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Report on EV charging pricing, regulatory framework and DSO role in the e-mobility development

final report

EXECUTIVE SUMMARY

E-mobility is an integral part of the long-term energy transition that the EU has committed to meet ambitious greenhouse gas emission reduction targets in the transport sector. The introduction and acceptance of e-mobility (electro-mobility) as a complete socio-technical system is a prerequisite for the performance of electric vehicles.

This report considers the **regulatory barriers** that significantly slow down the development dynamics of e-mobility, provides analyses **distribution system operator (DSO) position** with regard to the e-mobility, reflect the current market positions of key stakeholders and views on possible solutions to improve the regulatory framework as well as the institutional organization of the e-mobility.

In Croatia, the market model of e-mobility is in place in which the distribution system operator (DSO) is not involved in the installation and operation of charging infrastructure for electric vehicles. Such a model is in line with the guidelines of the Directive of the European Parliament and of the Council concerning common rules for the internal market in electricity [COM (2016) 864 final]. In such a model, the distribution system operator is responsible for developing the infrastructure up to a measurement point and the owner of the charging station for electric vehicles is considered to be the final customer of electricity. In this respect, the activity of the owner/operator of the EV charger is not considered to be a sale of electricity (energy activity) but the provision of charging for electric vehicles.

The countries where Distribution system operator (DSO) plays an active role, i.e. the duty to establish a network, are now in the process of leaving such models.

The role of the DSO in the development process for e-mobility concerns the provision of such a system to meet the needs of reasonably expected energy consumption for future e-mobility needs, and to facilitate synergies between renewable energy sources and electric cars. A prerequisite for this is the deployment and development of a system of advanced networks that will allow the coordination and management of the power system load during charging for electric vehicles.

Analysis of EV charging station status in the regulatory framework of certain EU countries

The analysis of the role of the distribution system operator (DSO), electricity network charges, as well as the amount and structure of fee for EV charging in several EU countries was carried out. Certain countries differ substantially in terms of responsibilities of DSO for installation and operation of EV charging infrastructure. While in Italy and Ireland and in part also in Slovenia, DSOs are responsible for developing electric vehicle charging infrastructure, in countries such as the Czech Republic, the Netherlands and Hungary and Austria, its development is based exclusively on market principles, and the DSO activity is reduced to the regulated activity of electricity distribution. Short summaries are given below.

In **Slovenia**, the Energy Act (Official Gazette RS, Nos 17/14 and 81/15) defines in Article 78 that the distribution system operator is responsible for the development of basic public infrastructure for electric road vehicles operating on the motorway network. In the event of an increase in the market interest in the establishment (investment and management) of the infrastructure for the rapid charging of electric vehicles, the phasing out of the SODO activity (which is in line with the recast proposal for Directive 2009/72/EU on common rules for the internal market in electricity) will be required. The SODO has published, in 1.1.2018 tariff lines for the customer group of full electric vehicles on fast charging stations on the motorway network.

Unlike Slovenia, where the distribution system operator is in charge of the development of charging infrastructure only on motorways, in **Ireland**, DSO is in charge of the development of all charging points. More than 1.000 chargers have been developed so far, which are all owned by distribution system operators. In order to separate the activities of the DSO from the operating of charging points, there was a need to make an accounting separation, i.e. part of the distribution tariff charged to end-users by the cost of the DSO when investing in the charging station infrastructure, to be kept in a separate account. Currently there is no fee for charging for electric vehicle owners in Ireland.

In **Italy**, the development process is taking place through demonstration projects to test different models of ownership and organization of charging points. Following an analysis of the implementation of these projects, and under the impact of the Directive on common rules for the internal market of electricity, a conclusion has been reached that the distribution system operator is no longer able to have any ownership of charging and it was left to commercial operators. In order to further boost the development and installation of charging infrastructure, the regulatory agency has introduced a new, enabling tariff for the use of the network, which only accounts energy.

In contrast to some of these countries, where the development of e-mobility is in the early stage, in the **Netherlands** the network is significantly developed, and interoperability is ensured throughout the country when using charging stations. It has also established an institute tasked with assisting local authorities and interested parties in the installation and opening of new charging points. In addition to the company taking care of existing charging stations, the institution was set up jointly by all transmission network operators in the Netherlands. Only market operators are the owners of charging stations in the Netherlands.

In **Greece**, the pricing method and billing conditions for EV users regarding the provision of use of recharging or electro mobility services are set as a free market model. Regarding the role of DSOs (in Greece currently only one – HEDNO), they are not permitted to own, develop, manage or operate charging points for electric vehicles, except for own private charging points solely for their own use.

The **Portuguese** Electric Mobility Network Management Entity (EGME) is MOBI.E, SA, a public company indicated by the Government, that ensures the management of the energy and financial flows resulting from the operations of the electric mobility network. The EGME has tariffs, set by the Regulatory Authority for Energy Services (ERSE), established to provide EGME with an amount of income calculated in accordance with the provisions of the Electric Mobility Regulation, applied to the electric mobility activities regulated by ERSE, covering the entire national territory.

In the Autonomous Region of the **Azores,** there is a dedicated network tariff for electric mobility defined by the Energy Services Regulatory Authority (ERSE) that is charged by EDA, the Azores

Energy Distribution entity. The tariff for Energy and Commercialisation of Electric Mobility, collected by EDA, for the charging of electric vehicles is composed of prices of active energy that are broken down by an hourly rate, in euros per kWh.

In the **Czech Republic**, distribution system operators are not involved in the installation and operation of the EV charging system. The current network of publicly accessible charging stations is developed on market principles, mainly by electricity companies. The role of the DSO on e-mobility is about developing and implementing new technologies on the medium and low voltage electricity grid in order to integrate electric vehicle charging infrastructure in the electricity system.

It should be noted that specific tariffs were set up in the Czech Republic for the use of the distribution network for electric vehicle users, both for households and for companies. One important and active role of DSO in e-mobility is to determine the period of application of a lower tariff for users of special tariffs for charging electric cars.

Under the regulatory framework in **Hungary**, DSO, and any other stakeholders, there is no responsibility for the development of electric vehicle charging infrastructure. The chargers may be built by any qualified market participant without any legal restriction, thereby facilitating free competition. In Hungary, there are no tariffs applicable to electric vehicle users. Installation of charging stations does not enjoy any priorities and the investor has to pay for the compensation for connection to the distribution grid.

1. PRELIMINARY OBSERVATION

The introduction and acceptance of e-mobility (electro-mobility) as a complete socio-technical system is a prerequisite for the performance of electric vehicles. In order for electric vehicles to be in a position to compete with conventional cars (ICE - internal combustion engines) in market conditions, it is necessary to develop a full set of e-mobility elements such as standards, regulatory frameworks, environment and energy policies, established practices, products and services, user experiences and needs, and charging infrastructure.

There are two global approaches to boost e-mobility:

- Bottom-up, where the initiative comes from both the beneficiary and the business segment that seeks to compel the government to introduce various forms of incentives. The main example of this approach is Norway.
- Top down, where the government seeks to impose e-mobility to society. Most countries in Europe follow this approach by setting targets and incentive schemes.

As in over Europe, Croatia applies the above-mentioned "top- down" approach, but the focus is mainly on fiscal stimulus and e-mobility measures. This ignores the need to recognize the shortcomings of the existing one and to create a new **legal and regulatory framework** which can underpin the future development of e-mobility. Clearly defined legal solutions are a prerequisite for creating a competitive market based on business models.

Many stakeholders in Croatia are active in following global e-mobility trends, and have identified market potential to develop their own network of charging points for electric vehicles, which are continuously expanded and upgraded. On the other hand, certain barriers of a legal and regulatory nature, such as, for example, the non-existence of specific tariffs for charging electric vehicles, prevent the realization of business models at an early stage in the development of the market as it is today.

This report has analyzed the current outlines of the regulatory framework relevant for e-mobility in **Croatia**, the role of distribution system operator (DSO), the role of market participants, payment for the use of electric vehicle charging networks, and the level and structure of price for electric vehicles charging. The same has been done for **certain countries in the European Union** and a comparative analysis has taken place.

2. CROATIA: REGULATORY AND ORGANISATIONAL ASPECTS OF E-MOBILITY

Developing the concept of e-mobility as an integrated part of the transport sector, electricity system and climate policies needs to meet not only technical requirements, but also adapting regulatory and organisational elements in order to create a clear and enabling environment for faster but also regulated and thus long-term sustainable development.

In addition to the concept of e-mobility, there are also completely new activities for which the current and new market players have an interest. On the other hand, unadjusted regulatory and legal elements prevent the establishment of business models for certain activities and thus hamper the development of e-mobility.

The following sub-sections analyse the current market relationships of stakeholders in the concept of e-mobility and analyse in particular the position and role of the distribution system operator (DSO). In addition, a comprehensive view of the market position of other involved companies is given. The potential for establishment of business models is evaluated, which requires an analysis of the regulatory framework, namely the tariff models applied to the charging station as the final purchaser of electricity.

1.1. THE MARKET RELATIONS OF KEY ACTORS IN E-MOBILITY

A key determinant of the market relations of stakeholders in the context of the electricity market is that the owner of the charging station is defined as an ultimate purchaser of electricity, i.e. the buyer who purchases electricity for its own use. In that connection, the provision of charging for electric vehicles is not considered to be a sale of electricity, but exclusively for the provision of services. Thus, the regulated activity pursued by the DSO covers activities which take place up to the point of connection to the distribution network, and all after that constitute a market activity in the field of e-mobility. The charging point for electric vehicles is treated as any other buyer or consumer connected to the electricity distribution network.

In the early stages of development of e-mobility, it is often the case that the same entity to perform a set of activities in the field of e-mobility. However, the progressive development of that activity is carried out on a stand-alone basis, which can be carried out by different entities. The owner of the EV charger, as the electricity final customer, has the option of transferring certain activities involving e-mobility to other entities. It is thus possible for the EV charging station to be managed and maintained by another entity other than the owner. Likewise, the provision of e-mobility services (charging of electric vehicles, user identification, subscriber services, billing, etc.) may be left to a separate entity through contractual relations.

For the market model described above, it can be found in the provisions of the Alternative Fuels Infrastructure Act (Official Gazette 120/16), Article 6, defining the provision of electric vehicle charging service in such a way that operators of recharging points accessible to the public (final

electricity customers within the meaning of the Electricity Market Act) provide recharging services for electric vehicles to users under a contract or ad hoc contract. Operators of recharging points accessible to the public may provide charging for electric vehicles on behalf of other service providers.

This is precisely the case of operators, where distribution system operators (DSO) are not involved in the installation and operation of EV charging infrastructure for electric vehicles, that are present in many countries where the concept of e-mobility is more developed than in Croatia. Those Member States which in the early stages of developing e-mobility implemented the market model where the DSO is designated to install and operate the EV charging stations are now leaving these models and have to reorganize them.

1.2. THE ROLE OF DISTRIBUTION SYSTEM OPERATORS IN E-MOBILITY

The previous chapter explains how the DSO as a regulated activity does not participate in the installation and operation of charging infrastructure for electric vehicles. The positioning of the DSO in the context of electric vehicle charging infrastructure is precisely defined under Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 concerning common rules for the internal market in electricity and amending Directive 2012/27/EU. Article 33, entitled "Integration of electro-mobility into the electricity grid", states that Member States shall provide the necessary regulatory framework to facilitate the connection of publicly accessible and private recharging points to the distribution networks. Furthermore, Member States shall ensure that distribution system operators cooperate on a non-discriminatory basis with any undertaking owning or developing or operating recharging points for electric vehicles, including their connection to the grid.

Article 33 (2) of the Directive stipulates that distribution system operators must not own, manage or operate recharging points for electric vehicles unless the distribution system operators have private recharging points for their own use only. Further, paragraph 3 of that Article sets out the conditions under which it is possible to derogate from paragraph 2 and essentially minimizes the ability of distribution system operators to own, develop, manage or operate recharging points for electric vehicles only if it is established when there is no interest of other operators to perform that activity. In the event that such a derogation is applied, it is necessary to verify the existence of interests of other entities on a regular basis and, in the event that it is reported, Member States shall ensure that distribution system operators' activities in this regard are phased-out.

Although the Directive clearly sets out how the DSO should not be involved in the development, installation and management of charging stations, the role of the DSO can be seen in the context of developing the overall concept of e-mobility as well as in the context of the installation and connection of charging points to the electricity grid.

The role of the DSO in the development of e-mobility can be seen in the context of Article 39. The Electricity Market Act (Official Gazette, 22/13, 95/15, 102/15, 68/18) which enumerates the responsibilities of the distribution system operator, stating, inter alia, that the distribution system operator is, in particular, responsible for:

- development of a distribution network which ensures the long-term capacity of the distribution network to meet reasonable demands for the distribution of electricity;

- the management of the distribution system in such a way as to achieve the reliability of the electricity supply and the efficient use of the distribution network;
- the collection of the total amount of electricity supplied into the grid from preferential producers connected to the distribution network, provided that the requirements relating to the maintenance of the reliability and safety of the facility are met, in particular according to the network codes of the distribution system;
- giving due attention to nature and the environment.

