The European Union is committed to tackling climate changes and has adopted many climate-related measures since its establishment in 1993. The transition to a low-carbon economy is a long and challenging journey, and several targets have been set to cut greenhouse gas emissions in future decades. An important element in helping to reach these objectives concerns the transport and production of electricity in Europe and the world as a whole.
Transport has always been mentioned as an important element that will help reduce greenhouse gas emissions. E-mobility introduces a new mode of environment-friendly mobility that has been developing rapidly in recent years.

Slovenia is no exception, and lately many Slovenian companies have been actively involved in various national and European projects, particularly in the field of EV charging infrastructure and EV integration into electric power system. In the near future, we can expect the rapid growth of electrification of the vehicle fleet all around the globe.

One can argue that the future of the transportation system is electric. However, there is no doubt that the massive introduction of e-vehicles alone cannot guarantee that the amount of greenhouse gas emissions will substantially decline. In order to achieve this goal, we need to ensure that all key stakeholders in the field of e-mobility will be actively involved in seeking solutions for two important issues.

Over the past years, ELES’s experts have been intensively investigating this field of science to find possible solutions for the above-mentioned challenges. Based on our outcomes, we have developed E8 – concept of integral development of infrastructure for mass charging of electric vehicles. This concept consists of eight key pillars, which ELES has identified as crucial in the transition towards the massive adoption of e-vehicles. Although particular focus has been given to personal passenger vehicles, the concept also covers some other fields of transportation electrification. All pillars will be described in detail in the following sections.
Electric passenger cars are no longer a thing in the distant future, but are rapidly becoming a choice in the car market. The electric vehicle (EV) will in many ways change the concept of mobility as well as the functioning of the electrical system as a whole. The pattern of electricity consumption will change and new opportunities for system services will emerge. Consequently, one should be aware that long-term transition to e-mobility is only possible with the close cooperation of key stakeholders – car users, the automotive industry, smart charging station manufacturers, building and parking space owners, transmission and distribution system operators, regulators and policymakers. An important part of this game will be the behaviour of e-vehicle owners, which will impact the decision whether to use, e.g., slow charging at domestic charging stations, or fast charging stations. Slow charging stations located on private parking lots will become the key element of future EV charging infrastructure, and should receive much more attention than it has today. Both home and office parking spaces are equally considered as private parking lots. These stations should not only smooth out EV consumption during the peak hours of power system operation, but also provide one of the most marketable flexibility services of the future. Smart charging on slow, privately owned parking lots with the long-term availability of connected cars for the power system, as well as their capability of being controlled remotely by distribution or transmission system operators, is the key process presented in this document. The main focus of this document is how to address the many logistic, social and technical obstacles that exist on the way to achieving the well-functioning of this process. Only in this way can society as a whole ensure that the energy for EVs will come from renewable energy sources. Passenger car owners can massively switch to EVs, and the price they have to pay for charging will be affordable and in line with their expectations. Controlled management will allow us to avoid costly investments in enhancing an already established grid and building, e.g., peak power plants in order to ensure reliable electricity supply, as well as defer investments in battery electricity storage systems that will be needed in the future low-carbon electric power system. We want to bring everyone's focus on finding the best solution(s) for all stakeholders involved.
E8 is a concept developed by ELES’s experts and consists of 8 essential pillars which we have identified as crucial for the successful transition to e-mobility. On the basis of these cornerstones, we elaborate further on various areas that should be taken into account in our further development activities, if we want to exploit as many positive effects as possible. Within the concept, we first describe users and their behaviour regarding the use of e-vehicles, then proceed to charging infrastructure and e-vehicles themselves. The concept concludes with an elaboration of how important the integration of charging infrastructure in the future electricity power grid is for its stability.

At some point there will be a big shift, mass adoption will happen, and we will have to be ready for it.
Diligent users

Looking around at cities worldwide, we can detect that the number of users who drive EVs has increased significantly over the past few years. This is also the result of a greater supply of different EV models and an extended driving range with a single charge. There is no doubt that EVs are triggering positive and negative emotions and thoughts to drivers, such as ecological awareness, limited driving range, lower costs of periodical maintenance, etc. All of these impact user experience and actually require them to consider making changes in their car driving or car treatment habits.

Most EV drivers are aiming at higher goals in their switch to EV, namely, to improve air quality and reduce CO\textsubscript{2} emissions, especially in big cities. Consequently, they expect their vehicles to be charged with green energy which, in countries with strong solar renewable potential, is produced to a large extent during the day when most EVs are not plugged in. Furthermore, most new EV users that have shifted from internal combustion vehicles expect they will charge their EVs very quickly in order to meet their travelling expectations. When such massive adoption takes place, it cannot be realized without negative impacts on the existing electric power grid infrastructure and energy prices.

