Market Models for the Roll-Out of Electric Vehicle Public Charging Infrastructure

A EURELECTRIC concept paper

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Task Force Electric Vehicles

Thomas THEISEN (DE) Chairman
Rui Filipe MARQUES (PT) Vice-Chairman

Federico CALENO (IT); Jose Manuel CORERA SANCHEZ (ES); David DENSLEY (GB); Esteban DIAZ EXPOSITO (ES); Anders Holm FOOSNAES (DK); Marie FOSSUM (SE); Jesus GARCIA MARTIN (ES); Fernando GARCIA MARTINEZ (ES); Elvedin GRUDIC (NO); Fabien HILLAIRET (CZ); Gilles JEHAN (FR); Jiri KODAD (CZ); Valy LIOLIOU (GR); Petr LISY (CZ); Senan McGRATH (IE); Philippe MEAN (CH); André POSTMA (NL); Hervé ROCHEREAU (FR); Rafael SANCHEZ DURAN (ES); Luis Manuel SANTOS MORO (ES); Gerd SCHAUER (AT); Paolo SCURO (IT); Ulrik STRIDBAEK (DK); Hendrik VAN ASBROECK (BE); Michael WELTIN (DE); Henrik WINGFORS (SE); Przemysław ZALESKI (PL);

Contact:
Sophie TIELEMANS, Policy Officer Networks Unit
stielemans@eurelectric.org

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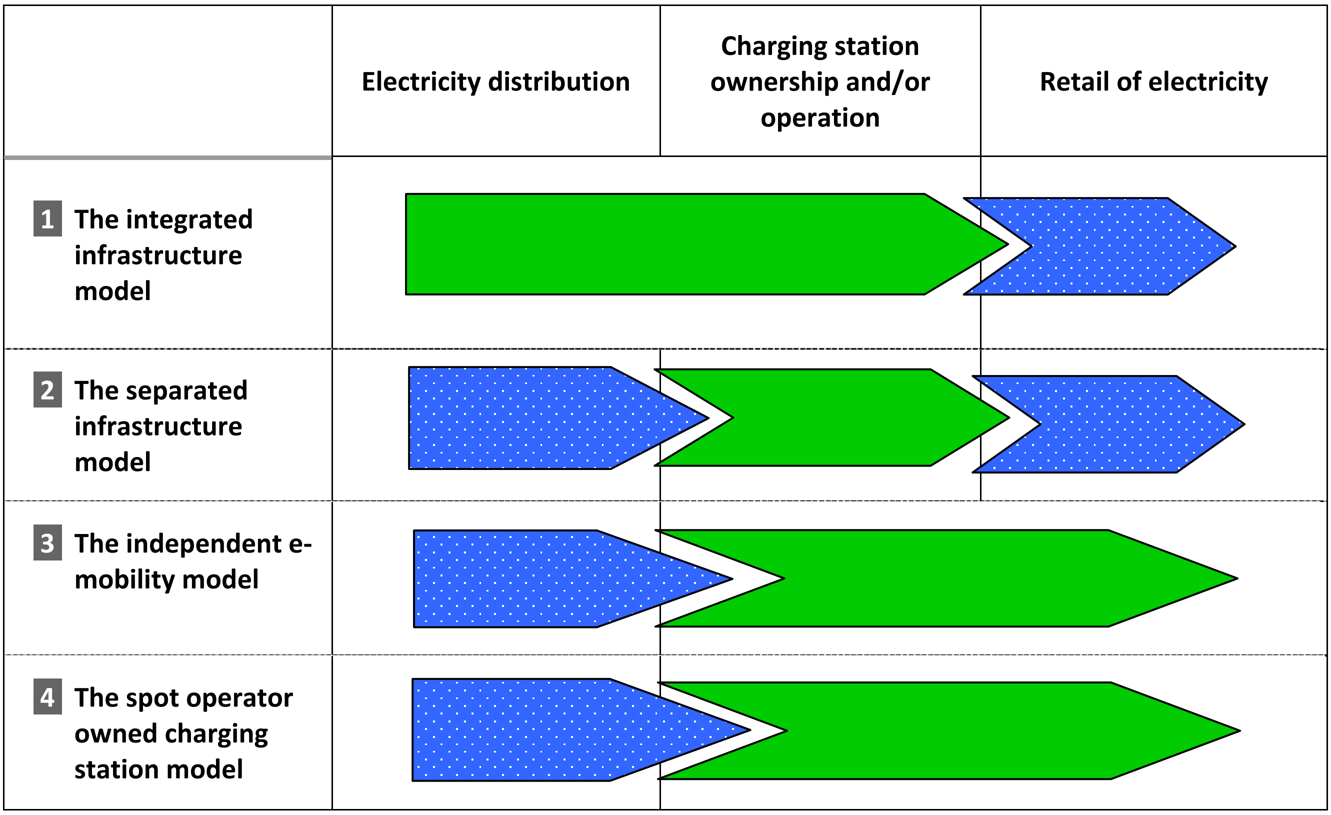
Executive summary