Although the responsibility of the DSO in relation to e-mobility is not stated explicitly, the highlighted provisions clearly demonstrate the role of the DSO in developing e-mobility, based on the provision of such a system to meet the needs of reasonably expected energy consumption for future mobility needs, and to facilitate synergies between renewable energy sources and electric vehicles. The key for a successful integration of electric vehicle charging infrastructure in the electricity system is the deployment of advanced grid systems and the inclusion of the highest possible part of electric vehicle charging in such a system. Coordination and load management for electric vehicle charging may facilitate the integration of renewable energy sources in the electricity system, enable network management in a flexible way, optimize the use of generation capacity, and provide a cost-effective solution avoiding unnecessary investments in network infrastructure.

Therefore, the current role of the DSO in the development of e-mobility is reflected in the monitoring of current trends in the development of e-mobility, the analysis of the expected energy needs and its impact on the electricity distribution network, and accordingly to adopt appropriate network development plans to ensure all the conditions for development of e-mobility.

On the other hand, as regards connection to the electricity grid, according to the current legislative framework of the Republic of Croatia, charging stations for electric vehicles are classified as simple connections and characterized as simple works in accordance with spatial planning and construction regulations for which there is no need to create conditions in a network. The connection as an integral part of the network forms the physical part connecting the network user to the distribution network and includes the measurement equipment and the charging point.

The role of the DSO in the construction process of a particular EV charger shall not be distinguished from other structures for which a simple connection is required and under the rules on connection to the distribution network, inter alia:

- the granting of an electrical conformity (EES), based on the user's consent requirements;
- award of connection to the network user;
- execution of connection to the distribution network.

The position of HEP-ODS d.o.o. (Croatian DSO) as a regulated entity that is not involved in the installation and management of charging stations is the correct approach and is in line with good practices found in many European countries. Countries where DSOs have played a key role in setting up the core network of charging points are now in the process of leaving such models and making existing infrastructure available to market operators.

1.3. REGULATORY FRAMEWORK AND TARIFF MODELS FOR RECHARGING POINTS FOR ELECTRIC VEHICLES

In previous chapters, it is explained how the owner of the charging station for electric vehicles is considered to be the final customer of electricity. In order to analyses under which conditions the final customer is able to purchase electricity, first of all, it is necessary to review the regulatory framework, namely regulated prices and the fixing of prices on the market.

1.1.1. Regulatory framework

The electricity market has been liberalized by the separation of regulated and market activities (Electricity Market Act, Official Gazette, 22/13, 102/15, 68/18, 52/19). Based on the breakdown, the core electricity activities are:

Market activities

1. electricity generation;
2. the supply of electricity (with the exception of supply as a public service),
3. trade in electricity.

Regulated activities

1. transmission of electricity,
2. distribution of electricity,
3. organizing the electricity market.

The transmission and distribution of electricity is not a market activity since it is natural monopolies. Regulated activities are controlled and regulated by the Croatian Energy Regulatory Agency (HERA). Accordingly, the structure of the energy price for final customers, which therefore contains a part of the price freely negotiated and part of the price regulated and is subject to the tariff system, is also set out accordingly. In addition, the price also contains allowances and other fees according to special regulations. In particular, the following price components for electricity exist:

1. Electricity (final customer purchases from supplier),
2. Compensation for the use of the transmission and distribution network (the so-called "network cost"),
3. Charges for renewable energy sources and high-efficiency cogeneration,
4. Excise duties.

As the supply of electricity is a market activity, this means that final customers have the right to choose the supplier with whom they wish to enter into a supply agreement freely agreeing on the volume and price of electricity, as well as other accounting elements.

On the other hand, compensation for the use of the transmission and distribution network (network cost) is regulated, which means that prices are determined on the basis of the tariff system. The tariff system shall be the prescribed methodology and the amount of the tariff item. Tariff systems should encourage mechanisms to improve energy efficiency and demand response, including the increased use of renewable energy sources and cogeneration. The tariff lines shall be determined on the basis of a tariff methodology, which in turn is based on legitimate business costs, replacement, construction or reconstruction of facilities and protection of the environment, and must ensure an adequate recovery of the reasonably invested funds and may be based on the incentive method or other method of economic regulation. The tariff methodologies and the tariff lines shall be adopted by HERA.

1.1.2. Tariff model and EV charging stations

The charging station for electric vehicles in the context of the regulatory framework is seen as the final customer of electricity. As explained, the supply of electricity is a market activity, and it is therefore necessary to take into account only the regulated component of the electricity price to be paid by the final customer when analyzing relevant framework for the development of the e-mobility.

Final customers pay a fee for the use of the transmission and distribution network and are classified in categories. The owner of the EV charger purchases electricity as a final customer for the purposes of producing goods and/or providing services and does not use it in his household and therefore falls within the category of "enterprise".

For end customers, the category of low voltage entrepreneurship is defined in the so called "Blue", "White", "Red" and "Yellow" tariff models. The vast majority of publicly accessible charging points for electric vehicles have a power exceeding 22 kW and are therefore subject to the tariff model "Red", which includes, inter alia, tariff lines for the "engaged peak power load" (HRK/kW).The engaged peak power load is the maximum average operating power measured during each accounting interval within the monthly accounting period at the time of the higher daily rate (Highest load power (kW) achieved during one month).

A large number of publicly available AC stations are designed to have two connections per 22 kW on motorways, larger urban and, at intermodal nodes, installed mainly DC high power recharging points, of 50 kW at more.

With regard to the use of the Red Tariff Model, it is clear that the electricity cost structure paid by the final customer will substantially depend on the amount of the tariff item of an engaged peak power load. The tariff lines for the White model (without the accounting of the engaged peak power load) and the Red model are shown in the table below.

Table 1 Tariff lines table for the use of the network for the buyers of the enterprise category; in application from 1 January 2019

Category of buyer	**Tariff model**	**Tariff item**				
		Labour energy (HRK/kWh)		engaged peak power load (HRK/kW)	Excessive reactive energy (HRK/kvarh)	Fixed monthly fee (HRK/month)
		VT	NT			
Entrepreneurship	White	0,35	0,17	2 —	0,15	41,30
	Red	0,21	0,10	**38,50**	0,15	41,30

(source:HEP-ODS, 2020)

As a result of the tariff model presented and of the tariff lines it may be made, the simple calculation of the monthly cost for the engaged peak power load, assuming that at least one charge at maximum full power is generated on the fast charging station.

Table 2 Calculation of the cost of the engaged peak power load

Power station connecting force (kW)	Engaged peak power load (HRK/kW)	Cost of engaged peak power load (HRK)	Cost of engaged peak power load (EUR)
22	38,50	847	113
50	38,50	1.925	256
175	38,50	6.737	898

(source:Author, 2020)

As shown by the budget, the cost of an engaged peak power load is very high, which represents a key barrier for setting up a business model in which that cost could be recovered from the beneficiaries of the initial stage of development of e-mobility, when the number of beneficiaries is relatively small. Indeed, the cost of an engaged peak power load in a given month does not depend on the number of customers (the number of charges) or on the energy supplied as a whole, but on the highest assigned power engaged at any time during that month. Therefore, the table below shows the calculation of the cost of the engaged peak power load divided by the number of EV charging in one month, for the various charging points.

Table 3 Calculation of the cost of the engaged peak power load per charging session number

		Cost of engaged peak power load per charging session (EUR/charging)		
Number of EV charging sessions per month	**Average number of daily charging sessions per day**	**22 kW**	**50 kW**	**175 kW**
1	0,03	112,9 €	256,7 €	898,3 €
5	0,2	22,6 €	51,3 €	179,7 €
10	0,3	11,3 €	25,7 €	89,8 €
20	0,7	5,6 €	12,8 €	44,9 €
30	1,0	3,8 €	8,6 €	29,9 €
40	1,3	2,8 €	6,4 €	22,5 €
50	1,7	2,3 €	5,1 €	18,0 €
100	3,3	1,1 €	2,6 €	9,0 €
200	6,7	0,6 €	1,3 €	4,5 €
300	10,0	0,4 €	0,9 €	3,0 €
400	13,3	0,3 €	0,6 €	2,2 €
500	16,7	0,2 €	0,5 €	1,8 €

(source:Author, 2020)

In the case of a fast charging station with a power connected with a power of 50 kW, it may be observed that only if the monthly charging number is higher than 100, the cost of an accounting peak is reduced to less than 2,6 EUR.This also means that on average more than 3 charging sessions per day are needed.

It can be concluded from the problem described how the current system makes it impossible to develop business models for investors in fast charging stations, as well as demotivating the private sector to engage in the development of electric vehicle charging infrastructure, especially at an early stage in the development of e-mobility when there is no sufficient number of users.

1.1.3. Connection to the distribution network

The connection of charging points for electric vehicles to the distribution network does not differ from the connection processes of other buildings. Thus, there are no specific conditions or rules that would apply to the EV charger. According to performance or the connection procedure two main cases can be distinguished:

1. Installation of charging points connecting to the existing network user installation through an existing billing site;
2. Installation of charging points through a separate connection position.

In the first case where the charging station is connected to an existing installation, the only condition is sufficient connection power in the existing measurement position. If the leased power is insufficient, it is necessary to apply for an increase in the corresponding distribution area. The most common example of such connection is for charging stations with less power, mainly in companies, restaurants, households and other.

In the latter case, the application for an electrical consent (EES) for the connection of electric vehicles charger located in the area in which the charging station is planned shall be applied for.

The connection to the distribution network is a one-off cost for the investor in the installation of the EV charger which is treated under this procedure as any other consumer. The calculation of the compensation is defined in the Methodology for determining the fee for connection to the electricity grid of new network users and to increase the connection power of existing network users (Official Gazzete 51/2017). According to the current prices, the unit price for the connecting power is HRK 1.350/kW (180 EUR/kW), and HRK 1.700/kW for the City of Zagreb (226 EUR/kW), without VAT. An example of calculating this cost for the various connections of EV charging points is shown in the table below.

Table 4 Examples of fees for connection of charging points to the distribution network (VAT excluded)

Amount for the connection fee (EUR/kW)	**180 EUR**	**226 EUR**
EV charging station connecting power (kW)	**Connection fee — City of Zagreb (EUR)**	**Connection fee — Others (EUR)**
22	4.987 €	3.960 €
44	9.973 €	7.920 €
50	11.333 €	9.000 €
100	22.667 €	18.000 €
175	39.667 €	31.500 €

(source:Author, 2020)

It may be noticed that the compensation for the connection to the distribution network may represent a very high cost and a large proportion of the cost structure of the total investment.

1.1.4. Charging of electric vehicles at home

Appropriate devices can be used to charge electric vehicles at home, with the possible charging of the vehicle using a direct home socket. Whatever method, charging the electric vehicle takes place under the same conditions as for all other appliances in the household. In other words, there are no specific tariff models relating to electric vehicle users and therefore the electricity fee is the same as for the entire household.

Using an existing tariff model with a higher and lower rate of customers, the user is motivated to take charge of vehicle charging during night hours, i.e. the lower rate period, which represents the basic measure of demand response. However, if special tariff schemes are in place for households using electric vehicles, it would be possible to create a more complex demand response that could increase user motivation to carry them out at set time intervals, depending on the needs of the electricity system.

3. STATUS OF THE EV CHARGERS IN REGULATORY FRAMEWORK BY THE SELECTED EU COUNTRIES

This chapter consists of analysis of position of DSO and role of other key stakeholders at the e-mobility market of several EU countries. Furthermore, the analysis of network costs and EV charging pricing is done.

Chapter IV of the Directive of the European Parliament and of the Council concerning common rules for the internal market in electricity [COM (2016) 864 final] provides some clarifications on the tasks of distribution system operators, in particular as regards their activities relating to the deployment of network services in order to ensure flexibility, integration of electric vehicles and data management. It also clarifies the role of distribution system operators (DSO) as regards storage and charging points for electric vehicles.

The Article 33 of the Directive states that Member States shall provide the necessary regulatory framework to facilitate the connection of publicly accessible and private recharging points to the distribution networks. Member States shall ensure that distribution system operators cooperate on a non-discriminatory basis with any undertaking that owns, develops, operates or manages recharging points for electric vehicles, including with regard to connection to the grid.

Member States may allow distribution system operators to own, develop, manage or operate recharging points for electric vehicles only if the following conditions are fulfilled:

- other parties, following an open and transparent tendering procedure, have not expressed their interest to own, develop, manage or operate charging points for electric vehicles;
- the regulatory authority has approved that the DSO owns and operates charging infrastructure for electric vehicles.

Member States shall perform at regular intervals or at least every five years a public consultation in order to re-assess the potential interest of market parties to own, develop, operate or manage recharging points for electric vehicles. In case the public consultation indicates that third parties are able to own, develop, operate or manage such points, Member States shall ensure that distribution system operators' activities in this regard are phased-out.

3.1. PORTUGAL

3.1.1. The role of distribution system operators (DSO) in e-mobility

The Portuguese Electric Mobility Program was enforced by the Council of Ministers Resolution nº 20/2009, according to which the Portuguese Government understood, in the context of the execution of the National Energy Efficiency Action Plan (NEEAP), to create the conditions for the

use of electric vehicles. The legal regime of electric mobility, which comprises the organization, access and exercise of electric mobility activities, was established in 2010, through Decree-Law nº 39/2010, amended by the Decree-Law nº 90/2014.

The legislation in force establishes a series of relationships between the various entities involved, namely:

- **Electric Vehicle Users** (UVE, in Portuguese) establish contracts with **Electricity Suppliers for Electric Mobility** (CEME, in Portuguese) for the electric vehicles' charging service, carried out at charging points of the **Charging Point Operators** (OPC, in Portuguese),
- The **Electric Mobility Network Management Entity** (EGME, in Portuguese) guarantees the necessary data flows for the invoicing of these contracts,
- EGME and the **Distribution System Operators** (DSO or ORD, in Portuguese) exchange information to allocate the consumption of the electric mobility network to the **Electricity Suppliers** (CSE, in Portuguese).