Users need to realize that, in most cases, green and fast charging are not compatible. Fortunately, there are some good alternatives that will, however, require certain changes in users’ habits. One of them is how often and for how long their EVs will be plugged in during different periods of the day. The longer, the better. Besides, users should also question their requirements for immediate charging at their private parking lots versus the central management of charging power. We believe these are the most important habits that will have to be considered by EV users in order to have a beneficial effect on the electric power system and the driver himself. Most of the time, EVs are parked and we need to take care that they are plugged in and support central power management in order to offer flexibility to the system and charge them with green energy.

With different charging rates, we can also influence customers’ charging behaviour. These rates can also vary on an hourly basis and thereby promote a longer charging duration of each EV. Drivers should, however, consider that hourly rates and central power management are two distinct features that are acting on different system opportunities and causing different (positive) effects. One should note that central power management cannot be replaced by local power management with dynamic tariff rates.

Users support frequent and longer charging, and accept the central management of charging power.

Dense network

The long-term vision of EVs shall be oriented towards the usage of slow charging stations. For the time being, this segment is being neglected since public infrastructure needs to be installed first. We are enthusiastically monitoring the development of public charging stations in Slovenia and Europe.

However, it is our opinion that now is the time to focus more on private and slow charging stations, which also need to meet certain requirements in order to avoid the negative impacts of the massive adoption of EVs on electricity power grids and user experience.

In suburban areas, we do not expect many difficulties in securing the slow charging option, since most EV users have their own parking garage with a suitable charging spot. At the time of the first investment, these chargers should become smart and connected, which will be explained in a later section. More challenges can be expected at work premises or homes in highly populated residential areas, where slow charging infrastructure will be more difficult to provide. We expect that some new business opportunities will arise for service providers in the above-mentioned areas. Furthermore, we expect that most companies will invest in slow charging infrastructure in order to provide their employees with additional benefits.

We argue that a slow charging option should be secured almost everywhere, especially in places where EVs will be parked for longer periods. This is especially crucial during the day, when most people are working and the energy output from renewables is the highest.

Long-term charging is available to all owners of electric vehicles.
Simple connecting

The current solution(s) of constantly having to plug in our EV is not user-friendly. This is especially the case during unpleasant weather conditions, when people are not inclined to plug in their vehicle. Since we want to ensure maximum connection of EVs to the electric power grid, new modes of simple connection(s) need to be developed.

Although a number of contactless solutions have already been developed, too many prerequisites need to be fulfilled for successful charging. This means that the driver needs to park his EV very precisely in order to successfully begin charging.

In our opinion, the development of new, automated, contact and low cost technologies is relatively lagging behind and undoubtedly needs to be given more attention. New solutions and technologies will have to be addressed jointly by car manufacturers and manufacturers of charging stations. We need to achieve that the charging of an EV will be easier than refuelling a traditional internal combustion vehicle.

With joint development and testing, we can surpass the above-mentioned obstacles that will discourage EV drivers from frequent charging of their vehicles. We argue that this needs to be addressed and solved urgently, if we are to achieve our goals within the E8 Concept.

Contact technologies allow for vehicles to connect frequently to charging stations.

Instant identification

Under this pillar, automatic and direct identification is considered crucial for a fast-running process, as well as an easy and outstanding user experience for EV drivers. In our view, most of the charging in the near future will be performed at private charging stations. We even expect that different EVs will be charged on the same spot during the day, and will be linked to various electricity providers. Roaming at private charging stations will prove to be even more challenging and important compared to public charging stations, since there will be more entities (retailers, aggregators) involved in the process. Standardized solutions need to be developed and agreed among service providers in order to offer good working solutions to EV drivers.

Our main intention here is to highlight the importance of private roaming from the user perspective. Namely, we want to avoid situations where a user does not charge/avoids charging his vehicle at specific spots, because it is not clear to whom the charging bill will be assigned, or simply because he will not have proper access rights or capacity to easily compensate his costs at a private charging station.

We need to make sure that developed solutions will be adopted more quickly, and that charging options and experiences will be as easy and transparent as possible. In this way we can guarantee that users will plug their EVs in more often and, consequently, their flexibility towards the electric power system can be provided to a full extent.

Charging stations automatically recognize vehicles and provide for advanced hosting.
Multi-level integration

A larger number of private charging stations for EVs will be connected to the electric power grid in upcoming years. This could have a major impact on the electric power grid, voltage and current discrepancies, if they are not addressed properly. From the technical point of view, a charging station is a passive load which burdens the existing technical infrastructure. However, with the remote powering flexibility mentioned in pillar number 5, charging stations can have a beneficial impact on the infrastructure as well. Due to its flexibility, it can help relieve congestion issues and enhance the utilization of existing electrical infrastructure.