This paper aims to initiate the discussion with policy makers and relevant stakeholders on how to structure the future e-mobility market. The document highlights four major market models describing the roles of possible market players in rolling out public electric vehicle charging infrastructure, without recommending any one model over another.

In practice, different models and solutions will probably be further implemented depending on the specific market conditions, economies of scale, government decisions and/or incentives, and technical know-how of each individual country. Moreover, the models are not necessarily mutually exclusive and could co-exist alongside one another. It is not deemed necessary for regulators or legislators to impose one specific model; rather, they should leave room for market development by leaving all options open.

The figure below is used to illustrate the identified market models for rolling out the public infrastructure for charging electric vehicles (EVs). The model represents one part of the value chain for public EV infrastructure, ranging from electricity distribution to the retail of electricity for charging EVs in public areas. The distribution of electricity is undertaken by the Distribution System Operators (DSOs), which are fully regulated private or public companies. The paper also discusses who will be responsible for rolling out the public EV infrastructure, i.e. the charging stations. The final step in the value chain, the retailing of electricity, is undertaken by private firms who base their strategies on commercial considerations.
Block arrows of the same colour indicate that these functions are executed by the same market players.



I. Introduction

1. Justification for the paper

Efforts to decarbonise our economies and society as well as the continuous focus on security of supply have increasingly drawn attention to the transport sector. At the same time, the increasing share of renewable energy sources (RES) in the EU electricity generation mix is transforming our energy supply system.

Given these policy challenges, electric vehicles (EVs) are very much in the spotlight and high on the political agenda for two reasons. On the one hand, electricity is being domestically produced across Europe and has the potential to be carbon-neutral. On the other hand, with an increased share of RES in our electricity generation schemes, EV batteries can provide a means to balance intermittent energy sources. Nevertheless active demand management and an "intelligent" electricity network, grids and meters are indispensable if EVs are to be efficiently integrated into the electricity system and potential synergies with RES are to be harnessed. These challenges and the ever-present need for transportation are the principle driving factors for EVs.

A great advantage of EVs compared to other alternative transport solutions is the fact that the majority of the infrastructure, i.e. the electricity grid, is already in place. Only the final infrastructural elements, i.e. the charging stations, remain to be rolled out. The infrastructural hurdles associated with the further spread of EVs are thus relatively small compared to the roll-out of a hydrogen infrastructure for example. Nonetheless, finding business models that foster these infrastructural developments is essential.

A range of issues regarding EV charging infrastructure are being raised by policy makers and stakeholders, all of which must be solved in a balanced way. For instance, one question of great importance concerns the degree of regulation needed for an effective and efficiently functioning market for the charging infrastructure. The evaluation of regulatory models is a complicated exercise given the relative immaturity of the industry and the difficulties in foreseeing what the outcome of a commercially based infrastructure deployment will be. Multiple interests need to be taken into account, and it is a challenging task to strike a fair balance between these interests in order to achieve the cost-effective development and deployment of the charging infrastructure while responding to market needs.

EV users will undoubtedly play a central role in these market models. On the one hand, users will face significant drawbacks during the initial market phase of EVs, among them the relatively short battery lifespan, the long recharging cycles and the higher acquisition price of the vehicles. On the other hand, users will benefit from a significant increase in comfort, including the possibility to charge the vehicle at home and the dynamic noise-free driving. The main advantages of EVs will however be felt by society at large, in particular in cities and dense areas, given that EVs have zero tailpipe emissions and do not produce any noise. Moreover, EVs contribute to the EU's energy and climate goals: electrically driven trains enable higher energy efficiency gains, and the electricity produced across the EU on the basis of different primary fuels or RES lowers the EU's oil dependency.

In order to overcome the initial drawbacks of EVs, users will likely demand more and easier access to information, ubiquitous charging infrastructure, universal access to infrastructure on a cross-border and Europe-wide basis, adequate fiscal or financial incentives and more user-friendly services. With their demand for coverage, charging services and anything else that supports electric mobility as a comfortable and interesting transport solution, it will be the users that will drive the development of EVs and the EV infrastructure.