E-REDES (former EDP Distribuição) is the Portuguese DSO (in the mainland) accountable for connecting all consumption sites to the distribution network, ensuring the security and reliability of the network to supply energy to all customers. In e-mobility, the consumption locations correspond to electric vehicles (EV) charging stations or installations that contain EV charging stations connected to the e-mobility network. Furthermore, the coexistence of several suppliers simultaneously at the same point of physical delivery of the network implies the existence of exchanges of information between the EGME and the DSO. Thus, E-REDES gives to the EGME the aggregate consumption of each delivery point where EV charging stations are integrated into the electric mobility network.

3.1.2. Network charge for EV chargers

The Portuguese Electric Mobility Network Management Entity (EGME) is MOBI.E, SA, a public company indicated by the Government, that ensures the management of the energy and financial flows resulting from the operations of the electric mobility network.

MOBI.E electric vehicles' charging points can be installed in both public and private spaces. Additionally, any charging point placed in a publicly accessible location (in public or private space) must be connected to MOBI.E network. The charging network operates in an interoperable manner; users can access any charging point in the country, regardless of who is the charging point operator, through a single access mean – a card. The number of charging points and its evolution can be observed in the table below.

Table 5 Number of electric mobility charging points, Portugal (Mainland and Autonomous Regions of the Azores and Madeira)

	2019	2020	2021
Charging Points owned by OPC *	1.575	3.547	4.274
Charging Points owned by DPC **	6	10	164
Total	1.581	3.557	4.438

Source: 2019, MOBI.E (real values); 2020, MOBI.E (estimated values); 2021, ERSE (estimated values)

** OPC – Charging Point Operator*

*** DPC - Private Access Charging Point Owners*

The EGME has tariffs, set by the Regulatory Authority for Energy Services (ERSE), established to provide EGME with an amount of income calculated in accordance with the provisions of the Electric Mobility Regulation, applied to the electric mobility activities regulated by ERSE, covering the entire national territory.

In this sense, since May 1st, 2021 (for the first year), the following tariffs are applied to assure the electric mobility network operation management:

- Tariff for EGME relative to CEME: € 0,1657/charging,
- Tariff for EGME relative to OPC: € 0,1657/charging,
- Tariff for EGME relative to DPC: € 0,0385/day/charging point.

3.1.3. Structure of charging price for electric vehicles

The price for using each charging point and the price for selling electricity for electric mobility are established on a market basis. The final price to be paid by the UVE for charging the vehicle, in the electric mobility network, depends on the contract established between the user and its supplier for electric mobility. The **total amount** charged by the CEME, with whom the UVE has a charging service contract, reflects several costs that can be grouped as follows:

- The **CEME component**, which is included in the contract negotiated between the CEME and the UVE, concerns the electricity supplied for charging the electric vehicle, that includes: the value of electricity and its commercialization (free market), tariffs for access to the electricity network (regulated, see table below), as well as the EGME tariff applicable to the CEME (regulated, see point 2.),
- The **OPC component**, which includes: the use of charging points (free market), as well as the EGME tariff applicable to the OPC (regulated, see point 2.),
- The component of **fees and taxes**, defined by the Portuguese State, namely: the special tax on electricity consumption (IEC) and the value added tax (VAT), if applicable.

The tariffs for access to the electricity network for electric mobility are charged by the DOS (E-REDES) to the CSEs that supply the CEME and market players integrated in the electric mobility network. There are two different tariffs, depending on the voltage level at the Public Service Electrical Network (RESP) delivery point (voltage level at which the charging point's electrical installation is connected), whether in Low Voltage (LV) or Medium Voltage (MV).

These tariffs are comprised by active energy prices broken down by time period, defined in euros per kWh. The fact that the price structure of these tariffs is hourly differentiated (in this case, bi-hourly and tri-hourly) makes it possible to guarantee the non-existence of cross-subsidization with other tariffs for access to the electricity network. The quantities of active energy for payment are determined at the charging points integrated in the electric mobility network.

Table 6 Tariffs regarding the Electricity Network Access for Electric Mobility to be paid by the CEME, at the charging points from the RESP

		Prices [EUR/kWh]
Active Power – MT		
Tri-Hourly Tariff	Peak Hour	0,1793
	Full Hour	0,0620
	Empty Hour	0,0342
Bi-Hourly Tariff	Out of Empty Hour	0,0887
	Empty Hour	0,0342
Active Power – BT		
Tri-Hourly Tariff	Peak Hour	0,2078
	Full Hour	0,0896
	Empty Hour	0,0412
Bi-Hourly Tariff	Out of Empty Hour	0,1165
	Empty Hour	0,0412

Source: 2021, ERSE

The breakdown of these values in tariffs per activity is presented in the tables below.

Table 7 Tariffs regarding the Electricity Network Access for Electric Mobility, divided by the various tariffs per activity - tri-hourly

	Prices [EUR/kWh]		
	Peak Hour	**Full Hour**	**Empty Hour**
Global Use of the System	0,0932	0,0580	0,0315
Use of the Transport Network – High Voltage	0,0403	0,0009	0,0008
Use of the Distribution Network – High Voltage	0,0077	0,0008	0,0005
Use of the Distribution Network – Medium Voltage	0,0381	0,0023	0,0014
Use of the Distribution Network – Low Voltage	0,0285	0,0276	0,0070

Source: 2021, ERSE

Table 8 Tariffs regarding the Electricity Network Access for Electric Mobility, divided by the various tariffs per activity - bi-hourly

	Prices [EUR/kWh]	
	Out of Empty Hour	**Empty Hour**
Global Use of the System	0,0660	0,0315
Use of the Transport Network – High Voltage	0,0099	0,0008
Use of the Distribution Network – High Voltage	0,0024	0,0005

Use of the Distribution Network – Medium Voltage	0,0104	0,0014
Use of the Distribution Network – Low Voltage	0,0278	0,0070

Source: 2021, ERSE

3.2. THE AUTONOMOUS REGION OF THE AZORES

3.2.1. The role of the Distribution System Operator in the EV charges development

In the Azores, the electricity distribution and commercialisation market is regulated by the Energy Services Regulatory Authority (ERSE), a national entity created for this purpose. Because of this, the only operator of the distribution network is EDA – Eletricidade dos Açores, S.A. (Electricity of the Azores). EDA has been collaborating with the Government, working towards the creation and expansion of the network of public access EV charging points, as well as on various other e-mobility projects. This includes the pilot project V2G Açores (*Vehicle to Grid*), which aims to develop the technology of future smart grids through the bidirectional interaction between electric vehicle batteries and the public electricity grid.

The Autonomous Region of the Azores began to develop its public network of charging points for electric mobility in 2019, after the approval of the strategy for the implementation of electric mobility in the Azores (Regional Legislative Decree No. 21/2019 / A, of August 8). In 2019, the Electric Mobility Plan for the Azores (PMEA) was also approved, including, among other measures, initiatives for the creation and expansion of the public network of charging points. Currently, there are 17 fast charging points and 13 normal charging points within the public access network, spread out through all nine islands of the Azores.

All public access charging points are operated by Charging Point Operators (OPC) – duly licensed entities that install, operate and perform the maintenance of public and private access charging points that are integrated into the national electric mobility network.

3.2.2. Network charge for EV chargers

The network tariffs for electric mobility in the Azores are defined by ERSE and are charged by EDA.

The tariff for Energy and Commercialisation of Electric Mobility, collected by EDA, for the charging of electric vehicles is composed of prices of active energy that are broken down by an hourly rate, in euros per kWh. This tariff is devised from the sum of the following components:

a) Energy Tariff applicable to low voltage supplies (BTN), with a three-part or two-part structure;

b) Commercialisation Tariff applicable to low voltage supplies (BTN), converted to energy prices per hourly rate.

The amount of active energy supplied to the electric mobility network must be determined within the charging points integrated into the network. The tariff for Energy and Commercialisation relative to Electric Mobility in the Azores is described in the document "Tarifas e Preços para a Energia Elétrica e Outros Serviços em 2021" (Tariffs and Prices for Electric Energy and Other Services in 2021), published by ERSE (https://www.erse.pt/media/14rb452m /tarifas-e-pre%C3%A7os-2021.pdf).

Table 9 Prices of the Energy and Commercialization tariff relative to Electric Mobility in the Azores

TARIFA DE ENERGIA E COMERCIALIZAÇÃO APLICÁVEL À MOBILIDADE ELÉTRICA NA RAA		PREÇOS
Energia ativa		(EUR/kWh)
Tarifa Tri-horária	Horas de ponta	0,0775
	Horas cheias	0,0713
	Horas de vazio	0,0565
Tarifa Bi-horária	Horas de fora de vazio	0,0727
	Horas de vazio	0,0565

The tariffs are updated and published annually on ERSE's website.

3.2.3. Structure of charging price for electric vehicles

According to the Electric Mobility Regulation, approved by the Energy Services Regulatory Authority (ERSE), the tariffs relative to the charging of electric vehicles on the public network of charging points are as follows:

- Tariff for Electromobility Service Providers (CEME);
- Tariff for Charging Station Operator (OPC);
- Tariff for Energy and Commercialisation relative to Electric Mobility in the Azores;
- Tariff for the Electric Mobility Network Managing Entity (EGME) relative to CEME;
- Tariff for EGME relative to OPC;
- Tariff for EGME relative to Charging Station Owners (DPC).

In the Autonomous Region of the Azores, users of electric vehicles can choose one or more Electromobility Service Providers (CEME). This makes it difficult to determine the exact fee being charged for electric vehicle charging. These providers operate on a competitive basis, offering several advantages in order to attract new customers. The amount of the monthly invoice to be paid by the user to the CEME includes government taxes and fees.

The amount of the OPC tariff depends on the Charging Station Operator, on the location of the charging station and on the charging power of the outlet in use. This tariff is applied according to consumed electricity (€/kWh), charging time (€/min) and usage number (€/charging).

The Energy and Commercialisation tariff relative to Electric Mobility in the Azores is regulated by ERSE relative to the electricity provided by EDA to the CEME, within the scope of e-mobility.

From July 1, 2020, the use of public networking charging stations has been charged and managed by the Electric Mobility Management Entity – Mobi.e.

On May 1, 2021, Mobi.e applied a new tariff charged at public charging points for electric vehicles. CEME, OPC and DPC began to pay the Tariff for Electric Mobility Network Management Entity, according to the following fixed amounts:

- Tariff for EGME relative to CEME: € 0.1657/charging;
- Tariff for EGME relative to OPC: € 0.1657/charging;
- Tariff for EGME relative to DPC: € 0.0385/day/charging point.

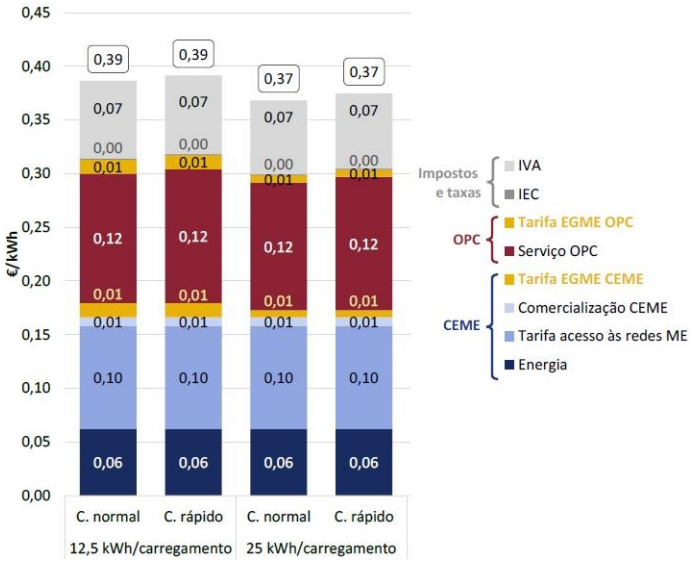

Figure 1 Average price paid by electric vehicle user for charged power (€ / kWh)

When charging electric vehicles in private access locations, as is the case of domestic charging, the tariff applied is the same that is contracted for the installation with EDA.

3.3. GREECE

3.3.1. Regulatory framework, pricing models and the role of the Distribution System Operator for EV charges

In Greece, the pricing method and billing conditions for EV users regarding the provision of use of recharging or electro mobility services are set as a free market model.