We can only achieve a positive impact if all installed charging stations are smart and enable remote powering. This will have to be complemented by a connection to the central distribution or transmission control systems in order to maximize the utilization of power grids. By employing proper and real-time optimization functions and measures, we can secure stable operation of the electric power grid and avoid any potential limitations of including new charging stations.

Flexibility is highly important, especially when this flexibility is being offered to the market of ancillary services. Charging stations will have to be connected to systems that are governed by so-called aggregators or other balancing service providers, which will offer services to system operators. This communication between systems is very complex and will need to be executed in real time.

We see a central platform and complex coordination and communication among different systems as crucial and needed steps towards multi-level integration. Several challenges, such as centralization, standardization, data exchange and confidentiality issues, will have to be addressed and resolved during this process.

Private charging stations are integrated into the electric power grid and connected into control centre (DSO, TSO).

Remote power control

With the massive adoption of EVs, we can expect that most of the charging will be executed at private charging stations. In order to control the power needed for charging and local congestions in the network, we support the building of smart and slow charging stations. All charging stations need to support complete digitalization in order to ensure the successful communication with other systems that is needed for a complete charging service. Charging stations need to be equipped with proper solutions for charging, costs settlement and remote power control for each charging session.

Once the massive construction of private charging stations is in progress, we cannot afford to neglect all the above-mentioned functionalities. We must make sure that investors take them into consideration and build only adequate solutions to secure a good user experience. Eventual subsidies or other incentives shall be considered for adoption by the regulatory authorities with the aim of overcoming the initial burden of car owners.

The power of each private charging station can be effectively managed remotely.
Strategic management

The E8 Concept will only evolve successfully if all complementary solutions are developed, implemented and introduced to EV users in a holistically balanced way. All stakeholders need to ensure that the final solutions need to be beneficial to both sides – the existing electric power grid and EV drivers. If the proposed solutions are easy for EV drivers, but harmful to the system, it will take us longer to reach a sustainable model of EV charging.

The development of private smart charging requires a coordinated approach with other charging solutions. Fast charging stations are an important part of the public infrastructure that we need to secure for successful migration towards e-mobility. Although we support the installation of fast chargers along highways and in places where people want to charge their EVs quickly, we would nevertheless like to avoid fast-charging replacing the potential benefits that can be created by slow charging.

Many other technologies and schemes are under consideration in the field of e-mobility, including contactless charging on highways, battery storage support at fast chargers, car sharing, autonomous driving, etc. The E8 charging concept can only reach its goals if all these alternative solutions are developed in a logistically and technologically sound e-mobility system.

The challenges of using fast charging stations and local electricity storage are managed effectively.

Market acting

With the increasing number of EVs, we expect that the market of ancillary services will also be enhanced to support the capacities of EV charging operators. It will be necessary to find a path where charging will be executed in the most beneficial way for electric power grid and EV users. However, the integration of charging stations into the electric power grid does not guarantee that users will monetize their active participation in sustainable charging. It will be crucial to develop new business models to support the integration of EVs into different ancillary services.

We assume EVs will have to be regarded as mobile batteries with a certain amount of power which can be available for system balancing. The location of each EV battery will have to be determined in order to maximize the benefits for the system and EV users. For the time being, we expect that the business model will be based on the aggregation of individual charging stations/batteries into larger units, which will then be offered via aggregators to system operators.

Most important to note, however, is that the advanced users of smart charging stations will be compensated and stimulated to offer their flexibility to aggregators. If this is recognized as beneficial for the system and EV users, new business models will develop and more EV drives will enter these services.

The goals mentioned within the E8 Concept will be more easily addressed and tackled if regulators and policymakers are involved. It is crucial that these challenges are addressed and discussed in detail among different stakeholders. Only together can we find solutions that will be beneficial to all stakeholders.

Charging stations are active on the flexibility market.
Conclusion

E-mobility can bring a lot of benefits to the community, but decisions related to passenger car charging will determine if these benefits can surpass the side effects and negative impacts of its massive adoption. If we want to introduce e-mobility under acceptable conditions for all electric power grid users, the competent stakeholders will have to deal with the challenges in a timely and high-quality manner.

We are aware that the long-term and unified progress of all stakeholders is the key to success in introducing massive electrical mobility in Slovenia, Europe and the world. Accordingly, E8 should play a key role in aligning the views of active stakeholders. The E8 Concept combines all these challenges with the intention of raising the awareness of all stakeholders that are, or will be, actively involved in e-mobility in order to find a common and the best path for all those involved.

References:


