 3000 vehicles are foreseen for the network. The future user will be able to choose from 3 different tariffs:

- A yearly subscription for 12€/month
  (5€ for the first half-hour, then 4€ and 6€ for subsequent half-hours)
- A 7-day subscription for 15€
  (7€ for the first half-hour, then 6€ and 8€)
- A 24h subscription for 10€
  (7€ for the first half-hour, then 6€ and 8€)

A test period has been envisaged for August 2011. The system launch to the broad public is planned for October 2011.

The Autolib project is planned to recover deployed investment costs by the income generated from the rates of usage charged to the system's customers. A one-time € 50 000 subsidy per charging station is, however, provided by the public authority. This amount has been made available under the condition that the Autolib project only deploys EVs and offers a one-way usage system (the return of the vehicles to the place where it was rented from is not necessary – the vehicle can be returned at any other Autolib station).

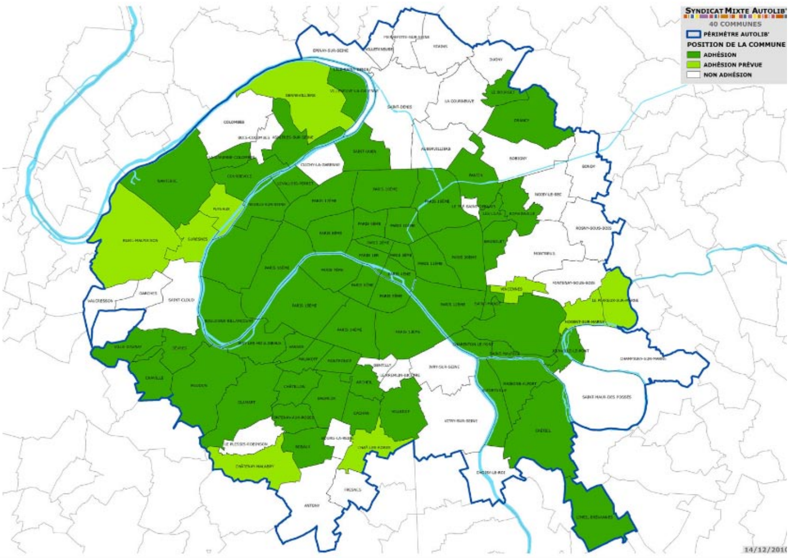


Figure 18: Perimeter of Autolib project

[6] See Autolib (2011), Mairie de Paris (2010)

3.4 Synthesis and Conclusion

Recent years have been showing increased public interest and financial investments in the development of EVs. Many European countries have defined quantified deployment goals that usually target the year 2020. Besides the objective to reduce environmental impact of the transport sector and the will to alleviate concerns related to energy dependency, policy makers seek to profit from industrial and economic development resulting from the evolution of EVs. European countries seem to be in competition for guaranteeing a leading role in EV technologies and deployment. Even countries for which the automobile industry has traditionally not been a major industry branch (such as Portugal or Great Britain) long for a share of the alleged potential related to the development of EVs.
Money that has been made available has primarily been invested into R&D activities. Especially activities focusing on the development of batteries, recharging infrastructure and IT systems have been supported. With the arrival of first new EV models of big brands on the market, the last 1-2 years have been showing increasing investments in EV deployment projects, were EVs are distributed among businesses or private users. Chapter 3.3 explored a number of such projects around Europe. Although each of the discussed projects shows its own specific characteristics, the following common points can be observed and conclusions can be drawn:

-) Deployment projects usually aim at testing new EV and recharge infrastructure technologies as well as accompanying IT and communication systems. Further, also customer behaviour is often closely observed in order to correctly estimate future needs on EVs and recharging infrastructure. Due to this focus of deployment projects, the economics behind EVs are seldom explored. Costs of vehicles are heavily subsidized for the projects; infrastructure development relies on public or private investments of which the costs are not transferred to the end users of the vehicles. Economic evaluations of EV deployment, in whichever scenario, therefore do not yet really exist.

-) Deployment projects are usually carried out on a local scale and mostly in urban areas. Most test projects are even launched in rather dense urban city areas, where a high usage rate of shared vehicles can be easily achieved, where infrastructure deployment seems to be a manageable task, and where vehicle autonomy does not play a significant role. Exceptions are the Better Place project in Israel, which takes a national scale (in a well delimited area), the Vlotte project in Austria, which takes a regional scale (also in a rather well delimited area due to geographic/topographic conditions), and Portugal’s Mobi.E project, which is envisaged to work on a national scale (however, first deployment is only been carried out in urbanised areas). The future French SAVE project will also work on a regional scale, however, in a rather densely populated environment. Strategies of how EV deployment can look like in rural areas have not yet been developed and tested. Primary markets are clearly seen in urban, densely populated areas.

-) Deployment projects usually work with EV fleets of 20 to maximal 200 vehicles, depending on the size of the targeted area, and a time period of 6 months to 2 years. Large scale distribution of vehicles has not yet been tested. Certain aspects of EV deployment can therefore only be predicted (such as the impact of large EV deployment on the electricity grid or potential impacts on (increasing?) security in passenger travel). From such pretty limited EV deployment projects, also optimal recharging network designs are very difficult to predict. In order to make sound conclusions on public recharge network demand, bigger vehicle fleets would have to be tested within longer time periods. Test projects with durations of 2 years might be able to give first sound indications. However, such projects time frames have not yet passed (with the exception of the still ongoing VLOTTE project in Austria). Better Place projects (in Israel or Denmark) will probably be the first ones to give information on those kinds of impacts during the upcoming years. Especially customers' perceptions of the deployed system will be interesting to analyse.

Austria's Vlotte Project is a very interesting project example. Not only has the regional scale made the project unique, but also the fact that much experience could have been gained throughout already almost 2 years. Such a long-term project that makes behavioural studies much more significant is unique so far in Europe. Further, the collaborative approach among many different participating actors seems like an extremely fruitful system deployment approach, which should be taken as good example for other deployment projects. Observing VLOTTE's future developments and results will therefore definitely be worthwhile.

Deployment projects do not yet cover all important aspects worthwhile exploring concerning the introduction of EVs. However, major automobile brands have announced their EVs for 2012 or even 2011. From then onwards, also 'real life' studies will become feasible, where e.g. single private users, their motivations and behaviours can be explored under completely realistic conditions. Israel and Denmark will serve as first study areas for large scale vehicle deployment.

4 Derivation of an EV uptake scenario

4.1 Major challenges of EVs today

The overview of EV models that have recently been launched on the market or that are soon to be launched on the market of chapter 3.2.1 clearly shows that purchase costs for EVs are significantly superior to those of comparable CVs. Not only that they are more costly in their acquisition, they are also bound to more restrictions concerning autonomy, speed and power. However, the efficiency of the electric motors and low electricity costs per kWh compared to fuel costs (whether diesel or petrol) per liter make usage costs of EVs by far inferior. Further, EVs profit from less maintenance costs, often less insurance costs[7], and additionally also from governmental purchase subsidies and/or tax breaks.
However, the purchase price which imposes an up-front barrier to potential EV users, remains one of the main obstacles for successful EV deployment and large customer acceptance.
Future scenario settings show that an EV's cost effectiveness will be much easier achieved due to economies of scale in production, increase of the sales market entailing more efficient distribution chains, due to technical advancements concerning the battery technology and finally also due to learning effects, which will allow electricity usage to decrease. Finally, also allegedly increasing fuel prices will contribute their share to the profitability of an EV compared to the CV (see results of the VLOTTE project in chapter 3.3.2 where such a future cost scenario is roughly sketched and a cost break even between EV and CV is predicted to be achieved after a usage period of 6 years).
Since it also has to be kept in mind though, that policy measures financially supporting EVs will decrease as demand increases. Endless EV subsidies and tax breaks will not be feasible for the national budget. Further, also other cost components such as infrastructure usage costs (which should cover infrastructure deployment costs at least in the long run) have to be taken into account. During the upcoming years it is therefore highly unlikely that vehicle purchase costs will be evened out between EVs and CVs. Total costs of ownership, taking all cost components related to the possession of a vehicle into account, will (at least in the upcoming years) only be equalized between the different technologies, if full potential is drawn from the

[7] Certain insurance companies have already announced preferential tariffs for EVs. This is mainly due the expectance of less accidents thanks to reduced speeds and more cautious driving of EV owners.

lesser running costs of the EV. This means though that high yearly (or daily) mileage will be a condition for a profitable replacement of a CV by an EV.

There have been several studies on the total costs of ownership that prove this fact. Also if final TCO will always depend on local parameters and conditions (such as fuel prices, purchase subsidies, consumption etc.) as well as on specific assumptions made concerning purchase prices, detention periods and annual mileages they all give a similar picture of the cost challenge of EVs.

The figure underneath shows the results in costs per driven kilometer of a total cost of ownership analysis carried out by EDF (2009). It can be clearly seen that neither in 2012, nor in 2020 cost effectiveness of EVs (here shown as VE) can be achieved under 'average' conditions (assuming a mileage of 8.000-15.000km/year depending on the type of usage and battery costs of € 800/kWh in 2012). Obviously, the cost difference decreases significantly. However, as also costs of the CV are assumed to decrease, since higher up-front costs always pose a higher disadvantage than incrementally occurring costs, and since in even the year 2020 does not show profitability for the EV, the drawn picture is, under 'average' conditions not really promising for the up-take of EVs.

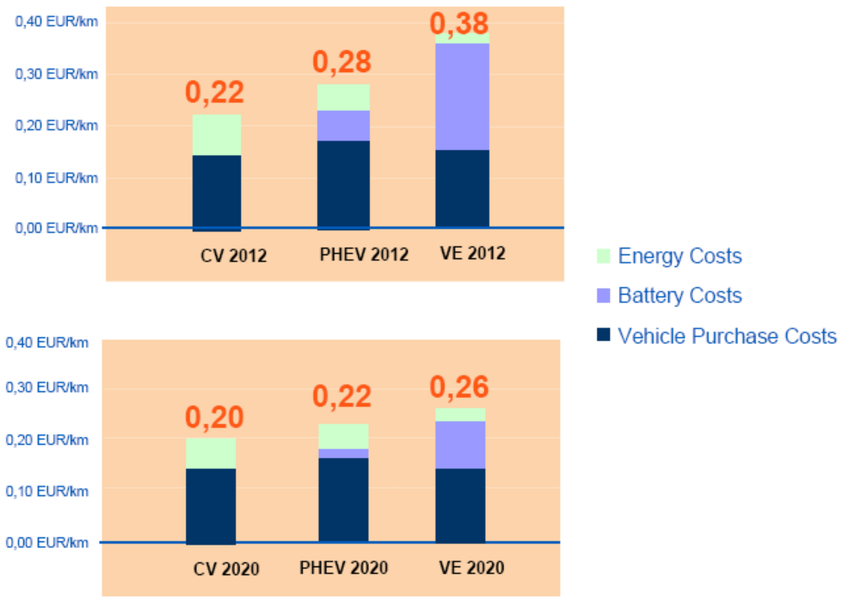


Figure 19: Total costs of ownership per driven km for CV (conventional vehicle), PHEV (plug-in hybrid electric vehicle) and VE (electric vehicle/véhicule électrique) in 2012 and 2020 (EDF, 2009)

Another study carried out by Oliver Wyman (2010) shows slightly more promising results. In 2025 cost effectiveness of EVs can be reached, even with a rather short vehicle detention period of 4 years and an assumed average yearly mileage of 15.000 km. Figure 20 underneath shows the obtained results per vehicle type and cost category.

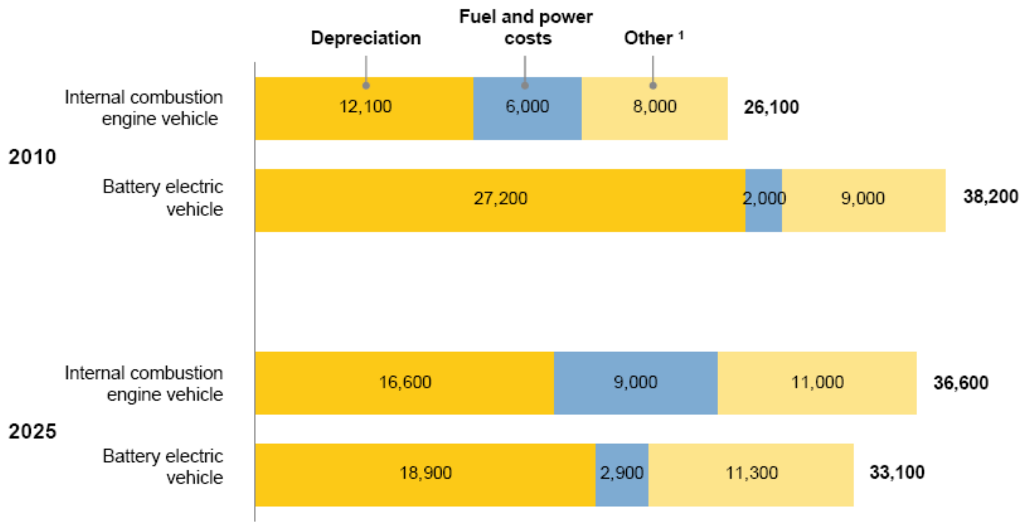


Figure 20: Total costs of ownership for a CV and an EV in 2010 and 2025 (Oliver Wyman, 2010)

The large cost difference for the year 2010 is, however, also not very promising for an EV uptake during the next couple of years.

A study of Deutsche Bank (2009) also takes a total cost of ownership approach. Costs (in $) are shown as a function of fuel price (in $/gallon). The study concludes on which future fuel price is needed in order to equalize costs of different technology vehicles after a 10 year usage period and an assumed mileage of 15.000 miles per year. Further, the study assumes predicted prices for battery technology in 2015 and $ 1.000 cost increase per year for CV in order to achieve fuel economy compliance. Assumptions on the development of electricity prices are not stated and therefore most likely to be assumed as constant over time.

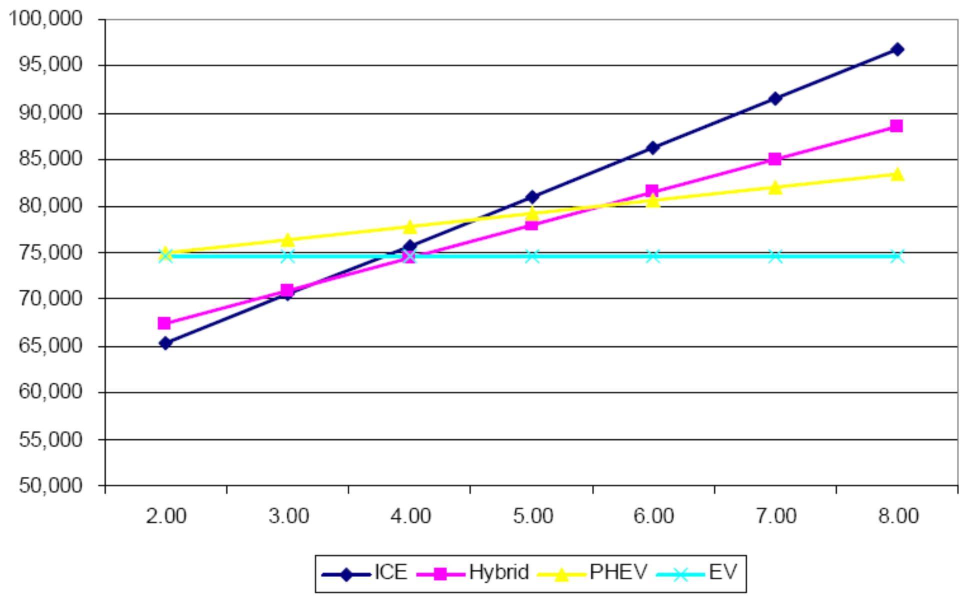


Figure 21: Total costs of ownership of different vehicle technologies in 2015 (Deutsche Bank, 2009)

The results of Deutsche Bank (2009) are probably the most promising ones. Figure 21 shows that EVs will be more cost effective than PHEVs, and that EVs can already compete with CVs at a fuel price level of $4/gallon (being approximately € 70c/liter). Clearly, this study that does not even take federal subventions and tax breaks into account gives the by far most promising picture for EVs in the year 2015 compared to the other reviewed studies. Reason for this more promising picture mainly stems from the advantageous assumption on battery prices for the year 2015, which are supposed to lie underneath $ 500/kWh. (EDF (2009) bases its calculations on the assumption of € 800/kWh in 2012 – a rather pessimistic value from today's point of view though)

The following results of a BCG study (2009) show the large impact of battery costs on the comparison of total costs of ownership between an EV and a CV. Also assuming rather high battery costs of $700/kWh in the year 2020 (and being this way even more pessimistic than EDF (2009)), the EV does not show a very promising picture. Extremely high oil prices would be necessary in order to make it profitable compared to the other technologies. With the assumption of moderate battery prices (which are, from today's point of view much more reasonable for the year 2020), the EV becomes already profitable within an oil price range of year 2008 levels. A 5 year usage period and yearly mileage of 14,500 km is assumed.

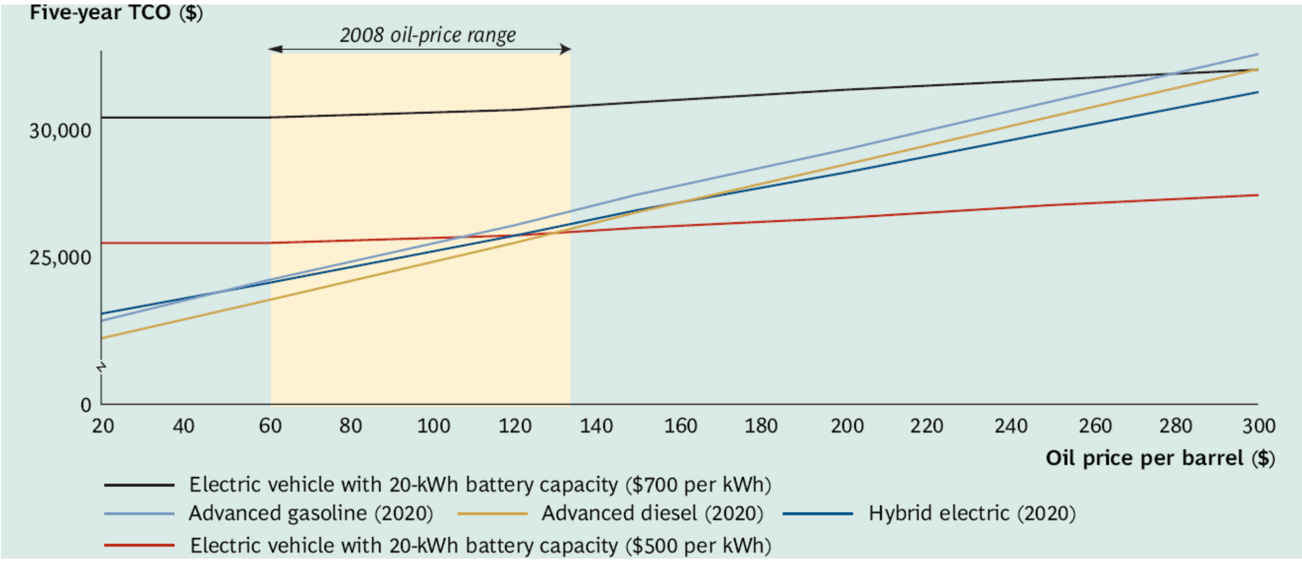


Figure 22: Total costs of ownership of different vehicle technologies in 2020 (BCG, 2009)

The results of examined studies show two very interesting things. First of all, it becomes apparent how results of different studies can vary. This is due to the fact that total costs of ownership depend on many parameter values that are not yet known. Also, as already mentioned, results depend very much the usage period and yearly mileage assumed, and local parameters such as fuel prices and policy measures. To get a clear cut impression of future costs is therefore very difficult, only ideas can be obtained.
However, shown studies mostly have in common that from a today's point of view a cost effectiveness of EVs is difficult to reach. Only by the year 2015, 2020 or even 2025 (depending on the study) financial profitability will be easily achieved by average usage rates of passenger cars.

A possible niche
It can be concluded, that only rather high mileage of vehicles turn EVs already from today's point of view profitable. An annual mileage of (e.g.) 30.000 km, combined with a usage period of 8 to 10 years of the vehicle, can most likely easily assure cost efficiency of an EV compared to a CV - even so by assuming today's costs for vehicles, fuel and electricity. 30.000 km means (e.g.) 120km/working day assuming 250 working days per year. Such a daily mileage clearly lies above national averages, but is perfectly imaginable for vehicles used for business reasons - even more so if these vehicles are deployed in rural areas of the country.

4.2 Major challenges of rural areas today

As already sketched in chapter 2.3, a major challenge of rural areas concerning transport is the provision of public transport means that assure the accessibility of the region to all groups of the population. Rural areas are nowadays more and more becoming dependent on the possession of private vehicles in order to assure individual mobility. Public transport lines, such as buses, that run on frequent and periodic bases have become less profitable and were cut down. It has become extremely difficult and costly for both, private and public transport operators, to provide such kind of traditional transport services.
However, demands for mobility should by no means be left unanswered. Unmet demand can easily entail economic stagnation and finally migration away to more urbanized areas where demands for mobility can either be met or do not occur in such magnitudes (due to usually shorter distances between locations of daily activities).
Especially young age groups, who do not dispose of a driving license, are often among the handicapped groups of population in rural areas concerning their demand for mobility. Their age binds them to public transport service offers for traveling independently. Also older people, being not in the condition anymore of driving their own vehicle, are often bound to public transport services. Frequently, they even need special transport services due to their physical constraints. Finally, also financially handicapped people, who can not afford their own vehicle mostly rely on public transport services in rural areas.
Public transport service offers are therefore crucial for the viability of rural areas and the well-being of sketched groups of population. However, rural areas do not offer the best conditions (e.g. concerning patronage) that are likely would turn traditional public transport to financially profitable services.

Possible solutions

Transport-on-demand services, as described in chapter 2.3., are therefore a viable and feasible solution for all participating stakeholders: Users can profit from a public transport service that often offers even much more flexibility than traditional offers (such as bus lines), while service operators can profit from higher patronage, more efficient services and therefore a higher potential for financial profitability of the service.
Also peer-to-peer car sharing services can be imagined as a viable solution for rural areas. However, not all discussed groups of the population could profit from such mobility offers. Neither young nor old (and physically handicapped) groups of the population are very likely to use those kinds of services. Further, peer-to-peer car sharing also requires a certain minimum density of dwellings in order to allow a working system. Certainly, such a minimal density will often not be given in rural areas. A lack of density will also be the main obstacle for ride sharing systems to develop. Even tough they have the potential to easily provide mobility means to all groups of the population, they rely on a dense area in order to successfully develop.
It can be concluded that transport on demand systems offer best possible means of public transport in urban areas. Besides their advantages sketched above, they even have the potential to attract people already used to their own vehicles, by lowering expenses for transport and increasing flexibility (e.g. by enabling one way trips and door to door services). This way, transport-on-demand services even have the potential to contribute positively to the reduction of emissions stemming from the transport sector.

4.3 Potential of EVs in rural areas

The two precedent chapters have explored a possible potential deployment of EVs, referring to high mileage and to a reasonably long usage period of the vehicle, and the challenges and a resulting possible transport solution in rural areas.
Combining these two in order to come up with a viable solution for the deployment of EVs while simultaneously offering a remedy to current problems, delivers an innovative EV deployment solution for rural areas.

The introduction of transport-on-demand services that are equipped with EVs seem to offer a perfect solution for transport demands in rural areas. On the one hand this is due to the advantages of transport on demand services in general (as sketched above) but on the other hand this is also due to the following additional advantages thanks to the specific features of the system caused by the deployment of EVs:

- By the potential high average usage of each vehicle deployed, the purchase of EVs will be easily profitable. Even more so, there is the high potential that even significant fuel savings can be achieved, which, in turn, further bear the potential to even turn the whole deployed service offer more financially profitable than this would be the case if CVs with high energy costs were to be deployed.

The usual autonomy issue of EVs is easily surmounted by their deployment in transport-on-demand (DRT) services. DRT services are characterized by vehicles driving on fixed, semi fixed or fully flexible tours. However, a certain start and/or destination point of a route is usually fixed. This way a dense net of recharge infrastructure does not become necessary. Vehicles can easily be charged (e.g. either by rapid charging stations or a battery swap system) throughout the day in case the daily mileage really surmounts the autonomy given by the capacity of the used battery. During the night (or throughout the day – whenever the DRT service is not offered) vehicles can easily be charged by normal ‘low speed’ charging stations in their hub. Rapid charging facilities for the simultaneous recharge of more than one vehicle at a time therefore become superfluous, as long as vehicle routing and scheduling algorithms also take care of optimal planning of the usage of recharge infrastructure. Costly recharge infrastructure can therefore be held to a very minimum, charging activities might be reduced due the ‘automatic’ charging during the night. The general market of EVs can be successfully supported and EVs can be easily promoted among the population. Obviously vehicles with a certain elevated passenger capacity have to be deployed, such as minibuses or vans.

A collaborative approach
As the example of the VLOTTE project has shown, especially tight cooperation of involved stakeholders seems to lead to a successful mobility service offer that finds high acceptability among the population. Also a potential DRT service based on EVs should therefore be based on a collaborative approach among stakeholders. Imaginable partners of such an EV deployment project could be:

- *Research institutes* that long for opportunities to study EV deployment and usage. Especially the high usage of vehicles can make such a deployment project to an interesting study area. Also mathematical questions such as optimal routing and scheduling with the possible conditional constraint of vehicle charging can be explored.
- *EV manufacturers* that want to promote their vehicles and test their new technologies under high usage scenarios.

- *Electricity and recharge infrastructure suppliers* that are keen on testing their equipments and the potential impacts of increasing EV demand on the electricity grid. Also especially sustainable energy providers could be interested in joining a consortium in case a fully 'green' transport service system is the objective of the project.
- *Public authorities* that search for low(er)-cost solutions for meeting local transport demand and that are therefore probably willing to support the deployment project by continuous financial means
- *Public transport authorities* that want to promote the use of public transport e.g. by offering combined tickets or mobility packages that lower costs for inter-modal trips using DRT services. Experiences show that public transport patronage usually increases as a result of DRT services (Mageean and Nelson, 2003).
- *Vehicle service providers* that want to gain experience with the new vehicle technology – certainly a future asset in the developing EV environment.

Public Private Partnership

Given the potential contribution of a DRT service to the accessibility of a region, regional and local authorities are certainly keen on supporting the proposed service in order to economize expenses for public transport services as well as for improving the region's accessibility and economic development. A public private partnership (PPP) would be a vital solution for a DRT service, which is generally 'unlikely to cover the cost of service in any market' (Mageean and Nelson, 2003) and therefore unlikely to be operated only by private operators. Furthermore, Mageean and Nelson (2003) state that 'viability of DRT services as a self-supporting system has not yet been demonstrated. Viability Is therefore measured in terms of citizen mobility and providing the cheapest public transport solution. Modal shift could be viable if costs are discounted against travel time savings and environmental degradation' – certainly many reasons for a local authority to support the introduction of a DRT and to even participate in a PPP. Brake et al. (2006) recognizes the potential for successful PPPs with regard to DRT services and proposes two exemplary repartitions of tasks and costs (see the figure underneath).

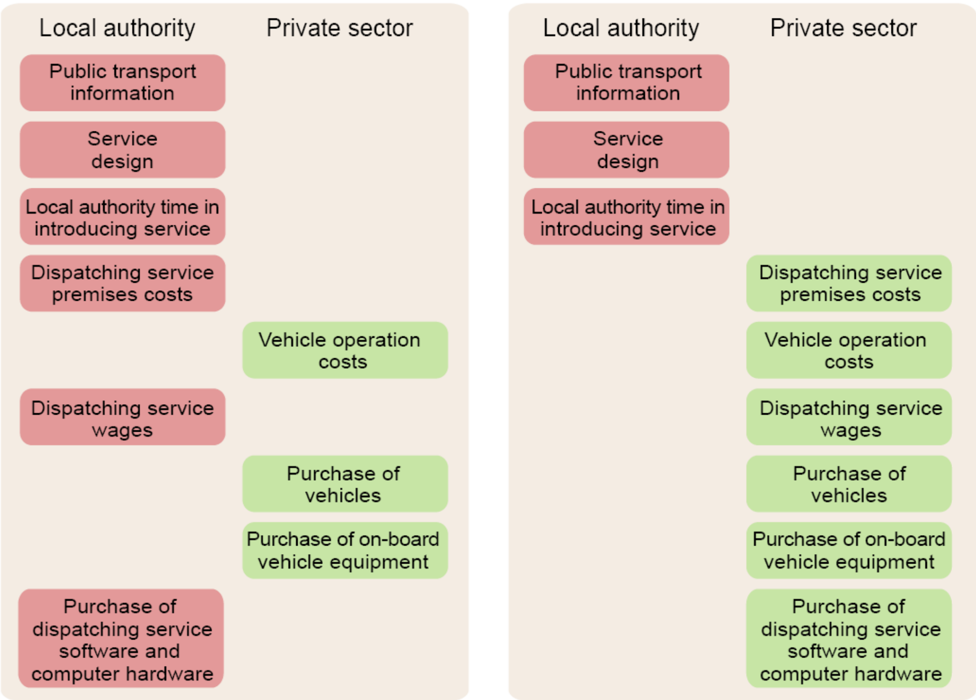


Figure 23: Ideas for sharing responsibility in a PPP (Brake et al., 2009)

Figure 23 allows concluding that there are obviously many possible ways how to organize a DRT service among the involved stakeholders. Specifications will depend on the regional setting and the willingness of the local authorities to contribute to the proposed system.

Conclusions

Obviously, the exact deployment approach for a DRT service using EVs has to be explored much more in detail and especially with regard to the local specification of the envisaged deployment area. However, the proposed solution seems to have large potential especially in rural areas. Many potentially involved stakeholders could profit from the deployed system; the public authority has all reasons for a strong support of the system development.

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ANNEX

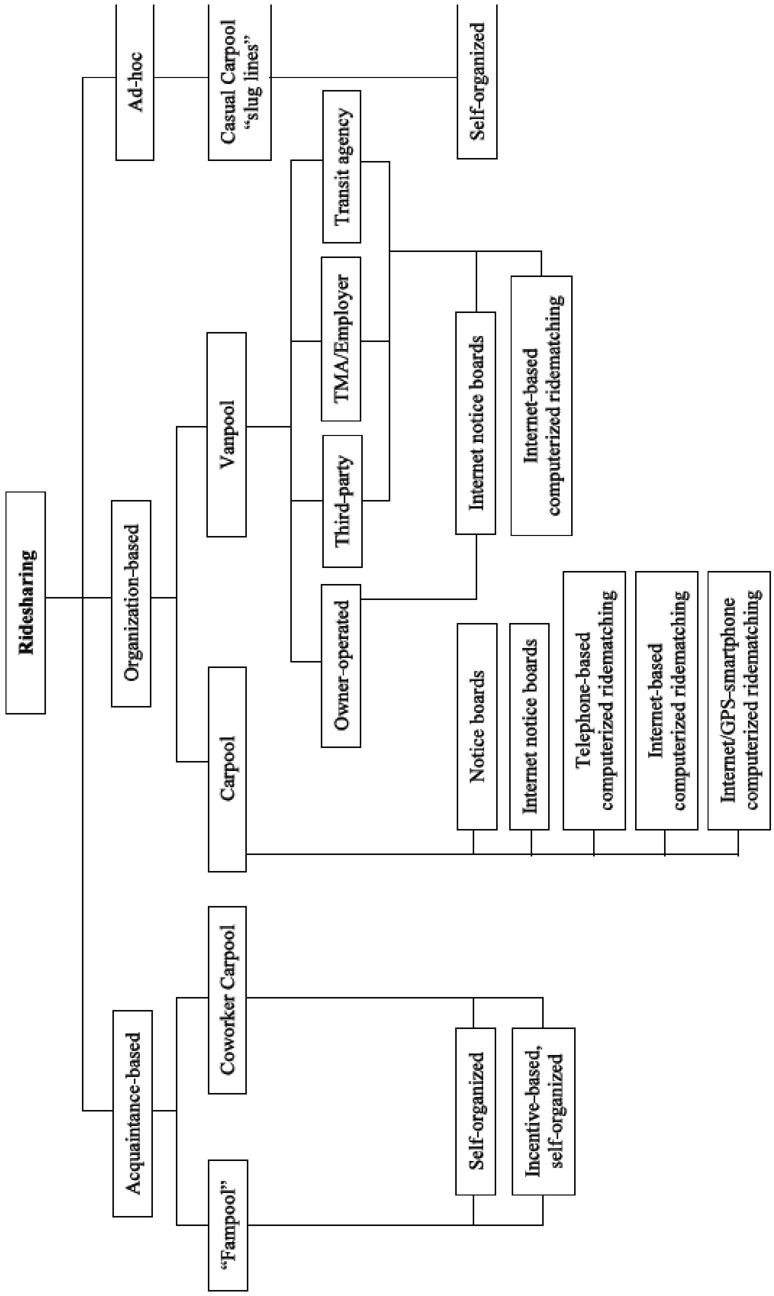

Figure A1: Classification of ride sharing concepts proposed by Chan et al. (2011)

Technological requirements of real-time ride sharing

Technological requirements of real-time ride sharing typically include (taken from Amey et al., 2011):

(1) Smart Phones – Many service designs rely on the recent proliferation of smart phones in the market place. The firms developing the underlying software for “real-time” ride sharing have focused their efforts on platforms with easy-to-use, attractive user interfaces such as Apple’s iPhone software and Google’s Android platform.

(2) Constant Network Connectivity – The need to communicate ride requests and accept offers on short notice requires that one be constantly connected to the network. Many smart phones are now offering (or require) unlimited data plans with new smart phone contracts, facilitating constant network connectivity.

(3) GPS Functionality – The use of Global Positioning System (GPS) functionality has been incorporated into many applications so that they become “location aware”. In other words, participants seeking a ride do not need to key in their current location because the GPS built into their smart phone knows where they are located and communicates this information automatically when trips are logged. This is often marketed as a time saving feature.

(4) Ride Matching Algorithm – All of the underlying systems use some form of algorithm to match riders and passengers. Some of the algorithms do so based only on origin and destination, while some of the newer algorithms match drivers and passengers based on the commonality of their travel route.

(5) Data Repository – All “real-time” systems (and Internet-connected rideshare systems in general) have a data repository where rideshare information is stored. The types of data stored 165 might include a current list of ride requests and offers, individual participant profiles and summary statistics on participation. Many (but not all) “real-time” rideshare services incorporate additional features such as:

(6) Stored User Profiles – Providers will allow users to create and save information profiles. Personal information such as name, employer, home and work locations, popular origin destination (OD) pairs with the user’s preferred route, and a photo are common. Some systems require a photo of the driver’s vehicle and license number be provided. Stored profiles require more participant time on the front end, but make future ride requests much less time consuming.

(7) Social Network Integration – Because of the propensity of individuals to share rides with people they know or share common characteristics with, some providers have linked their services to existing social networks in an effort to improve successful matches. For some, this has meant incorporating their services with online networks such as ‘Facebook’. In these cases, only friends within a given individual’s immediate Facebook network will be considered when searching for ride matches. For other providers, ‘social network integration’ has focused on offering services to a specific organization or institution. In these cases, only co-workers at the same organization are considered as potential partners.

(8) Participant Evaluation – “Real-time” services may allow participants to rate each other, much like the online auction service ‘eBay’. After a ride has been completed successfully, both the passenger and driver are asked to rate each other. The idea behind this feature is that it allows future users to evaluate potential partners quickly, based on others past experiences. The theory is that those with higher ratings are likely to be preferable shared ride partners.

(9) Automated Financial Transactions – “Real-time” services may allow for financial

transactions between participants. Some allow participants to name their own price, while others recommend a value based on standard Internal Revenue Service (IRS) vehicle cost estimates. Some providers facilitate automatic transactions through the use of online payment systems such as PayPal. Other providers simply calculate the recommended shared cost and allow drivers and passengers to negotiate and agree on a final amount and payment method.

(10) Incentives and Loyalty Rewards Linked to Participation – “Real-time” providers may offer incentives or loyalty rewards based on a given individual’s level of participation, much like airline loyalty programs. Those that participate more frequently earn more points or rewards. Providers hope that by providing incentives, existing participants will be encouraged to post rides more frequently, and new participants will be encouraged to join their service.

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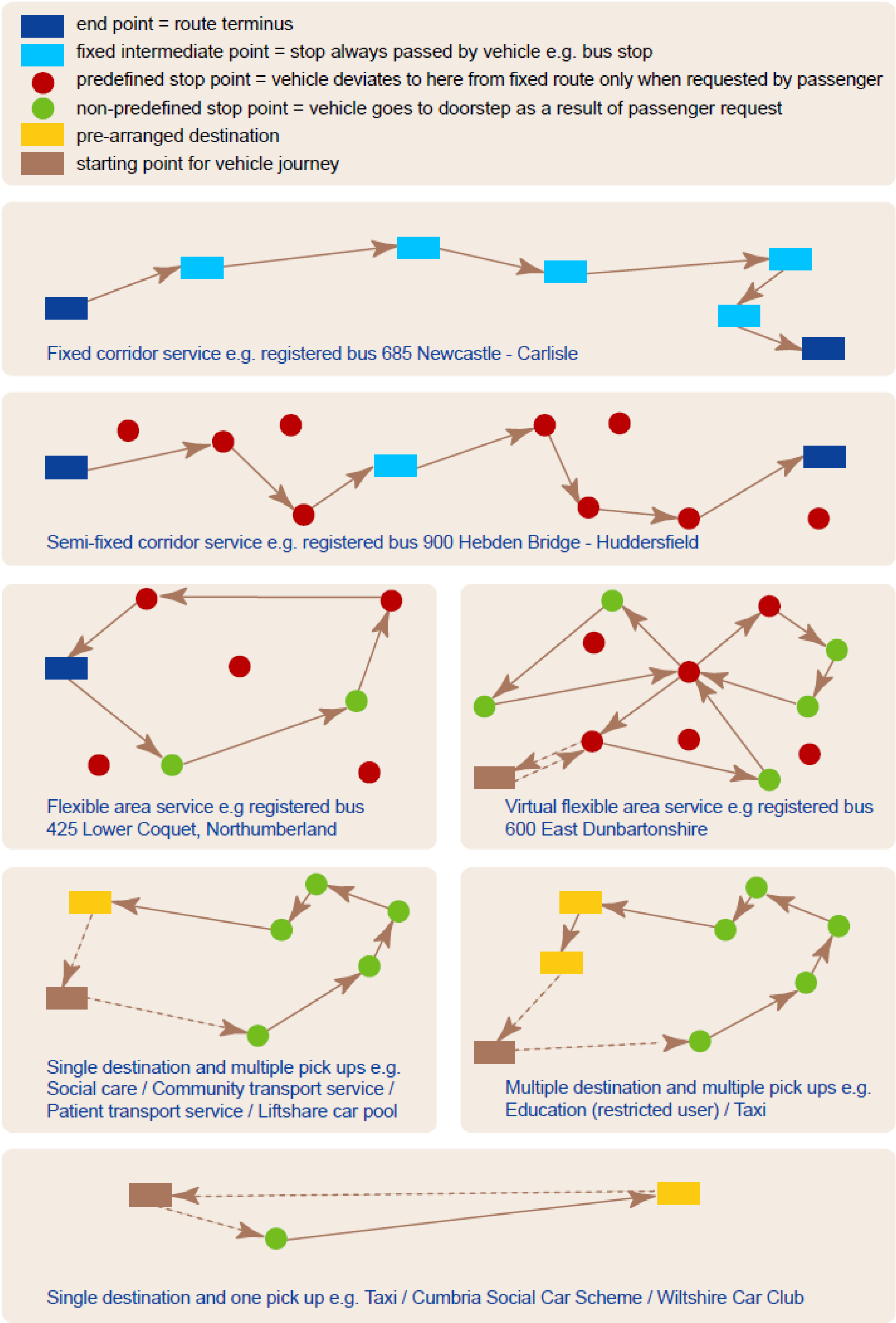

(Brake et. al, 2006)