Customers' expectations of easy and convenient access to charging stations must be balanced with the capacity of the local electricity grid to deliver the electricity in these places without putting the electricity distribution grid under pressure. Charging programmes on the basis of market price signals can contribute to balancing power supply/demand and lower intraday price volatility. The question of electricity distribution is an important one in this context, as a significant penetration of EVs, resulting in an increased power demand and un-forecasted mobility in connecting to the grid, could have an impact on national electricity systems. The general challenge of load management is already under extensive analysis, and a number of measures are being tested and developed across Europe to cope with the growing demand for power together with the increase of volatile energy sources like wind and micro-generation. Load management is a central justification for smart grids with their objective of managing the existing resources of electricity networks in such a way as to meet user needs in the most efficient and cost-effective manner. There are therefore clear benefits to integrating EVs into the smart grid paradigm, and also to using their batteries as storage resources for the grid.

Consequently, regulatory action will need to achieve a delicate balancing act: the idea that regulation should prevent a particular outcome such as an exclusive monopoly for building and operating the EV charging infrastructure must be balanced with the risk of regulatory failure, which might arise if the adopted regulation turns out to be inefficient compared to a commercially based outcome. Inefficient regulation could mean both a delayed adoption as well as adopting the wrong or sub-optimal solution in relation to the needs of the customers. Instead, regulation must ensure that competition is of direct benefit to users and should support steps of the value chain, given that the creation of a minimum coverage charging infrastructure is initially of low commercial feasibility.

Furthermore, it is necessary to keep in mind that the ultimate goal for the development of EV charging infrastructure lies in contributing to the overall take-up of EVs and, more generally, electric mobility as a more sustainable mode of transport. Therefore, customer needs should be placed at the centre of any development efforts. All other goals concerning, for instance, flexibility of energy demand, must be seen in that context.

Ultimately EV customers should be able to charge their EVs as easily as filling up traditional vehicles with petrol. They should be able to pull over, select their electricity supplier where there are several plugs available, and receive a transparent bill.

2. Scope of the paper

The paper presents a framework which policy makers can use when analysing different options to structure a market for rolling out public EV infrastructure. This document describes four possible market models, all in compliance with market liberalisation rules. The paper does not analyse the models with a view to highlighting pros and cons, but leaves this role to the reader, as any assessment depends on the country in question, market-specific conditions, economies of scale, technical know-how, etc. Hence this document serves as an objective fact sheet for modelling a market for charging EVs in public areas.

The following definitions are used to distinguish a market model from a business model:

Market model: describes the market for charging infrastructure and the services provided by the infrastructure, including necessary regulatory elements. The market model represents the different interactions among the various market players, defined according to their roles, under the given economic market forces.

Business Model: is based on a market model. Market players develop their own models and services in a regulated or competitive environment. The business model describes the different components and operation of a certain business together with the revenues and expenses the business generates.

The final choice of market model in a given country will depend on national characteristics which can be very different in nature. In the first instance, legislative and regulatory differences across countries will need to be taken into account and will determine the possible market structure to a large extent. The degree of unbundling within the electricity supply and electricity distribution companies also has an impact. Technical specifications and the currently installed infrastructure will also play a dominant role regarding whether or not connections are easy to obtain, the quality of the wires and electricity cables, the availability of garages, etc. In this respect, spatial planning will be crucial in ensuring the roll-out of charging infrastructure in locations on public property.

This paper proceeds as follows. First, it will consider some general thoughts regarding regulation and possible locations for EV infrastructure. This will be followed by a description of the four market models identified. Finally, the paper will present the possible market players.

II. General thoughts regarding the market structure for electric vehicle infrastructure

1. A regulated or non-regulated market?

Justification for regulatory action

Most industries in open and liberal societies are commercially driven and only regulated to a limited degree, reflecting the general belief in the ability of markets to reach an efficient outcome. In this view, regulatory intervention should only take place in case of market failures resulting in an inefficient outcome unless regulatory action is taken. Even if a market failure is present, some policy problems may be addressed more efficiently or effectively by a very limited regulatory effort, focused on ensuring framework conditions for the development of a well-functioning market. Regulatory intervention always implies the risk of regulatory failure. Such failures arise when regulation creates inefficiencies because no intervention should have occurred in the first place, or in cases when the regulator could have solved the problem more efficiently, resulting in greater net benefits.

Pollution and lack of environmental protection have often been described as public good market failures. The market failures arise because the non-exclusive and non-rivalrous nature of the environment allows for a situation where external diseconomies are not balanced by their costs to society. Other examples of public goods include public roads, street lighting, free parking spots, etc.

Another common type of market failure is the possibility of imperfect competition due to market domination. One reason for the existence of market domination can be the presence of a natural monopoly. Natural monopolies may arise in industries where there are economies of scale, giving the largest supplier on the market a significant cost advantage over potential competitors. A well-known example of a natural monopoly is the electricity distribution sector, where efficiency depends on having one single provider in each location and ensuring through regulation that all grid users can obtain non-discriminatory access to the network.

However, if the provision of the good or service in question has economies of scale comparable to other competitive business ventures, the foundations of a natural monopoly are not present. In such a case, market-based solutions are capable of reaching efficient outcomes, and the focus of the regulatory effort should lie on ensuring framework conditions for the market to develop under competitive conditions. Roll-out speed and size will thus not be a regulatory issue, but a result of careful commercial considerations. Framework conditions should include, but not be limited to, open access, standardisation, and regulation while simultaneously not undermining reward potential and/or removing investment incentives.

To sum up, access to public EV charging infrastructure can be considered as a public good, but the modalities of achieving this access depends on local political and regulatory choices in each country. Internalising the costs for rolling out the public charging infrastructure does not necessarily follow the same rationale as including externalities such as environmental effects in energy taxes. In some countries it is probably reasonable to argue that the users of the infrastructure should pay for the costs (through a grid fee for example), and not society as a whole (i.e. tax payers). In other countries the cost-effective choice might be for all users of a local grid as an existing natural monopoly to bear the additional costs for the public charging infrastructure.

Different regulatory options

With these general thoughts in mind, the paper presents various degrees of regulatory options below.

Non-regulation refers to a situation where an industry is completely unregulated and where multiple standards and services can be developed simultaneously. The result is a purely market-based outcome where the number of suppliers will be determined by factors such as economies of scale. This normally applies to markets which are inherently feasible and rational.

Self-regulation refers to the industry's own developed voluntary rules or codes of practice. The industry in question is solely responsible for compliance. The rules can be written and communicated by an industry association or they can be unwritten common knowledge among the firms operating in the industry. The government usually has no role under this form of regulation. Self-regulation can be effective where there is a cohesive and strong industry association representing the industry and/or where there are no economic incentives to deviate from the rules. Commonly accepted standards in any industry are examples of the optimality of such self-regulation. A firm is allowed to deviate, but has no incentive to do so because it limits the possibilities of using the product, thereby leading to customer inconvenience. This type of regulation normally applies to markets which are feasible but require intercompany collaboration in order to reach their full potential. The government can be more or less active on a market which is left to regulate itself. Public information and free public advice for instance can enable consumers to exercise their rights more actively.

Framework regulation refers to the range of rules, arrangements or standards which the regulator decides upon to create proper framework conditions for the industry to reach efficient outcomes based on commercial incentives. The regulation should be done based on 'minimum considerations', whereby only regulation specifically needed for the market to function should be introduced. Furthermore, the concrete regulatory initiatives should be decided on in close collaboration with the industry players in order to create the most efficient framework conditions for the industry. This type of regulation is well-suited for problems where purely commercial incentives are not sufficient to reach an efficient outcome. One example would be mobile phone chargers, where the market outcome has yielded a number of different charging plugs. Recent decisions on regulatory standards for such plugs will result in a more efficient outcome.

Full regulation refers to situations where the regulator sets extensive and legally binding rules and standards for the industry. For example, the regulator can set bounds on a firm's income to ensure that market power is not exploited excessively. Full regulation can be the optimal solution in cases where monopoly or oligopoly would be the market outcome, for example due to the presence of a natural monopoly. In such situations, framework regulation is insufficient to prevent a significantly inefficient market outcome, while full regulation can help to mimic market conditions and approach a more efficient outcome. Command-and-control regulation such as bans of certain chemical substances is often used in situations where deviations have high uncontrollable risks.

Regulation through public provision is a very interventionist type of regulation since it prevents new players from entering a particular market. It implies that the regulator decides upon a specific provider of the goods or service in question, and that the provider is publicly funded by regulation. In this case, the degree and type of provision will thus not be a result of commercial considerations, and the regulator will need to decide on all issues concerning the industry's further development. This type of regulation is the best solution in industries where the regulator derives extra benefits from directly regulating and controlling the provider. Such benefits can arise if there is a very strong political interest in a certain outcome and if the regulator is unable to provide incentives for reaching the desired outcome through full regulation.

The above-mentioned degrees of market regulation can be seen as long-term solutions to market failure. While the description above is static in nature, the real-life development process could involve various degrees of regulation as the industry matures. This has for instance been seen in industries which have been gradually liberalised. A high degree of initial regulation followed by liberalisation can be the preferred solution if the regulator wishes to direct the initial development for strategic reasons and thereafter prefers a commercially based outcome. Strategic targets can however be reached in many other ways, including support schemes that provide the right economic incentives for commercial players. That being said, adding dynamic considerations complicates the analysis significantly and will not be considered in more detail in this document.

2. Possible locations for EV infrastructure and their specific characteristics

The charging infrastructure for electric vehicles will need to be deployed in many different types of location (cities, highways, parking lots, residences, etc.). Although many issues are not location-dependent, each type of location has specific characteristics and related regulatory challenges which need to be taken into account. Grouping these locations together by shared characteristics leads to the following four types, which are very much related to the way the electricity supply structure is currently organised in most countries.

Public areas on public property

These types of location are normally owned by public authorities, often municipalities, and include roads, pavements, public telephone boxes, kerbs, public parking lots, etc. Currently, EV infrastructure deployment in public areas on public property is regulated by rules of concession, building permits, etc.

Electric infrastructure is available in the form of the DSO MV/LV (middle voltage and low voltage) network. This network runs under pavements, close to building walls or on elevated cables, and connects private installations on private property, normally through a single entry point. Currently there are no open access points available for users to plug in their electric application.

Depending on the location, considerable slack in power delivery conditions may exist in some cases that allow charging EVs free of charge. However, in many urban areas, power transformers may already be working at maximum capacity and might therefore require new investments in order to upgrade the delivery capability.

Existing electric customer installations (ECIs) are all for public purposes, including street lighting, traffic lights, and in some cases advertisement structures. Exceptions normally include temporary installations for the supply of electricity to events (fairs, concerts, etc.) or construction works, in which case DSOs make available a link for temporary private use. Other exceptions may include advertisement stands with permanent private contracts.

Charging in these locations will typically be undertaken by either EV customers who live in apartments without private charging facilities, or by customers parking their car for a shorter stay. While the first will require long-term charging, for example over night, the latter could imply a requirement for faster charging, for instance allowing the battery to reach 70-80% of total capacity within 20-40 min of charging. Stations for battery swapping are also a possibility here, allowing customers to change the discharged battery for a fully charged one, thereby quickly extending the EV range.

Public areas on private property

Public areas on private property are locations which can be freely accessed and entered, but where the property is privately owned. Examples of vehicle parking spots available to the public include shopping malls, private parking lots, and multi-office building garages. The following characteristics are worth mentioning.

The available electric infrastructure consists of the property owner's or user's ECI. It is connected to the DSO MV or LV network, normally through a single entry point, and is regulated by a power contract dimensioned to the property's needs. In principle end users have two contracts: a connection contract with the DSO and a supply contract with a retailer.

In this category, a single ECI exists for each property division and owner. Its purpose is to feed all electricity-consuming applications, ranging from electric machines, ventilation and lighting to electric socket outlets for portable and fixed applications like vacuum cleaners and computers.

The ECI's owner or user is responsible for the management and safety of the installation, from the DSO border equipment (meter and breakers) to all connected applications. He or she is also obliged to have a power contract with an electricity retailer to receive energy through the DSO managed network. Depending on national legislation, owners may or may not be allowed to resell electricity supplied at their installation to third parties.

In most of these locations several power socket outlets are available that can be used for EV charging. However, the ECI is normally not equipped to charge even a small percentage of the total parking spots without new cables, equipment and an upgrade of the power contract connection and/or supply contract. This is especially true for faster charging modes.

In outdoor locations of this kind there are normally no socket outlets available to the public, with the exception of countries with very cold weather, where there are low-power sockets for feeding cars' engine block heaters.

Private areas on private property

In private areas on private property, such as private homes, charging of the vehicle can take place in the garage. Electric infrastructure is available through the ECI of the owner or user of the property, which is connected to the DSO MV or LV network, normally through a single entry point and with a power contract dimensioned to the property's needs.

Fast charging locations

Fast charging is not a type of location, but rather refers to a technical sublevel within the classification of charging equipment. Fast charging can take place in locations such as (highway) fuelling stations and shopping malls, and especially in designated public spots in cities. Fast charging will most likely be situated in public areas on private property, but might also take place in public areas on public property.

The main difference between fast charging and normal charging lies in the additional service for the customer. Fast charging requires that the cables are permanently connected to the EV charging station. DSOs should therefore be closely involved in the planning of the feeding power for the fast charging stations, allowing for proper load management and avoiding problems in the electricity system.

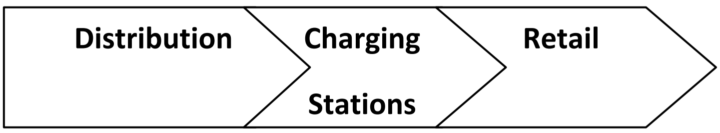
It is important to note that there is as of now no universally accepted technical definition of fast charging. Many interpretations are possible, including an AC 3-phase supply up to 43kW, direct DC from 20kW up to hundreds of kW, high power induction charging, etc. For the purposes of this document fast charging refers to a load higher than a 32A, 230V AC power connection.

III. Description of the identified market models

The market models for the charging infrastructure are defined in relation to the regulations for the locations of type 1 – public areas on public property. Sub-models are possible for each market model. Hybrid schemes are also possible, and the implemented models can change during the timeline of infrastructure deployment, as has been demonstrated for example in the energy and telecommunications industries.

These models take into consideration that investments have to be recuperated by some means, with a time period and operational cash flows adequate to the risk factor of the investments and corresponding financing conditions. Medium to long-term models for the free supply of electricity for e-mobility were not considered: since no such thing as free electricity exists, they would be unsustainable and would not incentivise efficiency in energy consumption.

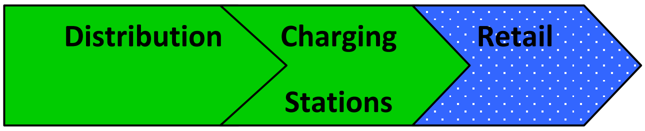
The following part gives a brief overview of the identified market models. When presenting the various market models for EV charging infrastructure, the following diagram will be used:



The model presents the part of the value chain for EVs that covers the electricity distributors, charging stations, and the retailers of electricity for EVs. It does not include other services such as battery leasing, operation and maintenance of vehicles, real-time information to drivers, etc. that may be provided to EV users.

Distribution of electricity is undertaken by the DSOs, which are fully regulated private or public firms. In the diagrams of the market models, boxes of the same colour represent integrated market functions.

Model 1 - The integrated infrastructure market model



In this model the current electricity supply market structure is kept in place, i.e. the charging infrastructure is fully integrated into the DSO's assets. The EV charging sockets are therefore considered as distribution assets. The commercial relationship for the supply of electricity is conducted, as is usual in the electricity market, between the users and the retailers. Under this model the deployment of the charging infrastructure is collectively financed.

The current tariff structures are kept in place, with the costs of the infrastructure reflected in the regulated tariff for LV/MV network usage. In this utility based model, the market is characterised by free retail: all retailers are free to offer their products and services.

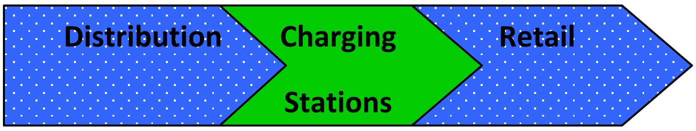
In the "integrated infrastructure" model, network investments are remunerated on the basis of Regulated Asset Bases for all the charging network assets which are integrated into the regulated MV/LV distribution system.

Within this open access infrastructure the customer will be charged a price established by the market. This model does not charge any additional access fee, as all the costs are covered by the network usage tariff, common for the whole system. However, when the customer opts for fast charging services, a regulated premium above the market price/tariff will likely be charged by the corresponding DSO.

In this model, the user has a contract with a retailer for e-mobility which can be pre-paid or post-paid. The main difference to a normal electricity contract is the fact that it gives mobility to the users, allowing them to charge their EV at any location within the charging network managed by the DSOs while still receiving the same bill from the retailer. The DSOs may provide users with an ID key which is associated with an e-mobility power contract with one retailer. The user may have more than one such contract and ID key, just like a mobile phone user may have more than one SIM card.

Alternatively, users could have the ID key but be able to choose the retailer each time they charge their EV, or the system may even use existing debit/credit card systems to charge users directly.

Model 2 - The separated infrastructure market model



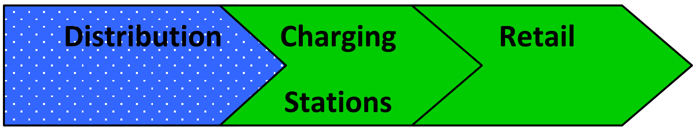
In this model, the EV infrastructure is conceived as a new, separate and independent step in the value chain for e-mobility, with the creation of the new role of charging infrastructure operator. The infrastructure however still falls under the rules concerning the unbundling of infrastructure and retail, and therefore all retailers have access to all EV charging sockets of all charging infrastructure operators. Under this model the charging infrastructure is financed by the "user pays" principle.

In this model all direct assets for the charging of EVs are considered to be outside the existing distribution network, and are therefore regarded as a new element to the value chain of electricity. However, the new operator is still only a special distributor who is independent of retailing electricity and agnostic regarding the commercial relationships between the users and the retailers. The financing of the charging network is governed by the "user pays" principle, where only the revenues from the electricity supplied at the infrastructure are used for the recuperation of the investment costs. Therefore the charging network operator will add an access fee onto the retailer's price, resulting in a final user e-mobility electricity price which will be higher than the normal electricity price. These operators will have to create a new billing and authentication system for their own network, with interfaces to all other networks and retailer data systems (just like a DSO), or they may cooperate and share one central IT system that manages the entire network, regardless of which operator owns which EV sockets. The model thus creates two roles: the central network management responsible for information and clearing, and the operators which only physically operate and maintain the charging points.

Within this scenario the market is structured by a regulated or non-regulated e-mobility infrastructure developed by one or more independent operators, who need to have licenses to install and run the EV charging sockets conceded by the municipalities. Access to the electricity network is open to all electricity retailers. The power retail market is assured by free market players and/or regulated retail electricity tariffs.

Like in model 1, network operators will probably charge higher access fees for fast charging in order to compensate for the higher investments in this infrastructure.

Model 3 - The independent e-mobility market model



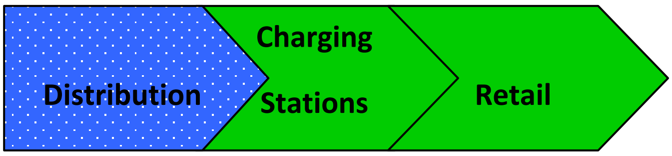
In this model there is a new role for an independent e-mobility provider that installs a proprietary network of EV charging sockets and provides electricity bundled with other services, including the charging. This new entity only sells services within its national network. Under this model the charging infrastructure is financed by the "user pays" principle.

Instead of charging users per kWh, e-mobility providers might base their charges for giving users access to the network on a different marketing metric or on a monthly or annual rate, in a similar way to a mobile phone network provider.

The market structure consists of an integrated network of charging stations and e-mobility electricity retail operations. At least during the initial phase, the market is dominated by a national or regional monopoly which encompasses all the assets of the network operation. The single entity acquires the electricity from retailers at liberalised market prices. Final e-mobility prices will include the costs of financing the network. In this scenario fast charging may or may not imply an additional premium on the market price/tariff.

The network operator can be a public company, a publicly regulated company or a private operator with a national concession or licence.

Model 4 - The spot operator owned charging stations market model



In this model the charging stations and the selling of electricity are conducted by the parking spot owner or operator, who does not directly own the spot but rather has the right or license to operate the spot. These entities build the EV charging sockets and control the selling or reselling of electricity in the spots they manage. Under this model the charging infrastructure is financed by the "user pays" principle.

Municipalities own the spots on public pavements, but they can introduce a licensing scheme for multiple companies to bid for high-interest locations. A new type of electricity actor would emerge, enabling customers supplying EV charging equipment on public property within a normal power contract to resell electricity to mobile customers that connect to this EV charging equipment.

In the “spot operator owned charging stations” market model multiple low-scale market players, together with existing players like electricity retailers and DSOs (outside their regulated activity), compete for the high-potential spots, but are less interested in installing charging stations at less utilised locations unless forced to do so by license. The model may allow the creation of “local monopolies” similar to the current fuel distribution model, where EV customers cannot choose their spot operator freely because of an EV’s limited range or local restrictions. Operators acquire electricity at market prices through standard supply contracts.

The model may also require an EV customer to sign up to more than one spot operator in order to access EV charging equipment in adjacent areas. Alternatively “roaming” might be foreseen: the spot operator would recognise the ID tags of other operators and would allow access to their charging equipment. In a market where IDs are not required easy park-and-charge solutions will be developed. The network remuneration is included in the final e-mobility electricity price. Possessing the most effective spots will allow operators to charge a premium above other electricity prices. It may also be the case that spot operators charge for a bundled product (e.g. parking) and do not specifically measure the electricity consumption. The energy consumption would then be recorded in the main supply for the site (e.g. multi-storey car parks) and paid for by the site operator in the overall bill.

The operators will determine the electricity prices freely, considering each spot’s potential and competitive pressure. In this market model also, fastest charged electricity implies a premium over the market price or the market tariff. The operators will compete with home charging, work place charging and free charging in parking spots where the owner wants to attract clients for other reasons, for example in suburban shopping areas.

Infrastructure operation and maintenance companies may offer their services to different spot owners in order to benefit from a larger scale effect in managing these sockets.

IV. Identification of the market players

The described market models influence, and are influenced by, different stakeholders with different economic and social interests in the EV paradigm and in the overall energy and transport markets. These stakeholders will look for opportunities to launch new businesses or changes to their activity, while trying to minimise any possible threats to their currently performed roles, duties, businesses or interests.

The market models should be analysed with regard to the different impacts and opportunities for at least each of these major groups of stakeholders:

Current electricity customers - Households, companies, municipalities, etc. that are currently using electricity in their applications, with existing power supply and/or electricity point connection contracts.

E-mobility electricity customers - Existing and future users of EVs that need to charge their vehicles both at currently available “normal” electric installations and at future dedicated charging infrastructures.

National governments - These have an interest in promoting the utilisation of EVs and the creation of a freely accessible and job-creating e-mobility market, whilst maintaining control of transport sector efficiency and tax-related income.

DSOs - The distribution system operators are companies currently holding and managing the assets for MV and LV distribution networks, responsible for connecting all loads to the electric system and maintaining a stable, safe and reliable network for the supply of electricity to all customers.

Retailers of electricity - These are the present and future companies that hold licences (or are active on the market - not all countries have licenses) to sell electricity that they produce themselves or purchase on the electricity markets to end users, with whom they have power contracts with fixed locations for the supply.

National and international electric grid control entities - State-owned or private entities with the responsibility of managing national and international electric systems as a whole, ensuring an equilibrium between electricity generation and the use and flow of energy and power between regions. Depending on the country these entities may be the national TSO and may also have dispatch control over large generation.

Electricity regulators: Regulate the electricity market to protect electricity consumers by promoting on a European level a single, competitive, efficient and sustainable internal market for electricity.

Equipment and service providers: Companies that provide a service or equipment to the e-mobility market, e.g. telecom or ICT industries that enable communication between the EV and the electricity grid.

New entrants - These are entities or companies that are currently not performing any of the previous roles and are willing to take up the e-mobility paradigm.

V. Conclusion

This paper sets up an analytical framework of possible options for structuring and designing the market for EV public charging infrastructure by providing a descriptive snapshot.

The paper takes three major roles within the value chain of e-mobility electricity - distribution, operation of infrastructure, and retail - as a point of departure to identify and describe four major market models that encompass most, if not all, options currently being implemented across Europe or developed on the drawing board. When analysing these models, different stakeholders should not only consider the impacts on other stakeholders along the value chain, but also a number of important issues related to EVs in particular, and to the wider electricity and transport sectors in general.

At present it would be premature to recommend one particular market model over another. In practice, different models and solutions are likely to be implemented depending on the specific market conditions, economies of scale, government decisions and incentives, and technical know-how of each individual country. Moreover, the models are not necessarily mutually exclusive and could co-exist alongside one another. It is not necessary for regulators or legislators to impose one individual model; rather, they should leave room for market development by leaving all options open.

Market operators and authorities should at present mainly focus on the further development of adequate EV products. The electricity sector is contributing to this effort, not least through its participation in EV standardisation activities. At the same time, the demand for EVs should be stimulated by appropriate policy measures. In the first, introductory phase, EVs can be charged without specific new charging infrastructure (e.g. at home or in private parking stations); in the second phase different options (e.g. specific mono- or multi-supplier charging stations in private or public locations) can be implemented in order to successfully deploy EVs.

VI. Glossary

DSO – Distribution System Operator

ECI – Electric Customer Installation

EV – Electric Vehicle, referring in this paper to battery electric vehicles and to hybrid plug-in electric vehicles

MV Network – Medium Voltage Network

LV Network – Low Voltage Network

RES – Renewable Energy Sources

Union of the Electricity Industry - EURELECTRIC aisbl
Boulevard de l'Impératrice, 66 - bte 2
B - 1000 Brussels • Belgium
Tel: + 32 2 515 10 00 • Fax: + 32 2 515 10 10
VAT: BE 0462 679 112 • www.eurelectric.org