The main regulatory framework for electric mobility in Greece is Law 4710/2020 (FEK A 142 - 23.07.2020) – Among other and specifically regarding EV charging, L. 4710/2020 provides:

- the regulatory framework for EVs charging services market
- urban planning regulations for charging infrastructure

Especially regarding the regulatory framework for EV charging services market, L. 4710/2020 foresees:

1. The role of the electric vehicle charging point operators (CPO). Among other, CPO is responsible for the technical maintenance of the charging infrastructure, ensuring the availability and operation of the recharging points they manage, their supervision and control, as well as for the provision of the necessary data and data. In addition, CPO may be the owner of the Charging Infrastructure and may establish a connection contract with the Distribution Network Operator and a supply contract with one or more electricity suppliers with which it is contracted as a final consumer.
2. The CPO provides on-site recharging services (ad hoc) to non-contracted EV users by directly invoicing them, to EV users contracted with CPO as well as EV users contracted with other e-mobility service providers (EMSP). In the latter case, the necessary interoperability is achieved through processors of e-mobility transactions (PEMT) or through bilateral contracts between operators in the electricity market.
3. **Regarding the role of DSOs** (in Greece currently only one – HEDNO), they are not permitted to own, develop, manage or operate charging points for electric vehicles, except for own private charging points solely for their own use. In addition, it cooperates, in a non-discriminatory manner, with any company that owns, develops, operates or manages charging points for EVs, in connection with, inter alia, the connection to the distribution network.
4. The role of the EV Load Aggregator, on the utilization of the load management of the EVs through remote monitoring systems and control of the charging infrastructures. The Aggregators may contract with other stakeholders in the electricity market, such as EMSPs and CPOs or directly with EV users or owners of non-publicly accessible charging infrastructures, in order to ensure the possibility of managing the load of the EVs connected to the EV network, which they represent.
5. The same legal person may be at the same time CPO, EMSP, PEMT and Aggregator
6. For the systematic monitoring of Charging Infrastructures and the bodies that are active in this market, the optimal information and service of the EV users and the support of the development of the infrastructures, there is a provision for an electronic Registry of Infrastructures and Electricity Market Operators, to be updated by the Ministry of Infrastructure and Transport.
7. The Ministry of Environment and Energy supervises the operation of the electricity market, as well as the relevant procedures for the free and equal access of market participants to it, in cooperation with the Regulatory Authority for Energy (RAE) for matters of competence relating to the energy market

Furthermore, regarding the recharging services pricing, Law 4710/2020 foresees:

1. The pricing method, the relevant prices and the charging terms of the EV users regarding the provision of recharging or electric services are freely configured.

2. The applicable pricing for the case charge is selected by CPO and must be notified to the EV user before the start of the recharging process, with a clear mark on the recharging point or in an adjacent area of the recharging point or at the entrance of its installation site, in the case of controlled access areas. The final charge of the EV user includes all the parameters of the charge that form the final price, such as energy consumed or duration of the session and power or type of charge, as well as other charges. Charging data and additional charges used to calculate the final charge must be made available to inform the EV user while he / she is still at the point in one or more ways, such as display on the charging station screen, indication on a receipt or invoice issued at the same place and sent through a suitable electronic application and sent directly to the contracted EMSP, if they are contract users.

Furthermore according to law 4710/20 and among other, the municipalities compulsorily prepare an Electric Vehicle Charging Plan (EVCP), with which they plan the location of a sufficient number of publicly accessible normal or high power EV recharge points, and locations within their administrative boundaries. The elaboration of the EVCP, can be financed from the resources of the Green Fund. To this direction, the Joint Ministerial Desicion ΥΠΕΝ/ΔΜΕΑΑΠ/93764/396/2020, provides the technical instructions for the elaboration of Electric Vehicle Charging Plans (EVCP) by the municipalities.

Based on the adoption of a competitive market operating model for e-mobility, in law 4710/2020, it is clarified that the development of public accessible EV recharging infrastructure takes place as a matter of priority freely, at the initiative of those interested in entering the market, and may be carried out through transparent tenders, which will be undertaken by the municipalities.

In addition, Law 4643/2019 has set the rules that should be followed by the bodies and stakeholders (CPO, EMSP, PEMT, Aggregators) for the organization of the market for the charging of electric vehicles

In addition, Ministerial decision 42863/438/4.6.2019 has set the technical specifications for installing public charging stations according to international and European standards.

More specifically about the role of the DSO, two distinct competencies are conferred to HEDNO SA (the Greek DSO): the competency relating to the management of the Hellenic Electricity Distribution Network (HEDN), and the competency concerning the management of the markets of non-interconnected islands.

Therefore, among other the DSO (HEDNO) must maintain voltage within regulated margins and stabilize fluctuating power requests and injections from decentralised renewable generation (for example renewable energy generation). In that respect, smart charging enables load management to provide the required flexibility to the system, taking into account multiple physical system constraints without causing severe inconvenience to the electricity customer.

Furthermore, HEDNO runs currently specific infrastructure projects that aim to upgrade and strengthen the capacity of the distribution network which will give the opportunity for further penetration of emobility related loads.

Especially regarding Non-Interconnected islands in Greece (where apart from DSO it is also the market operator), the mission of HEDNO is to accelerate the green transition of the Greek islands focusing mainly on maximizing the penetration of RES. Consequently, HEDNO is implementing special pilot projects, such as the project for the island of Astypalea, soon to become a smart and sustainable island by achieving **zero-emissions mobility**. More specifically, HEDNO is contributing by:

- Upgrading the electricity network to maximize RES penetration in the energy system.
- Rolling-out smart meters for 100% of the grid connection points.
- Working closely with all parties involved to meet the technical specifications for the integration of charging points to the grid and balancing energy needs with RES production.
- Constructing all necessary grid infrastructure for the connection of electric vehicles' charging points.

3.3.2. Network charge for EV chargers

They refer to charges to consumers that use the NATIONAL ELECTRICITY SYSTEM (that is, the power transmission and distribution networks, Services of General Interest, the special duty of Greenhouse Gas Emissions reduction). These charges are the same for all the consumers irrespective of the power supplier selected.

These charges include the following:

• The use of the greek **transmission network**:

This charge covers the operation, maintenance and development expenses of the Transmission Network (Transmission System) that transfers electricity in high voltage lines through pylons from power plants to urban Substations so as the power to reach the final consumers of the country through the Distribution Network in middle and low voltage. It includes a fixed charge (deriving from the power supply agreed) and a variable charge (depending on the consumption).

IPTO as Independent Power Transmission Operator is responsible for the operation, maintenance and development of the Transmission Network so as to assure the country's electricity supply.

Calculation formula: [kVA x Days /365 x UFC(€kVA&year)] + [kWh x MMX(€/kWh)]

where,

UFC: Unit Fixed Charge

UVC: Unit Variable Charge

kWh: kilowatt hour consumed

kVA: Contractual Capacity : it is the maximum capacity which the customer is entitled to consume from PPC network and it is stated in the Power Supply Contract

• For the use of **distribution network**:

This charge covers the operation, maintenance and development expenses of the Middle and Low Voltage Distribution Network. It includes a fixed charge (deriving from the power supply agreed) and a variable charge (depending on the consumption).

HEDNO as the Hellenic Electricity Distribution Network Operator is responsible for the operation, maintenance and development of the Distribution Network so as to assure normal and uninterrupted power supply of the properties.

Calculation formula: [kVA x Days /365 x UFC(€kVA&year)] + [kWh x MMX(€/kWh)/cosφ]

where,

UFC: Unit Fixed Charge

UVC: Unit Variable Charge

kWh: kilowatt hour consumed

kVA: Contractual Capacity: it is the maximum capacity which the customer is entitled to consume from PPC network and it is stated in the Power Supply Contract

cosφ: Power factor: it is referring to certain categories of customers with high contractual capacity and it is calculated on the basis of the active and reactive energy. For all other customers, the power factor is considered to be equal to one (cosφ=1).

- For Other Charges: These are charges imposed by the legislation applied for the good operation of the market.

Calculation formula: kWh x Unit Charge (€/kWh)

• For Services of General Interest (SGI):

According to the decision of the Minister of Development (Greek Government Gazette Issue B' 1040/07), the following services are characterized as Services of General Interest (SGI): a) power supply to consumers of the non-interconnected islands, using the same billing methods per consumer category with the billing methods applied to consumers in main land, b) power supply with special tariffs to large families and to vulnerable groups of population as defined by the existing legislation, c) power supply with special "Social Residential Tariff" to vulnerable consumers as defined based on the equivalent Ministerial Decision. The unit charges for the Services of General Interest are based on the in force legislation and d) power supply with "Solidarity Services Tariff" to all legal persons governed by public Law providing welfare services, such as church-charity institutions, non-profit bodies governed by private law that provide social welfare services etc.

Calculation formula: kWh x Unit Charge (€/kWh)

• Special Duty of Greenhouse Gas Emissions Reduction (ETMEAR):

According to the existing legislation, this duty, according to the existing legislation, it is destined to the payment of the electricity producers from Renewable Energy Sources (RES). It constitutes our contribution to the reduction of greenhouse gas emissions.

Calculation formula: kWh x Unit Charge (€/kWh)

(Source: https://www.dei.gr/en/oikiakoi-pelates/xrisimes-plirofories-gia-to-logariasmo-sas/logariasmos-kai-xrewseis/giati-stous-logariasmous-sas-uparxoun-duo-katigori/ruthmizomenes-xrewseis)

3.3.3. Structure of charging price for electric vehicles

Practically the owner or any corporate user of an EV can charge the vehicle at home or at a shared charging station. The charge at home is directly proportional to the 'amount' of energy you will draw from the network - of course the cost per kWh depends on the pricing policy of each provider. Furthermore, the EV owner needs to take into account further regulated charges per kWh, including the ones for the Independent Power Transmission Operator, the DSO, της Services of General Interest (SGI), the Special Duty of Greenhouse Gas Emissions Reduction (ETMEAR) and the VAT. In some cases and depending on the pricing policy of each provider and the time of energy use, it is beneficial to recharge during the night, as several providers offer lower prices for using energy during this timeframe.

Regarding shared charging stations, there are currently three choices.

The first of these has to do with the utilization of public chargers of fast or semi-fast charging, such as those that can be found today in the Motorists Service Stations along motorways. Access is free for all owners / users of electric cars (and of course plug-in hybrid vehicles), without the use of a card or any other subscription and at a cost that currently depends on the charger usage time and may also include an additional cost per charging session.

The second option for users is to charge their EV to shared network chargers owned by a provider. Here, semi-fast (AC) and fast charging (DC) solutions are provided, while in any case it is necessary to identify the user - a process that can be done using an RFID card or with a special application (app) via mobile. In this case, just like mobile phone providers, the user chooses to subscribe to the Mobility Service Provider through a contract in one of the existing programs (usually there is a fixed monthly charge and an additional charging price per minute) or alternatively through a prepaid charge card, which can be renewed online.

The third and most difficult (currently) case is the use of common low power chargers, in which there is absolutely no charge for charging an electric or PHEV vehicle. Such chargers are usually found in large parking lots, shopping malls, supermarkets etc.

3.4. GERMANY

3.4.1. The role of distribution system operators (DSO) in e-mobility

Germany is experiencing a continuous growth in renewable power generation, causing an upheaval in the traditional supply chain for electricity. The maximum voltage transmission grid is owned by four transmission system operators (TSOs) - TenneT, 50Hertz, Amprion, and TransnetBW -, which are responsible for the operation, maintenance, and development of

their respective sections of the grid. It is their job to regulate the power supply, including balancing fluctuating power from renewables with more predictable conventional generation.

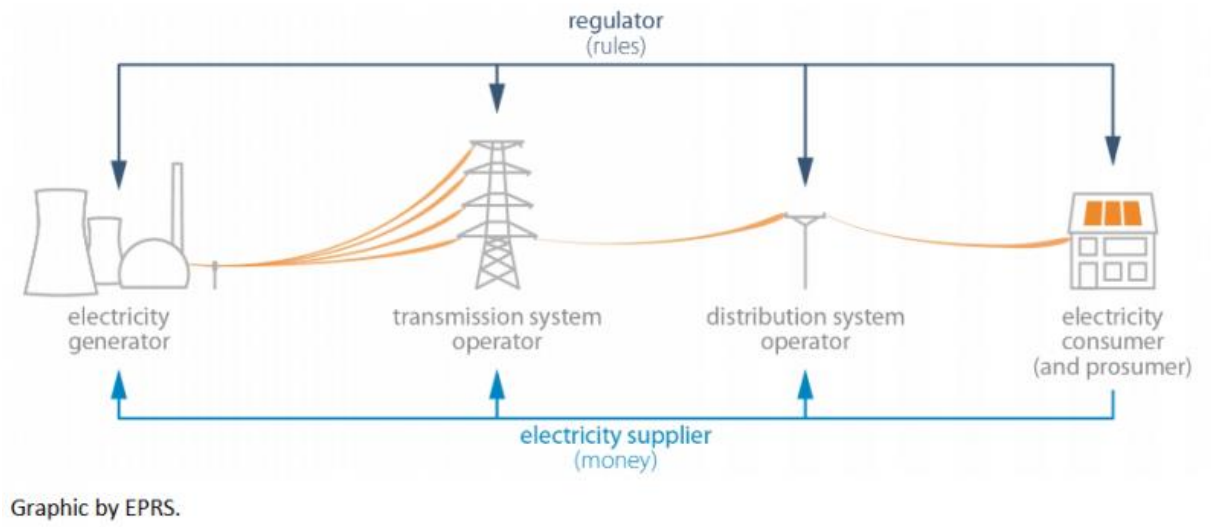

Figure 2 Schematic overview of the electricity system

Source: EPRS 2016.

In Germany, the construction and operation of the charging infrastructure is based on a competitive approach. While in other European countries the distribution network operators are initially obligated to build the infrastructure, in Germany there is competition among the providers that aim to connect charging points to their networks. The nationwide rollout of the charging infrastructure for e-mobility must therefore be subject to the existing framework conditions and be carried out in coordination with the distribution network operators. The common goal should be to optimally prepare the power grid for e-mobility and to implement the necessary grid expansion as little as possible but as comprehensively as necessary from an economic point of view. In this way, the costs for the e-mobile end customer and the general public, who also participate via the increase in network charges associated with a network expansion, can also be limited.

The distribution grids must be strengthened to meet the requirements of e-mobility in certain areas (conventional grid expansion combined with innovative and intelligent solutions). For this reason, distribution grid operators are working together with manufacturers and users on intelligent and future-proof solutions for the rapid and efficient expansion or optimized use of grid capacity for the optimum grid integration of e-mobility.

In order to ensure a secure and trouble-free supply, network operators specify requirements for the connection and operation of electrical systems to the low-voltage network in the form of technical connection conditions (TAB in German, Section 20 of the Low-Voltage Connection Ordinance – NAV in German). The TABs thus also include requirements for charging facilities for electric vehicles and become part of the grid connection contracts between grid operators and the operator of the charging facility as the connected one. (BDEW, 2016)

In general, the technical connection conditions of the grid operator (TAB) and the generally accepted rules of technology must be observed. From this, the following basic requirements can be derived for the grid connection and grid integration of e-mobility:

1. Charging facilities must be registered with the grid operator
2. The grid connection of charging facilities > 4.6 kVA should be three-phase
3. Grid-serving load management with e-mobility must be possible
4. Charging processes must be able to be controlled by grid operators in critical grid situations (red phase according to BDEW traffic light concept)
5. Charging stations must be able to generate reactive power (system service: voltage and frequency maintenance at grid connection point)

Source: CEW (Journalism for the energy transition) 2021, BDEW 2017

3.4.2. Network charge for EV chargers

Germany is going to spend € 2,5 Billion Euros for the loading-infrastructure by 2025. Nevertheless, the German approach of a decentralized and competitive development of the charging infrastructure leads to a sometimes confusing situation with different market participants. Charging stations for electric vehicles can be installed in both public and private spaces. The focus is on nationwide deployment along the highways. The number of public charging station and its fast evolution can be observed in the figure below.

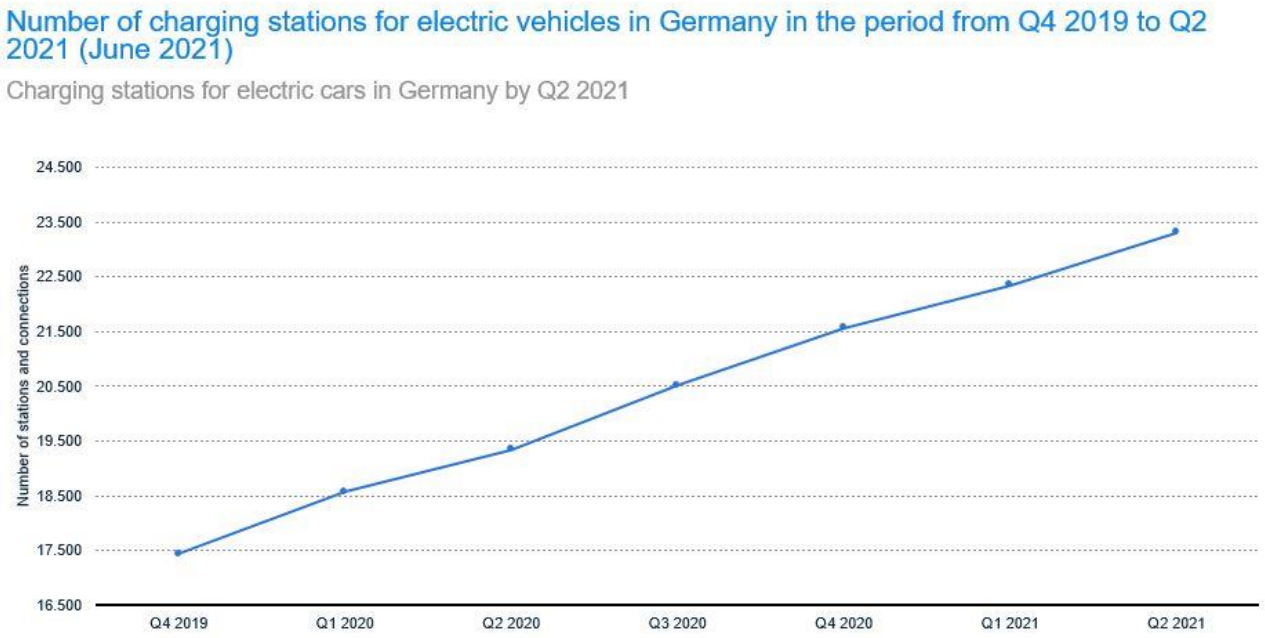

Figure 3 Numver of charging stations for EV-s in Germany

Source: Statista 2021

If charging processes are shifted over time due to time-variable electricity prices (virtual power plant), very high simultaneities of charging processes can occur. The resulting very high total charging power places a particularly high load on the power grid and can cause grid bottlenecks. This can cause grid expansion costs that are disproportionate to the savings from time-variable

electricity tariffs. In addition, in certain situations, the tariff incentives for load shifting could conflict with grid-serving load reduction through charging management.

The price structure in Germany is as follows. 15 kilowatt hours costs a total of 4.54 euros at the current electricity price of 30.29 cents per kilowatt hour (as of 2020). In reality, however, the actual price will be lower or higher because the recovery of electricity and the type of charging are key factors in determining the costs. The simple calculation of electricity costs per 100 kilometers should therefore be seen as a rough guide.

The following table shows an overview of the different charging options in Germany:

Table 10 Different charging options in Germany

Power type	Connection / Outlet	Charging capacity	Charging time	Price
Alternating Current (AC)	Household Outlet (Schuko)	up to 3,7 kW	10 - 14 hours	**30,29 ct / kWh**
Alternating Current (AC)	Typ 2 Plug AC 1-phase	up to 7,4 kW	3 - 5 hours	**5 - 10 Cent / Min.** **29 - 40 Cent / kWh**
Alternating Current (AC), Direct Current (DC)	CCS	up to 50 kW	30 - 60 minutes	**25 - 35 Cent / Min.** **39 - 50 Cent / kWh**
Direct Current (DC)	CHAdeMO	up to 50 kW	30 – 60 minutes	**25 - 35 Cent / Min.** **39 - 50 Cent / kWh**

Source: Energieheld 2020

The real costs per 100 kilometers can usually only be calculated as an average after a few months, when the same charging stations have been regularly visited. In the following table, we have summarized the current tariff models for you (price per kWh and price per charge). The prices listed refer to a standard AC charge with a Type 2 plug (1-phase).

The following table shows the results from the calculations:

Table 11 Results from the calculations

Charging	1 Hour	2,5 Hours	5 Hours	10 Hours
Range	20 km	50 km	100 km	200 km
kWh needed	3,2 kWh	8 kWh	15 kWh	32 kWh
Theoretical price per kWh: **30,29 Cent**	**0,96 €**	**2,40 €**	**4,50 €**	**9,60 €**
Charging price for flat-rate billing	**5,90 € (cheapest all-inclusive price)**			

3.4.3. Structure of charging price for electric vehicles

For a public charging station (electric charging station), a so-called charging card is almost always required. There are many different providers with very different prices. Once you have found 2 or 3 suitable cards, charging at an electric charging station is usually the cheapest solution. Many charging station providers nowadays join forces to form networks so that the respective charging card not only works at the company's own charging stations, but can also be used at other providers.

As a rule, the cards are free of charge; at most, a one-time activation fee may be due. Although you also have to pay a different price with a charging card from a charging card association network at charging stations from different manufacturers, at least you can use the charging station at all. The same applies to regional associations such as ladenetz.de. The charging cards from large networks are particularly recommended if you regularly travel across Germany and not just in one city.

Some charging stations charge per kilowatt hour for charging your electric car. At Horizont Mobil in Hamburg, for example, a kilowatt hour costs 29.5 cents, so charging is almost as expensive as at home, but much faster. 30 kilowatt hours thus cost 8.85 euros for a Nissan Leaf and 3.54 euros for 100km.

Table 12 Price per kilowatt hour

Range	Price per kWh	Current quantity	Charging Time	Price per charge	Price per 100 km
250 km	**29,5 Cent**	30 kWh	5 hours	**8,85 €**	**3,54 €**

In addition to payment per kilowatt hour, a flat-rate price per charging process has now also become established. Providers such as e-Tanken or E.ON no longer calculate costs according to consumption; instead, you pay a one-off price per charge. The prices range between 5 and 10

euros. In addition, the following applies: Faster charging methods are always more expensive than slower ones.

Table 13 Flat-rate price per charging process

Range	Current quantity	Charging Time	Flat price per load	Price per 100 km
250 km	30 kWh	5 hours	**5,90 €** (cheapest all-inclusive price)	**2,36 €**

Source: Energieheld 2020

3.5. CZECH REPUBLIC

Directive 2014/94/EU (AFI) has been implemented in the Czech Republic by means of an amendment to the Fuel Act and the Law on Road Traffic. In October 2015, the Czech Ministry of Economic Affairs and Trade adopted the National Action Plan for Clean Mobility. In addition to the strategic plan, a large number of party measures are in place to support the development of e-mobility, such as subsidies from the Operational Programme of Enterprise and Innovation for Competitiveness for the purchase of electric vehicles and for charging points, support from the Ministry of the Environment for the acquisition of organic vehicles for municipalities, cities and their organizations, subsidies for the purchase of electric buses and the installation of public charging stations. In addition to financial measures, other forms of measures are also present, such as restricted access for vehicles to a city centre (free access to electric vehicles only), free or cheaper parking, lanes dedicated to public transport, etc.

The current network of charging points for electric vehicles was developed exclusively on a commercial basis, with some support from the EU CEF programme.

The position of the charger within the legal framework of the Czech Republic is generally defined by the Act on the running fuels, which regulates the supply and sale of motor fuels (including electricity), sets out the technical conditions for the installation of charging points. In addition, the Act distinguishes between standard (up to 22 kW) or fast (over 22 kW) charging stations and defines the notion of their public availability.

The Ministry of Industry and Trade of the Czech Republic, on the basis of the aforementioned Act on Power Fuels, is responsible for keeping records available to the public charging points for electric vehicles. The charging station operator is required to submit the details of the charger before commissioning to the Ministry.

Furthermore, the Law on motor fuels provides that an operator shall disclose information on the compatibility of charging stations and electric vehicles to the charging station itself, clearly indicate charging prices for vehicles, and provide for charging to consumers who do not have contracts with a recharging service provider.

The Energy Act stipulates that the operation of charging points does not require a licence. Indeed, an electricity dealer in an e-mobility company is not considered a supplier but such activity is regarded as a provision of electricity charging service.

From the tax point of view, it should be noted that the Consumption Tax applicable to diesel and petrol as motor fuels does not apply to electricity. In the context of VAT, the electricity is considered to be goods and accounted for if the operator of the charging station is subject to VAT.

3.5.1. The role of DSO in the EV charges development

The electricity distribution network in the Czech Republic was divided into three different companies, to which the Energy Regulatory Office (ERU, Energetický regulční úřad) was awarded a licence for the distribution of electricity.These are:

1. ČEZ Distribuce,
2. E.ON Distribuce and
3. Distribution, a.s.

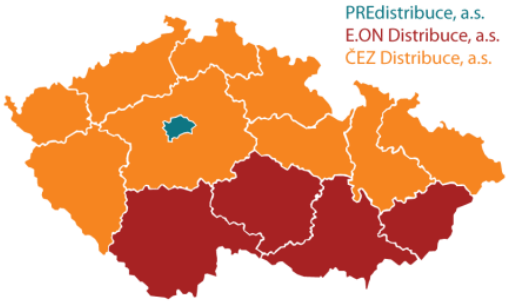

Figure 4 Electricity distribution operators in the Czech Republic

In legal terms, as regards electricity distribution system operators and e-mobility, it is stipulated that the Rules on the operation of the distribution system must include the technical requirements for connection of equipment which allows the storage of electricity and the technical requirements for connection of charging points for electric vehicles.

One important **role of the electricity distribution system operator** is to determine the period of application of lower tariffs to electric car charging tariffs. Tariffs for charging electric vehicles for both households and entrepreneurs are based on an eight-hour period of validity of the low tariff, where the distribution system operator itself determines the timetable and duration of the lower set period. The period of validity of a lower tariff may be assigned to up to two (households) or three (companies) in the period between 18 and 8 on the following day.

ČEZ group

'E-mobilita' is an organisation within the group of a ČEZ group, with the biggest energy group in the markets of central and south-eastern Europe. The group has an important focus on electro-mobility since 2009, and today runs the largest network of charging stations in the Czech Republic. As part of their network, there are more than 100 rapid recharging points financed by the EU funds (CEF).

Figure 5 ČEZ group's chargers area

In relation to the production, distribution and sale of electricity, ČEZ group considers e-mobility is a logical business focus, as e-mobility represents a new market segment for electricity and related products. Thus, in its long term vision, the main aim is to build a functioning and accessible network of charging points, which will provide optimal coverage in the whole territory of the Czech Republic, thereby ensuring that short and long distances can be undertaken.

In 2005, unbundling of the group's ČEZ group was carried out with the distribution of electricity (ČEZ distribution) as a separate regulated activity. **The role of ČEZ distribution in the development of e-mobility** relates to the development and deployment of new technologies on medium and low voltage electricity networks. Increasingly decentralised electricity generation, as well as many other measures enabling progress and e-mobility, require distribution system operators to be able to adequately manage the distribution system at all voltage levels. ČEZ distribution is also actively involved in the National Action Plan for the Smart Grid project. National Action Plan for Smart Grids project.

The ***InterFlex*** *project (Horizon 2020), in which the distribution is active, started in 2017 (http://www.enedis.fr/interflex-0), focusing on functionality testing that is not yet standard in the distribution systems. The main aim of the project is to improve the ability to connect decentralised generation units and simplify integration of charging points for electric vehicles into the distribution system. It focuses on the integration of photovoltaic power stations with advanced autonomous functions to regulate active and reactive power, reactive power regulation at medium voltage level, development and deployment of smart charging stations, and the integration of photovoltaic installations in combination with energy reservoirs on the side of the consumer. The project will involve the commissioning of the two charging points in order to test different modes of operation in order to verify the impact of rapid electric vehicle charging on a possible deterioration of certain electricity quality parameters. In addition, testing voltage stability in selected locations in medium and low voltage distribution networks with high RES and distributed generation will be tested. The objective is to assess the effects and impact of a high proportion of distributed electricity production on voltage quality in the medium voltage and LV network.*

In the case of ČEZ, distribution is free to determine a period of low tariffs for users of special charging tariffs for electric cars.

E.ON group

E.ON group participated in the market of the Czech Republic since 1998 and currently supplies electricity to around 1,2 million customers, mainly in the southern Bohemia region and southern Morava.

E-mobility has become an integral part of the business development of the E.ON group. Until 2016, EO.N only had a few e-charging points in the Czech Republic and more intensive construction of charging in a subsequent period was based on active participation in international projects for the development of recharging infrastructure co-financed by EU funds, such as FAST-E, EAT-E and NEXT- E, which build upon each other.

However, it is worth highlighting the investment made by the E.ON group in the construction of the most complex area of e-charging, which was opened in 2016 in Humpolec, at the heart of the Czech Republic, in order to make it easier to travel on a longer distance. Charging points are five different types of chargers, thus enabling almost all types of electric vehicles to be charged.

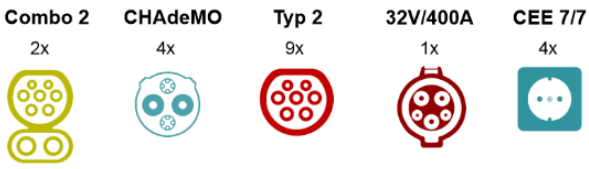

Figure 6 Type and number of chargers available at the Humpolec e-charging

In the framework of E.ON's group, **also E.ON Distribuce, a.s.,** an operator and a distribution system owner, a legal person, an electricity and gas distribution. Licensed under the Energy Act, its work is regulated by the Energy Regulatory Office (ERO) and works very closely with the Ministry of Industry and Trade of the Czech Republic.

E.ON manages and develops a distribution network, connects customers and provides additional services related to the distribution of electricity, gas and energy. Furthermore, acting as the contact point on the Energy Regulatory Office, it is responsible for long-term planning of distribution resources, planning for the maintenance of the electricity and gas networks, and preparing agreements for connecting new users to the grid.

As regards e-mobility, the **role of E.ON is about** providing the maximum functionality of the distribution system to the point of connection to the electricity grid and to the development and deployment of new technologies that will enable more integration of the electricity system into the electricity system.

In addition, like other electricity distributors, E.ON autonomously determines the timetable and the duration of the period of validity of the low tariff for customers who are subject to the tariff for electric car owners and users.

Pre group

The group shall consist of the parent company of the subsidiary Pskeskská energy a.s. and the subsidiary. The main activities of the Group are the sales and trading of electricity and natural gas throughout the Czech Republic, the distribution of electricity in the capital city, Prague, the generation of electricity from renewable energy sources and energy services.

It also monitors modern trends in the use of electricity, such as e-mobility. Thus, since 2011, the group is developing its network of public and private charging stations, which currently consists of more than 50 charging points in the whole of the Czech Republic, but the highest number is located in Prague City. In addition to the standard ones, a number of rapid recharging points are also present in the network, each of which is to be applied by RFID cards. In addition to the classic offering of services for mobility, the PRE Group also develops in parallel on the market other related services, such as the sale and hiring of electric and hybrid cars, electric bicycles, construction and servicing of charging stations, and the sharing of electric cars.

Figure 7 Area of the group's charging area

PREdistribution a.s., PRE Group member provides the electricity distribution service in the capital city, Prague City. It was established in September 2005 as a subsidiary of Energy and was part of the PRE Group.

It has a power distribution licence issued by the Energy Regulatory Office (ERO), valid for 25 years for distribution in the capital, Prague City. The company manages and develops the distribution network, connects customers and provides other services related to the distribution of electricity, in particular to the customers connected to the low-voltage and high voltage network and to electricity producers.

The development strategy of PREVENT has acknowledged the expected development of electro-mobility and underlines the need for adequate responses to develop the infrastructure of the distributive network and the uptake of new technologies.

From the annual report by the distribution network, 2017.

"In 2016, pilot projects were carried out to test solutions in the field of smart grids and related technologies such as the AMM. Advanced Meter Management, electro-mobility and storage, which is relevant to urban distribution networks. These projects shall examine the technical facilities and their impact on the daily activities of the distribution network, including the costs of implementation and operating costs. The adopted strategy aims to ensure that the distribution system of the distribution system is prepared for the introduction and greater penetration of new trends in the world, such as decentralised electricity sources, electro-mobility, the AMM, the development of energy services, etc. PRICE, pays a great deal of attention to new trends and developments in the deployment of modern solutions. Together with the City Council of Prague, a future mobility project ('Smart Prague'), which is one of the strategic projects in the Smart Prague initiative, aimed at implementing the world-renowned concept of 'smart city' in the Czech metropolitan area.'

3.5.2. Network charge for EV chargers

The energy regulatory office (ERO), established in 2001, is the administrative authority in charge of regulation in the energy sector, including for setting special tariffs intended to charge electric cars.

In the Czech Republic, two tariffs for electric cars are in place, one of which refers to households (D27d) and the other to companies (C27d). These two tariffs are available to households and companies demonstrating ownership or the right to use (leasing) by electric car.

The lower price tariff shall be valid for a minimum of 8 hours in the period between 18 and 8 hours and the timetable and duration of the lower rate shall be set by the relevant DSO for its distribution area.

Households using this tariff have the same incentive to use all appliances for the duration of the lower rate, while companies may only use a lower rate for charging electric vehicles. It also means that companies using C27d should have a separate supply and measuring location for electric vehicles.

For the purposes of defining these tariffs, electric vehicles are considered to be battery electric, electric cars with extended range and electric and rechargeable hybrid vehicles. The tariffs cannot be used for charging electric scooters and electric bicycles.

The Decision has summarised below a review of the decision of the Energy Regulatory Office, dated 21 November 2017, which sets the prices for electricity distribution services to final customers connected to the low-voltage network.

It should be noted that the tariff item relating to the power of connection represents a fixed monthly amount depending on the power of the connection itself and the payment is defined regardless of the use of that power during the month or not.

Tariff for electricity distribution service

The tariff C 27d is a two-stage tariff rate for companies with an operational management of low-fare applications of 8 hours. It may be used by companies that demonstrate that they are owned

or entitled to use (leasing) by electric car. The price components for electricity distribution are given by the following tables.

Table 14 Power charge at the nominal power of the connection before the consumption measurement device

Type of connection	Measurement unit	DSO		
		ČEZ	**E.ON**	**PRE**
to 3x10 A and to 1x25 A	EUR/month	4,1	4,9	4,8
Connection above 3x10A to 3x16 A	EUR/month	6,6	7,8	7,6
Connection above 3x16A to 3x20 A	EUR/month	8,3	9,8	9,6
Connection above 3x20A to 3x25 A	EUR/month	10,3	12,2	12,0
Connection above 3x25A to 3x32 A	EUR/month	13,2	15,7	15,3
Connection above 3x32A to 3x40 A	EUR/month	16,5	19,6	19,1
Connection above 3x40A to 3x50 A	EUR/month	20,7	24,5	23,9
Connection above 3x50A to 3x63 A	EUR/month	26,0	30,9	30,1
Connection above 3x63A to 3x80 A	EUR/month	33,0	39,2	38,3
Connection above 3x80A to 3x100 A	EUR/month	41,3	49,0	47,9
Connection above 3x100A to 3x125 A	EUR/month	51,6	61,3	59,8
Connection above 3x125A to 3x160 A	EUR/month	66,1	78,4	76,6
Connection above 3x160 A for each 1A	EUR/month	0,4	0,5	0,5
Connection above 1x25 A for each 1A	EUR/month	0,1	0,2	0,2

Table 15 Price for the amount of electricity in the high tariff (s)

Tariff	Measurement unit	DSO		
		ČEZ	**E.ON**	**PRE**
High	EUR/MWh	69,80	79,20	81,20
Low	EUR/MWh	2,80	3,00	2,90

Household tariff for the distribution of electricity

The tariff D 27d is a two-hour tariff rate for households with a fixed duration of 8 hours. It can be used by households who prove that they are owned or entitled to use (leasing) by electric car. The price components for electricity distribution are given in the following tables.

Table 16 Power charge at the nominal power of the connection before the consumption measurement device

Type of connection	Measurement unit	DSO		
		ČEZ	**E.ON**	**PRE**
to 3x10 A and to 1x25 A	EUR/month	2,0	1,9	1,9
connection above 3x10A to 3x16 A	EUR/month	3,2	3,0	3,1
connection above 3x16A to 3x20 A	EUR/month	3,9	3,7	3,8
connection above 3x20A to 3x25 A	EUR/month	5,0	4,6	4,8
connection above 3x25A to 3x32 A	EUR/month	6,3	6,0	6,1
connection above 3x32A to 3x40 A	EUR/month	7,9	7,4	7,7

connection above 3x40A to 3x50 A	EUR/month	9,9	9,3	9,6
connection above 3x50A to 3x63 A		12,4	11,7	12,1
connection above 3x63 A for each 1A		0,20	0,19	0,19
connection above 1x25 A for each 1A		0,07	0,06	0,06

Table 17 Price for the amount of electricity in the high tariff (s)

Tariff	Measurement unit	ODS		
		ČEZ	**E.ON**	**PRE**
High	EUR/MWh	67,00	65,80	62,00
Low	EUR/MWh	2,80	3,00	2,90

As regards a one-time fee for connection of the charger to the distribution network, it is defined on the basis of the power of the connection, which is approximately EUR 30/kW.

3.5.3. Structure of charging price for electric vehicles

Charging service providers in the Republic of the Czech Republic set out different paymnet schemes and charging prices. Each service provider shall base the calculation on the amount of energy supplied, each over the time-table, and the individual application of the flat-rate scheme regardless of the duration of the charge and the amount of energy supplied.

Examples of charging models as well as the amount of individual items in the charging stations of a service provider in the composition of the companies referred to in the previous chapter are given below.

ČEZ group

Payment for charging of electric vehicle for stations in the group's ČEZ group is based on a flat rate:

- The accounting period is half a year;
- Recovery shall be retroactive for a previous period of 6 months;
- In 2018 the cost of the service is approximately EUR 17,5 (net of VAT) per month, i.e. EUR 105 (VAT excluded) for the six-month period.

E.ON

For example, charging charging points of an electric vehicle to charging points at the place of Humpolec, which is located at the junction hub, constitutes a complex recharging point where five different connections are installed. The payment is based on the power of the used port and the time-table.

Current list of e-charging stations "Humpolec"	
Power of connection	***Price (including VAT)***
3.7 kW	EUR 0,01/min
22 kW	EUR 0,06/min
43, 44.50 kW	EUR 0,13/min

Pre group

Payment for EV charging in the network of PRE is based on the constant fee to be charged on a quarterly basis, the amount of energy supplied and the timing of the charging for more than two hours. An extract from the current schedule is shown below.

The current schedule of the charging stations of the group		
A permanent quarterly amount for the possession of the chip/card (including VAT)	***Price for energy supplied (inclusive of VAT)***	***Price during charge * (including VAT)***
EUR 1,4/quarterly	EUR 0,19/kWh	EUR 0,01/min

** to be charged only during no more than 120 minutes from the start of the charge*

3.6. SLOVENIA

Slovenia has transposed in the legal framework the Directive 2014/94/EU on the Regulation on the deployment of alternative fuels infrastructure (Official Gazette RS, No 41/17). Subject matter of the Regulation, Article 3 (which refers to electricity supply points) defines distribution operators for electricity (DSO's) performing an economic public service under Article 78 of the Energy Law as entities in duty of the development of recharging points.

Reporting on the number of recharging points made publicly available for electric vehicles and on the amount of electricity surrendered via the same lays down the rules on the type of data provided by energy service providers and other taxable persons (Official Gazette RS No 22/16 and 24/16). The reporting shall be provided on an annual basis, except for the number of connections to and the energy consumed, to be provided and the location of the same and the share of electricity from renewable energy sources.

In addition, Article 382 TFEU provides: The Energy Law (Government Gazette RS, Nos 17/14 and 81/15) states that operators, namely owners of public parking areas, and owners/operators of public sector operators are required to report to the ministry responsible for energy, the number of their chargers for electric vehicles and on the electricity used on them.

Currently, there are more than 600 publicly accessible charging points in Slovenia (in different locations), of which more than 80 recharging points allow for the transfer of electricity to an electric vehicle with a power of more than 22 kW (high power recharging point). The main players in the market are Elektro Ljubljana d.d., Petrol d.d., the Federal Power Station of Maribor d.o.o., Elektro Maribor d.d., Elektrometro d.d., and Elektro Govojska d.d.

3.6.1. The role of DSO in the EV charges development

The Slovenian Energy Law (Official Gazette RS, Nos 17/14 and 81/15) in Article 78 defines that the distribution system operator is responsible for the development of basic public infrastructure for electric road vehicles operating on the motorway network.

In accordance with the above mentioned Act, SODO (the system operator of the distribution network), in cooperation with the Department of Infrastructure, has established a basic infrastructure in the framework of the Slovenian Green Corridor project (part of *the European Green Corridors European* project). By the end of 2015, a total of 26 fast charging points were powered in the Slovenian motorway enabling two vehicles to be charged at the same time (50 kW DC and 43 kW AC). On the basis of the contractual relationship between the SODO and Petrol (which was a partner in a project in charge of providing the conditions for selecting suitable chargers), as a provider of infrastructure services owned by the SODO, it is required to provide the following: Ensure seamless and continuous charger work, collect charging parameters and collect charging parameters, ensure roaming/interoperability, allow the payment of RFID cards and prepaid cards, allowing infrastructure to be used by users who do not have a contractual arrangement with a service provider, provide information on the charging service to the infrastructure owner, pay network charges in accordance with accounts issued for each specific location, provide customer users with the infrastructure (help-desk), upgrade the software at the charging station, in accordance with the latest available versions, provide periodic overviews of the functionality of all the charger segments, provide information to users on availability, occupancy, reservations and failures, and carry out additional training activities and promotion of e-mobility.

According to the conclusions of the public consultation on electro-mobility in Slovenia, the opinion[1] is of the view that the development of infrastructure in the upcoming future should be left to the market. The role of the SODO, which was added to it's Energy Law (to install a basic infrastructure of high-speed charging stations on a motorway network), is in principle fulfilled, and should in the future apply only to the provision of energy infrastructure (networks) to the point of connection of the charging point infrastructure to the distribution system.

The SODO activity is regulated (a natural monopoly reaction), therefore the role of SODO in the development of electric vehicle charging infrastructure must include only the provision of adequate energy infrastructure to the point of charging infrastructure, the non-discriminatory cooperation with each stakeholder set up and/or managed by publicly accessible charging points, and participation in the adjustment of the consumption/load of charging infrastructure. The recommendation is that the SODO is also participating in different pilot projects focusing on smart grids and charging for electric vehicle charging.

In the event of an increase in the market interest in the establishment (investment and management) of the infrastructure for the rapid charging of electric vehicles, the phasing out of the SODO activity concerned (which is also in line with the Directive 2009/72/EU concerning common rules for the internal market in electricity) will be necessary.

3.6.2. Network charge for EV chargers

In 2015, Slovenia, in the Act on the methodology for establishing the regulatory framework and methodology for calculating the network charge (Official Gazette RS, Nos 66/15, 105/15, 61/16 and 46/18), provides in its Article 119 identifying a specific group of customers using electricity for charging electric vehicles on publicly available fast charging points infrastructure (on the motorway and beyond). In this context, rapid charging constitutes a charging station that allows the transfer of electricity (at least one recharging point), with a power greater than 43 kW.

This is also justified by the fact that these tariff preferences will result in the initial development of the electromobility market, with the risk of resistance at the public, as in this case the group of customers concerned is privileged compared to the others.

According to the above, the SODO has published, with 1.1.2018, tariff sets for the group of customers who are electric vehicles on fast charging stations on the motorway network (table below).

Table 18 Common list of network and other contribution charges (SODO — 1.1.2018)[2]

		Tariff preferences		
Voltage	**Buyers group**	**Power [EUR/kW)**	**Energy (EUR/kWh)**	
			VT (higher day)	**MT (Daily)**
Low voltage	**Charging of electric vehicles on the motorway network**	2,34490	0,01133	0,00872

[1] Https://www.agen-rs.si/documents/10926/30768/Posvetovalni-dokument-Elektromobilnost-2.-cikel/76d288ea-ad1b-487a-b3a0-aaec491b69b6

[2] Https://www.sodo.si/_files/5301/sodo_export1855.pdf

In the last amendments to the Act, the tariff preferences for fast charging stations are abolished in 21.6.2018 years, and Article 131 has recognized a special group of customers using electricity for charging electric vehicles on publicly available infrastructure (not just fast charging).

As regards the connection of charging to the electricity grid, the current draft changes to the existing Instructions for the Management of the Electricity Network (Official Gazette RS, Nos 41/11 and 17/14 — EZ-1), which, in Article 278, lays down the conditions for the admission of electric vehicles to the motorway division of electric vehicles on the motorway network and spread through fast charging stations. According to the present draft, the rapid charging can be public or private regardless of the location within the Slovenia, it must have its own measuring site at low voltage, connected to the distribution system, and the possibility to transfer a power of more than 43 kW. The measuring station may be connected to the necessary equipment to which lighting, electrical energy for communication, protection, etc. may be connected.

The measurement place belonging to a specific charging group is classified in the group "Consumers on low voltage — with power measurement'". The SODO has defined network charges for connection power for the consumer group in question from 1.1.2018 (the same table below).

Table 19 Network charge for the connection network charges (SODO 1.1.2018)

Final Consumer Group	Price excluding VAT (EUR/kW)
Consumption on NN — of power measurement	90,30

In the context of the project referred to above, final consumers of electricity will not be charged any additional surcharge for the development of the network of specific charging establishments owned by the SODO, as SODO has been recapitalised by the Government for this purpose (the company is 100 % owned by the State).

3.6.3. Structure of charging price for electric vehicles

Directive 2014/94/EU defines the Member States' obligation to ensure that the legal framework allows the supply of electricity to a recharging point to be the subject of a supplier contract which does not need to be a supplier of electricity to a household or construction where a recharging point for electric vehicles is situated. The Slovenian legal framework also does not allow for it; The rules on the functioning of the electricity market (Official Gazette RS, No 105/15) provide, in the second paragraph of Article 31, that a handover location connected to a distribution area with power of less than or equal to 40 MW can coexist with only one supplier at a time. In that context, amendments to those Rules are necessary.

In general, the public charge in Slovenia is currently charged on the locations operated by Petrol, while charging in other locations is in most cases still free of charge. The trial collection period on the locations in question started at the beginning of 2016, when one charge had to be set aside in EUR 2,5. Shortly afterwards, Petrol introduced new payment models, and there are currently three users packages holding Petrols payment cards; The package base in which the charging rate is EUR 0,20/min (provided charging power is more than 22.01 kW). The package needs to be contractually committed for 12 months in addition to the monthly fee of EUR 10,4, charging price EUR 0,11/min (provided that the load power is above 22.01 kW), and the package, where a contractual obligation is required to reach 12 months with a monthly fee of EUR 30,90 and the equivalent of kWh per month on a charter of 225 kWh. The charge price shall be

calculated for each load day started. Users who hold subscriber cards are able to transfer electricity on the charging stations operated by Petrol and are located on the motorway network (26 points of charging for the project). Use the same, EUR 5 for the first 30 minutes of charging, and EUR 5 for each started 31 minute charging. Users having contractual obligations with Petrol's roaming providers (via their identification cards/mobile applications) may also be authorized on the infrastructure operated by it; SMATRICS GmbH & Co Co (Austria), GreenWay Infrastructure s.r.o. (Slovakia), SE (Slovakia) and The New Motion (Netherlands, Germany).

3.7. ITALY

3.7.1. The role of DSO in the EV charges development

The Italian Energy, Network and Environmental Regulatory Agency ([3]ARERA) started dealing with e-mobility in 2010 and launched several pilot projects aimed at developing electric vehicle charging infrastructure. The aim was to trigger the opening of the chargers, but also to remove any possible regulatory or tariff disturbances observed in the implementation of those projects.

In Italy until 2010, there was no regulatory framework for e-mobility, and for that reason ARERA decided to launch a tender for demonstration projects in order to develop infrastructure for charging stations in public spaces, with a view to finding effective and competitive solutions for this new activity. The ARG/ELT 242/10 decision defines the selection criteria and incentives for the next five years.

As this area was unexplored in Italy, it was decided to use demonstration projects to test the different business models of charging stations, thus finding an optimal solution and building on the newly created regulatory framework needed to further develop e-mobility. At this initial moment, the pilot projects were based on three different business models linked to the charging of electric cars in public places:

- In this model, the DSO should develop and operate recharging infrastructure at public places by the distribution system operator in this area. To ensure competitiveness in this model, it was necessary to define what is needed to achieve this model, and the same implied a number of sellers, i.e. electricity providers, which would then ensure the freedom of choice of the electricity supplier; and accounting separation of charging and distribution services within the DSO.
- The licensed service provider model in a given field — in this model there is only one recharging service provider for electric vehicles in the area not allowed to be DSO and who receives this job in a public tender and receives a local public service licence.
- A model of competitive service provision — in this model charge service can be provided by a variety of industrial players other than DSO and providing a service in the same field as other players, and competing with each other.

Specific conditions are laid down in the application of the DSO model, such as the 'multiseller' condition of the charging companies, i.e. the freedom of choice of suppliers at each transaction and accounting separation. These conditions are set in order to make it possible to maintain competitiveness and to avoid DSO's investments in infrastructure distortion of regulated tariffs to end consumers. Throughout the year, the role of the DSO has been extensively addressed. The DSO is also the owner of the distribution network and could therefore be privileged to plan, build and operate a network of charging stations, which could only be seen as new points of delivery of electricity connected to the grid, but at the same time the DSO is operated under certain conditions, it is a monopoly that is subject to regulators, regulated tariffs and could not be suitable

[3] *ARERA (tall.*Autorita di Regoulazione per Energia, Reti e Ambiente*) this name is given only at the beginning of 2018.She has been renamed the AEGI (tall.*Autorita per l'Energia Elettrica il Gas e il Sistema Idrico) *after both regulatory work related to waste has been included in the scope of work.*

for the development of e-mobility, and thus seriously damage the development of this new market.

The DSO model in pilot projects was based on long-term contracts and access to charging stations through specific RFID cards. The option to opt for a supplier at every transaction, theoretically mandatory, is overlooked because of excessive complications. Interoperability was insufficient and it further complicated the use of RFID cards for users to access wider infrastructure. The results of the pilot projects have not demonstrated any advantage of the DSO, especially compared to other models.

Under the AFI directive, an Italian regulatory agency decided that the DSO model will no longer be used in the development of EV chargers. This decision was supported by the fact that various commercial operators were present at the final stage on the market, demonstrating the appetite of private companies to invest in the chargers, and in this new environment of agencies, it concluded that there is a need for a number of participants to compete in order to achieve market competition.

Italy has followed the instructions set out in the Article 33 of the Directive on common rules for the internal market in electricity. In 2010, in the design of e-mobility, there was no interest in opening and managing charging stations and was also open to DSO. With the emergence of an interest in commercial operators, the regulatory agency decided to remove the possibility for DSO to own or operate charging stations.

3.7.2. Network charge for EV chargers

Decision R.G/ELT 242/2010 allows the operators of public charging points to pay for so-called[4] monotonous tariffs (EUR/kWh) as opposed to the usual tronomalial which also uses fixed components and components for peak power (EUR/measuring location/year and EUR/kW/year). That decision was adopted as an incentive for the development of recharging points infrastructure and applies only for points which exclusively serve as charging points for electric vehicles. The amounts of tariffs applied are shown in the table below.

Table 20 A comparison of the charging stations and other consumers.

Item	Measurement unit	Management of measurement		Costs of the system	
		BTA[5]	BTVE[6]	BTA	BTVE
Fixed component	Measurement of EUR/point/year	24,17-24,64	0,00	23,68-25,36	0,00
Power take-off unit (s)	EUR/kW/year	28,30-31,46	0,00	29,12-32,38	0,00
Electricity component	CEUR/kWh	0,85	6,55	5,43-5,08	11,30

BTVE tariffs are only applicable if electricity is consumed at the connection point for electric car charging only, and its variable component, which is the only charge for the charger, is significantly

[4] *Monomalial tariff is the tariff paid separately for the EV charging company and takes into account only the cost of energy taken over*

[5] *BTA Tariff — trivial tariffs designed for low voltage network users*

[6] *ITE tariff — monocular tariff for electric vehicle charging points*

higher than the same component for other consumers in order to cover partly the costs of the system and the network charges.

3.7.3. Structure of charging price for electric vehicles

The charging price for electric vehicles is determined to the maximum extent by the electricity price .The cost of charging is the combination of the price of primary material, which is determined by the market, and the two regulated components — the cost of the system and the network charges prescribed by the regulatory agency. Taxes and VAT are added to the price of electricity. In Italy, the charging cost differs depending on where the charging service is carried out[7]:

- **Charging in private premises, i.e. the use of infrastructure at** home, in which case the same tariff as for households applies and is paid by the user who has a contract with the supplier;
- **Private charging**, i.e. the use of a system which is separate from the household, such as separate garages. In this case, the user pays a tariff for other low voltage users to the supplier with whom the supply contract for the garage has been entered into;
- **Public charge**, for which there is a separate tariff set by the regulatory agency and described in the preceding chapter. This tariff is paid by the supplier of the charge service to the company with which it has concluded a supply contract.

Regulated components are higher for the public charging category than those for private premises, when only the household supply fare is paid.

[7] *https://www.enelx.com/content/enel-x-it/en/questions-and-answers/emobility/why-does-charging-in-public-and-charging-at-home-differ-in-cost-.html*

3.8. HUNGARY

The implementation of Directive 2014/94/EU in Hungary is being implemented in several legislative stages. The main provisions and concepts introduced by the directive were implemented, mainly in 2016 and 2017, through several legal acts and governmental and ministerial decisions.

According to the European Alternative Fuels Observatory (EAFO) data, a network of charging stations is currently located in Hungary with more than 580 chargers, of which more than 80 are of greater power (over 22 kW).

The Hungarian Government has adopted a number of amendments to the legislative framework in order to promote e-mobility, inter alia by defining the activity of charging an electric vehicle to e-charging station, and no longer falling within the remit of the Law on Electricity.

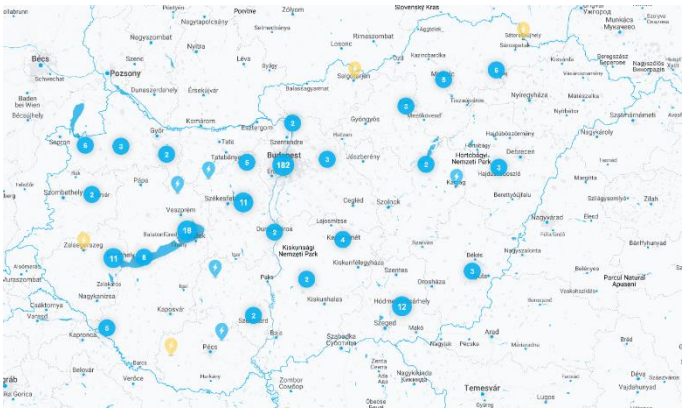

Figure 8 Map EV chargers in Hungary

As regards e-mobility in Hungary, it is important to highlight the Hungarian **E-Mobility Cluster 'Ányos Jedlik'**. It is the umbrella organization of relevant stakeholders involved in the development of e-mobility in Hungary. The cluster was established in 2014 as an advisory platform for government and involved in shaping the necessary development policies, exploring the economic, social and environmental potential of electromobility and recommending action by politicians and the business sector. The current cluster has more than forty cooperating members and partners, including car and bus manufacturers (Nissan, Porsche, Renault, MABI Bus), energy utilities (E.ON, MVM Hungarian Power Company, ELMÜ), IT Companies (Qualysoft), international consultancy companies (KPMG, PwC), car suppliers, providers of mobility solutions, the Hungarian Academy of Technology, the Technology University of Budapest, the research institutions, transport undertakings and several municipalities.

3.8.1. The role of DSO in the EV charges development

Under the regulatory framework in Hungary, DSO, and any other stakeholders, there is no responsibility for the development of electric vehicle charging infrastructure. As a consequence, any qualified market participant can build on EV charging points without any legal constraints, and the development is driven by free competition between all market participants.

In addition, the government has established the organisation of E-Mobi Electromobility (a non-profit limited liability company) with a basic aim to install EV charging stations through competitive procedures.

3.8.2. Network charge for EV chargers

In Hungary, there are no tariffs applicable to electric vehicle users.

Installing of the EV chargers does not enjoy any priorities and the investor has to pay for the compensation for connection to the distribution grid.

3.8.3. Structure of charging price for electric vehicles

The report did not find any regularity related to charging models for electric vehicles. It is only evident that the high number of charging services is still free of charge.

3.9. NETHERLANDS

3.9.1. The role of DSO in the EV charges development

The Netherlands started developing e-mobility and charging infrastructure for electric vehicles very early. In 2009, a National Action Plan for Electric Driving was carried out in the Netherlands, which provided, inter alia, for initiatives to set up charging points. For this reason, the Netherlands is currently the country with the most developed electric charging system in Europe, with the highest charging points in their territory. In 2010, the network operators established a consortium called 'E-laad Foundation', which aims to establish 10.000 charging points in public places and help local communities to develop e-mobility, as well as to create new EV charging points.

The owners of all EV chargers in the Netherlands are private companies and, in accordance with the European Union's recommendations, distribution system operators are not permitted to be in possession of electric vehicle charging systems.

3.9.2. Network charge for EV chargers

The network tariffs in the Netherlands shall be determined by the regulator, the ACL (Authority for Consumers and Markets), which is charged by the transmission network operator in the Netherlands, TenneT. The tariff is divided into two parts, the connection fee and the charge for the electricity transmission services. The compensation for electricity transmission services also consists of two parts, a consideration for non-transmission services, i.e. an administration service, and a charge for the transmission itself of electricity charged per kWh of energy transferred.

The tariffs shall be renewed annually and the decision to adopt new tariffs shall be published on the regulator's website and on the transmission system operators' pages.

In the Netherlands, stimulation of installing of the EV charges is carried out at local levels in cities and municipalities. There is no specific network charge for EV charging stations, but cities and municipalities are separately encouraged to build and install EV chargers. In order to support the development of the EV charging stations, the NKL foundation was established at the end of 2014 (National Charge Infrastructure Knowledge Platform Foundation), whose primary aim is to reduce the costs of EV charging stations. To that end, the NKL cooperates continuously with distribution system operators in the Netherlands, as well as municipalities and operators in the area of charging stations, in order to facilitate the installation and operation of the EV charging stations.

3.9.3. Structure of charging price for electric vehicles

In the Netherlands, various market participants are present in the charging services for electric vehicles and, unlike other countries, this market is quite developed in the Netherlands, which means that there is a significant number of different charging prices, and it has become difficult to define the charging price for electric vehicles accurately. Operators offer different prices and benefits in order to attract customers, and given that over 15 different bidders already exist with most market shares, competition is at a high level. By 2012, charging was entirely free of charge.

Charging starts from 1.1.2013, with a price varying from EUR 0,28/kWh to EUR 0,30/kWh. Since June 2014, the market has been fully liberalised and more and more operators are entering the market. It is then possible for charging station operators to determine the charging price themselves and charge it to service providers, who charge consumers for a service, and may add to them the cost of their services, such as a subscription service.

The price differs depending on the operator or the EV charger. It is permitted to have multiple tariffs depending on the location of the charging station or charging speed. There is a charge per volume of the electricity assumed (kWh), per time attached to the charging station (which does not have to be equivalent to the charging time) and for the amount of electricity taken (kWh) plus service charge. The average fee for the service is EUR 0,42 and charging cost EUR 0,32/session.

In addition to the costs paid by the consumer to the operator, there is a cost to be paid to the service provider. This includes a one-off purchase cost (EUR 0-10), a monthly subscription (EUR 0-5), with a possibility to pay a charge by use (EUR 0-0,61) with an increase per kWh (EUR 0-0,03) or using a fixed tariff independent of the operator. Charging at a similar location can be cheaper or more expensive depending on the choice of the service provider.

3.10. IRELAND

In May 2017, a National Policy Framework for the deployment of alternative fuels infrastructure was adopted in Ireland[8]. In Ireland, there is currently a network of more than 1.100 public, standard and fast charging stations across the country[9]. This includes over 300 Northern Ireland public chargers. They can be found in the streets, public car parks, purchasing centres, etc. All chargers are accessed using a subscriber card.

While the distribution system operator is the owner of almost all the charging stations, the rest of market player are gradually introducing into this market area.

3.10.1. The role of DSO in the EV charges development

In Ireland, a DSO model is currently in place, allowing distribution system operators to be charging station operator, and considering owning of charging points to be an extension of their regulated activity. The Irish DSO invests in the charging station infrastructure and the costs are offset by the distribution rate charged to all end-users of the network. The proceeds from the distribution rate shall be held in a separate company, in a separate account, which shall give account to the separation of the EV charging service. The service for billing is also separate for the end user, and in the future, when charging rates are set, will not be provided by DSO, so that the separation of accounts is complete. The Irish regulator has also approved the research and development budget of the DSO.

3.10.2. Network charge for EV chargers

The fee for the use of the transmission and distribution network accounts for about 30 % of the electricity price for the final recipients. In Ireland, there is no specific network charge at this time

[8] *Http://www.dttas.ie/press-releases/2017/minister-publishes-national-policy-framework-alternative-fuels-infrastructure*

for the use of the EV chargers, in particular because the owner of the chargers is the distribution system operator.

3.10.3. Structure of charging price for electric vehicles

Currently, charging stations and charging at the public charging stations are free of charge.[10]

[10] *Https://www.esb.ie/our-businesses/ecars*

4. A COMPARATIVE ANALYSIS OF THE SITUATION OF EV CHARGING AMONG SELECTED COUNTRIES

The development of e-mobility within the EU, including the installation of infrastructure for charging of electric vehicles as one of its key segments, has strong dynamic over the past decade, but the absence of a common policy has led to uncoordinated developments which resulted in different market and business models of installation and operation of EV charging stations in individual Member States.

Thus, some Member States present diametrically opposed **roles of electricity distribution system operators** (DSO) as one of the key stakeholders in the process of developing e-mobility. In certain countries, the DSO was given responsibility for the installation of chargers (Italy, Ireland, in part), while in certain countries the role of the DSO was reduced exclusively to their traditional set of regulated activities, namely the management of the distribution system up to the point of connection of the final customer (the Croatia, Czech Republic, the Netherlands). As regards e-mobility, EV charger represents the final customer and the role of the DSO is about the development of the distribution infrastructure and the introduction and application of new technologies to enable the integration of an increasing number of EV charging points in the electricity system. This concerns the development of advanced networks ("smart grids") in the context of the challenges and advanced charging of electric vehicles.

In the light of the uncoordinated approach, efforts have been intensified with efforts to create a common policy framework for the development of e-mobility at EU level. This is reflected in the adoption of legal acts complying with European directives (Directive 2014/94/EU and the Directive laying down common rules for the internal market in electricity). The current installation principles for charging infrastructure for electric vehicles go in the direction of total unbundling of electricity distribution system operators from the installation and operation of the EV charging stations, which should be based on market principles.

Thus, the relationship between the stakeholders in the process of developing e-mobility is more difficult to reconcile with systems established in the Czech Republic, the Netherlands, Germany. While certain countries (Italy) have left approach where the DSO was in charge of the development and deployment of electric vehicle charging infrastructure, in some countries the model is still present (e.g. Ireland, partly Slovenia). They seek to find the right way to align with countries that have developed a model that is aligned with the EU's recommendations.

Such processes are currently being realised in Slovenia, where the DSO, which is legally still in charge of the development of recharging infrastructure for electric vehicles, is set to only traditional regulated activities.

In Greece, the pricing method and billing conditions for EV users regarding the provision of use of recharging or electro mobility services are set as a free market model. Regarding the role of DSOs (in Greece currently only one – HEDNO), they are not permitted to own, develop, manage or operate charging points for electric vehicles, except for own private charging points solely for their own use.

The Portuguese Electric Mobility Network Management Entity (EGME) is MOBI.E, SA, a public company indicated by the Government, that ensures the management of the energy and financial flows resulting from the operations of the electric mobility network. The EGME has tariffs, set by the Regulatory Authority for Energy Services (ERSE), established to provide EGME with an amount of income calculated in accordance with the provisions of the Electric Mobility Regulation, applied to the electric mobility activities regulated by ERSE, covering the entire national territory.

Both offices/agencies for regulating the energy activities of individual countries are also one of the key stakeholders in the development of eMobility. Their role is to recognise, propose and guide the implementation of the necessary regulatory changes, to promote smart grid projects that include e-mobility, and to ensure the optimisation and harmonisation of electronic data exchange with the EU, i.e. to promote the use of open standards.

In most of the Member States analysed, the need to introduce new tariff models to compensate for the use of electricity grids for electric vehicle users has been recognised. By setting up such tariffs, it is intended to encourage the widest possible share of electric vehicle charging to take place outside peak power times of the electricity system.

For example, in the Czech Republic, the tariff for electric vehicle users of network charges for the duration of the lower rate is around 25 times lower per unit of energy supplied in comparison with the higher rate. In Netherlands and Ireland there are no specific tariff models for e-charging units, but prices are equivalent to those for other users, and depend on different parameters (electricity consumption and power, location, etc.).

In the Azores, there is dedicated network tariff for electric mobility defined by the Energy Services Regulatory Authority (ERSE) that is charged by EDA. The tariff for Energy and Commercialisation of Electric Mobility, collected by EDA, for the charging of electric vehicles is composed of prices of active energy that are broken down by an hourly rate, in euros per kWh.

In Slovenia, similar to the Czech Republic, there is a lower charging rate for electric vehicles (about 21 % lower energy price compared with the higher rate).

In Italy, a new tariff is designed for the electrical charging station, which only charges the delivered energy at the load, and no fixed charges such as connection and peak power fees are charged.

In Greece, the network charge for EV chargers refer to charges to consumers that use the NATIONAL ELECTRICITY SYSTEM. These charges are the same for all the consumers irrespective of the power supplier selected.

As regards payment for charging electric vehicles, there is a wide range of different charging models set up by individual service providers within Member States, thus large disparities within the EU exist. E-mobility service providers in individual countries have developed simpler and more complex charging models.

In the countries analysed, certain service providers currently use flat-rate payment models (fixed price for a specific period of time), charging models based on the quantity of energy supplied (Italy), as well as the combined models involving an energy component, a connected power, and the timing of the charging time. The Netherlands is one of the countries analysed with mixed models.

In Slovenia, partial recovery is made, which currently only refers to fast charging, including time component (unit of account) and fixed fee.

5. LIST OF FIGURES

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