White paper

# Go further with less: What is needed to roll out EV charging infrastructure by considering highly efficient EVs


ubitricity
A Member of the Shell Group

Lightyear

# Executive Summary

This white paper combines ubitricity's low power charging infrastructure and Lightyear's highly efficient vehicle **as a solution to boost EV adoption and to bring electricity to everyone, everywhere.**

With the accelerated acceptance of electric vehicles set to reach 84 million in Europe by 2030 comes a string of challenges [1]. Vehicle electrification will demand a substantial increase in the charging infrastructure and weigh heavily on the existing electricity grid.

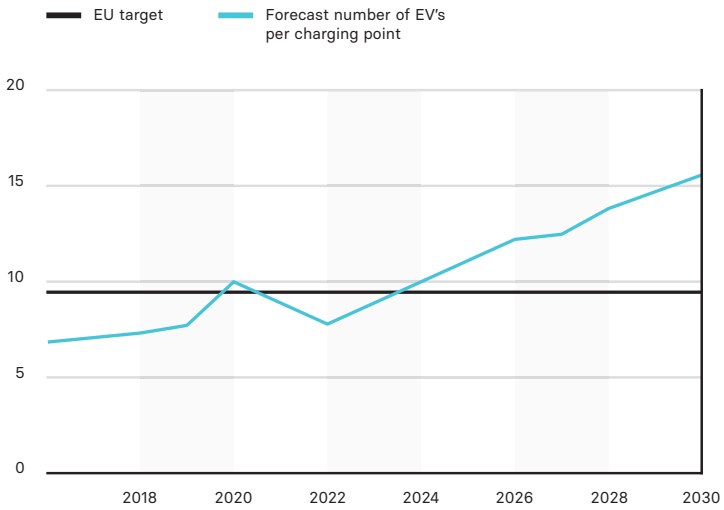
Low-power chargers are the root charging solutions today, that enable a cost-efficient expansion of charging infrastructure, which is fit for most charging use cases. Highly efficient vehicles need to be charged less frequently, while having a higher charging speed on low power chargers. This would relieve some of the existing pressure on the electricity grid by reducing the power demand from EVs.

By implementing electric vehicles and the associated infrastructure in an intelligent manner, it is possible to expedite and reach Europe's climate ambitions, while providing benefits and reducing the costs for grid operators and end-consumers.

In order to meet the ambitious targets set for decarbonization of the transport sector, we need to tackle the current challenges from several angles. Higher vehicle efficiency allows for more EVs charged per charger, and installing low-power chargers results in more chargers for every euro spent.

## Sufficiency indicator EU: EVs per charging point

Figure 1 — This graph shows the current target for EVs per charge point, according to the EU regulations - also the forecast until 2030 [2].



# Statements

# 1 Definitions

# Definitions

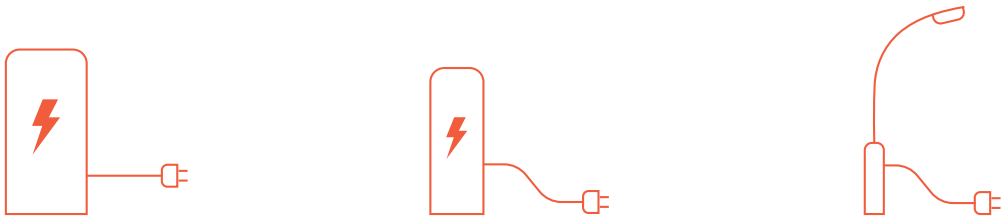
This paper introduces two main concepts, that point in the direction of a sustainable and rapid adoption of electric vehicles. These two concepts are: low-power charging infrastructure and EV efficiency. Low-power charging infrastructure can be scaled cost-effectively to answer the increasing EV adoption rate in Europe, while EV efficiency enables vehicles to charge fast on low-power.

## 1.1 Low-power charging

Power is the measure of the speed at which electricity flows. As a general rule, a higher power means a higher flow of electricity. Consequently, the higher the power a charge point offers, the more robust the infrastructure needs to be to transport the electricity.

Charging infrastructure is being deployed as a response to the increase in EVs globally. The three main categories of charging infrastructure (high-power, mid-power and low-power) and their main use cases will be explained.

Figure 2 — Overview of different EV charging infrastructure



High-power charging (↗ 50kW)
Typical installations cost: €€€€

Mid-power charging (7.4 to 22kW)
Typical installations cost: €€€

Low-power charging (1.4 to 7.4kW)
Typical installations cost: €€

For long-distance EV drivers who need to quickly charge and continue their journey, high-power charging offers the possibility to charge around 80% of the battery in less than an hour. This charging solution is located at charge hubs and highways.

Another important use case is destination charging. This type refers to charging at locations where vehicles are parked between half an hour and a couple of hours (e.g. shopping malls, supermarkets). In these locations, and because of the relatively short duration of the charging event, semi-fast to fast chargers make more sense (22kW- 50kW). To install these charging stations, new grid connections are needed, increasing the overall cost of installation and the complexity of planning with different stakeholders.

Low-power charging, starting from 1.4kW, can be found anywhere. Every house socket or street lamp is potentially a low-power charging point. This type of charger utilizes the time that cars are parked anyway, in order to charge them, mitigating the impact on the grid and offering a more scalable solution. It is the prefered charging option for EV drivers who have access to a dedicated parking spot at home and usually charge their vehicles overnight. An average EV user commuting to and from work can get the required energy from low-power chargers during the usual parking hours. For EV drivers that live in residential areas, who do not have a private driveway, existing street furniture (such as lamp posts) can be retrofitted and utilized for charging electric vehicles.

## 1.2 EV efficiency

EVs are already more energy efficient than their internal combustion engine (ICE) counterparts. While an ICE has an efficiency of around 30%, meaning it only utilizes around 30% of the energy contained in the fuel, an EV has an efficiency of above 80%. Within this white paper, we will use kilometers per kilowatt hour (km/kWh) as a measurement for the efficiency of an EV. An efficient EV would require less energy to drive from A to B than an inefficient one, given the same conditions.

Efficient EVs will consume less energy and thus be able to charge at lower power or for shorter periods of time. This could allow better EV charging **integration to the electricity system** by introducing flexible mechanisms (e.g. load management), and turning **EV users into active actors**, instead of only consumers of the electricity infrastructure.

Efficiency comes down to three elements: aerodynamic drag resistance, rolling resistance and powertrain efficiency. By optimizing these three elements, the energy consumption of the vehicle will be minimized.

By minimizing the vehicle's energy consumption through efficiency, the integration of solar panels on the vehicle, in order to lengthen its range becomes a viable option. As done with Lightyear One, the vehicle will not only become a mobile charging station, but is also able to charge at even higher charging speeds during daytime. To further examine this, it helps to dive deeper into the definition of charging speed.

## 1.3 Charging speed

By minimizing the vehicle's energy consumption through efficiency, it can make use of renewable energy sources such as solar energy. By integrating solar panels on the vehicle, it can become a mobile charging station. The vehicle is also able to charge at even higher charging speeds during daytime. To further examine this, it helps to dive deeper into the definition of charging speed.

Currently, charging speed is expressed in kilowatt hours (kWh) per hour charged. However, consumers are typically not aware of the kWh needed to drive a certain distance. Therefore, within this white paper charging speed will be addressed in terms of kilometers charged per hour. Using this metric, the more a car is energy-efficient, the faster it charges, as depicted in the figure below:

| | **Efficiency** | **Charging speed** at 7 kW charger | **Charging speed** at 11 kW charger | **Charging speed** at 72 kW charger |
|---|---|---|---|---|
| Efficient EV → | 10 km/kWh | 70 km/h | 110 km/h | 720 km/h |
| Less efficient EV → | 5 km/kWh | 35 km/h | 55 km/h | 360 km/h |

Figure 3 — Energy savings of the Lightyear One compared to a regular EV and the principle of lightweight design.

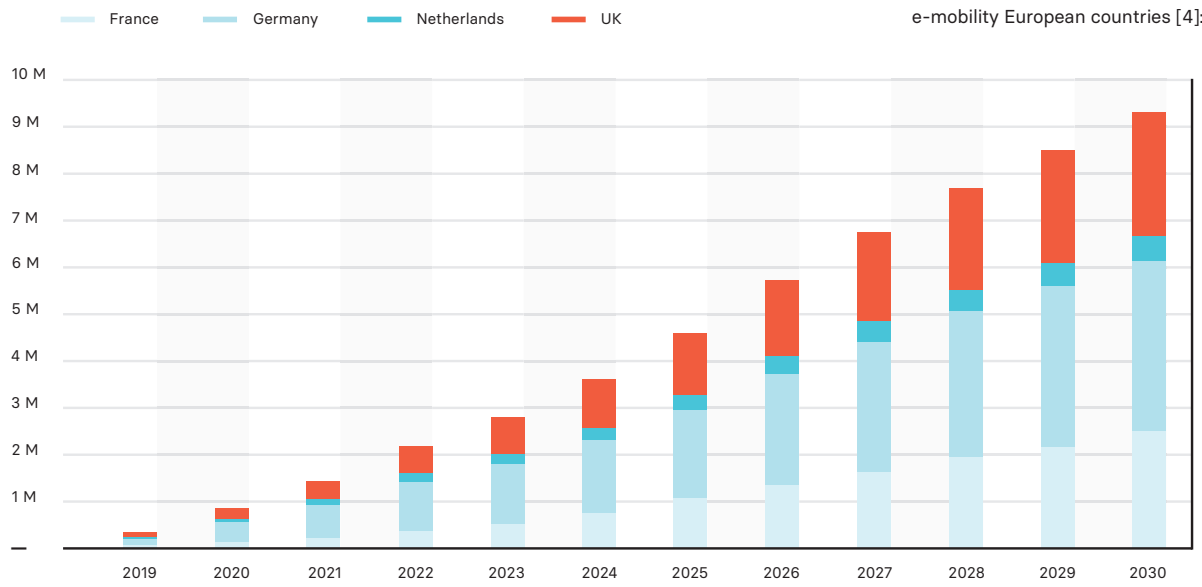
# 2 Context

## 2.1 EV Outlook

Due to the EU's policy objective of reducing greenhouse gas emissions from transport, interest in electric vehicles has seen a seismic shift in the past two years. Because of the “Fit for 55” EU legislations, countries are now planning to phase out the sales of their ICE vehicles, which will accelerate the transition to sustainable vehicles. Norway has banned ICE fuel vehicle sales by 2025; the Netherlands, Denmark, Sweden, Slovenia, and Ireland are set to follow suit in 2030; and France and Spain plan a phase out by 2040 [3].

In 2030, 84 million cars will be electric in Europe [1], with higher proportions in Western and Northern Europe, where investment in infrastructure and purchase subsidies will accelerate deployment.

Figure 4 — See projections for the top 4 e-mobility European countries [4]:




Because of the electrification of the car fleet, electricity demand by electric vehicles will grow from nearly 0% of the EU’s total electricity production today to about 10% in 2050, assuming a scenario in which 80% of the cars are electrified [5].

The increase in electricity demand can contribute to integrating more renewable energy to the electricity grid. However, it can also further stress the system depending on EV use and charging behaviour. Hence, it is important to understand user behaviours, to ensure that the implementation of electric vehicles and the associated infrastructure happens in an intelligent manner.

## 2.2 EV charging scenarios

The increase in the number of EVs is going to inherently challenge existing distribution systems and put additional stress on the electricity network in general. Uncoordinated EV charging (i.e. without any type of smart charging mechanism) will increase the peak demand for electricity between 6pm and 8pm to around 1.2GW in Belgium and 6.5GW in Germany [6]. That represents around 10% increase in the peak demand and poses a big challenge for the current system and the integration of renewable energy. A variety of factors that are not directly tied to the transport sector will already contribute to an increase in peak demand for electricity. Some examples of these are connected devices, shifts to electric cooking, and air conditioning units [5].

The main challenge with an increase in the electricity demand is not the energy itself, but rather the power. Our electricity systems were physically designed to handle a limited amount of power, hence having an increase in peak demand puts the grid under stress. On top of that, the inclusion of renewable energy sources, like photovoltaic and wind farms, added an extra level of complexity to balancing supply and demand for system operators.

A study modeled the required investment for an average grid operator until 2030, given an assumed EV penetration and a certain level of smart charging. The results showed that, even though some level of grid reinforcement investment is to be expected, this investment will drastically vary from a scenario with optimized time and location of charging (smart charging), to a non-optimized one [7]. Implementing smart charging mechanisms will help keeping the energy prices from drastically increasing for end -users.

The study outlines that all the investments made by the operator may not be able to be covered by the increase in revenue from additional electricity sales. Because of that, an increase in the electricity tariff to EV users is to be expected. The difference in the expected rise of electricity tariff for end-users, between the optimized and unoptimized charging scenarios, increases significantly as EV penetration goes up. For 20% EV penetration, the increase in tariff for the optimized scenario would stay below 1%, whereas, for the unoptimized one, it would be around 11%. In the case of 50% EV penetration, the increases would be around 2% and 38%, respectively.

| EV penetration | Optimized scenario | Unoptimized scenario |
|---|---|---|
| +20% | +1% | +11% |
| +50% | +2% | +38% |

Figure 5 — Increase in end-user tariff

## 2.3 The need for on-street charging infrastructure

EU cities are densely populated areas, where private parking spaces can be scarce. It is common to encounter areas with on-street parking. In the case of Berlin in 2017, 60% of the cars in the city had to park on the street [8]. In December 2018, there were around 263,000 on-street parking places in Brussels [9], about one per every 4.5 inhabitants of the city and roughly one per every 1.9 vehicles registered in the city.

However, a recent study showed that around 80% of current EV users own a private garage or a driveway. **EV adoption has been limited to a specific part of society.** Hence, after successfully connecting the early adopters (with garages and driveways) to EV home charging, now it is time to provide a convenient on-street charging solution for all drivers.

# 3 The path forward to charge all electric vehicles

## 3.1 Low-power charging: cost-effective solution for on-street charging

Low-power charging would satisfy the daily energy needs of most EV users who have a longer parking duration. It also mitigates the stress on the local grid, and can be used to help integrate renewable energies into the electricity mix using smart charging.

Solutions that use what already exists could significantly reduce the required investments to transform the mobility and energy sectors. These savings would not only relieve some financial pressure on the local authorities, but would also be reflected on the end price for EV users. If the limitations of the existing grid are not taken into consideration, it could lead to unexpected upgrading costs.

ubitricity has integrated more than 3,600 low -power (max. 5.5kW) EV charging points into lighting infrastructure in the greater London area. Usage data from over 340,000 charging events from ubitricity's users shows, that on average, EVs are plugged in for approximately 11 hours, but only charge for around 4 hours. In fact, 62% of the EVs are plugged in at least one hour longer than they require to fulfill their energy needs.

In the future, it is likely that drivers will need access to high-power chargers (50kW+) along highways for long-distance travel, mid-power chargers (7.4-22kW) for destination charging and a large number of low-power chargers (1.4-7.4kW) to fulfill everyday home and workplace charging needs.

## 3.2 EV efficiency: enabling higher charging speed on low power

An accelerated deployment of EVs is needed to reach the European Union's climate goals. Yet the deployment of charging infrastructure is a major limiting factor. By building efficient cars like Lightyear One, which charge less, we can support more electric vehicles on the same infrastructure. Efficient vehicles can adapt to any charging infrastructure. This, including low-power charging, reduces the threshold to buy an EV and enables vehicles to become mobile charging stations due to solar power integration.

An efficient car with a low-power charger can still charge additional range faster than an inefficient car with faster charging. See the comparison of a standard EV platform and an efficient EV platform in figure 8.

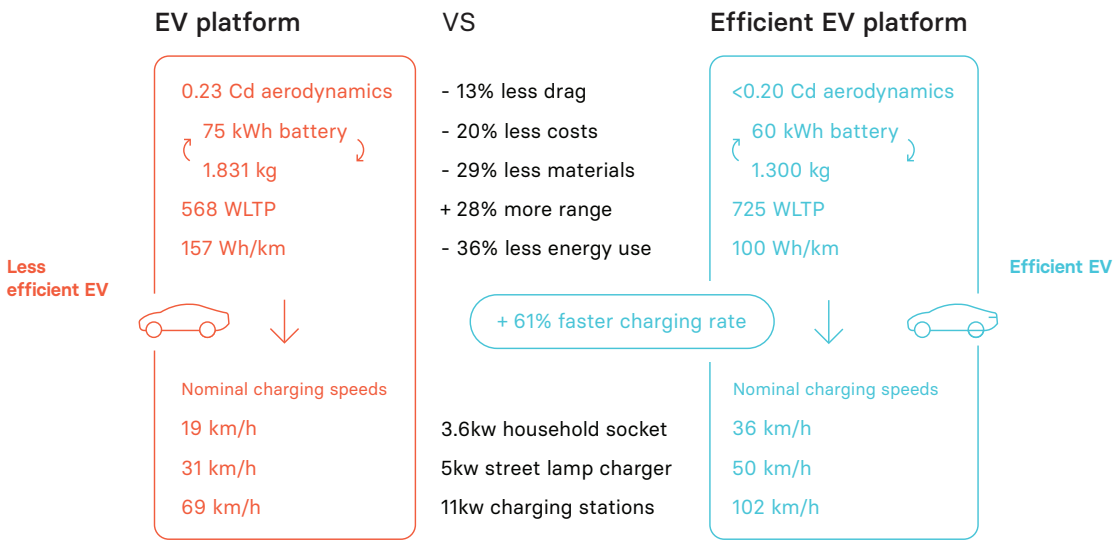



Figure 6 — Characteristics of a standard EV compared to the Lightyear one

To accelerate EV development, most countries have implemented subsidy schemes to incentivise EV purchases. This focuses on lowering the price of mid-range electric vehicles, to help them achieve cost parity with ICE vehicles. This has significantly sped up the deployment of EVs in countries with the most generous schemes. But a better approach is now needed to make sure the most efficient electric vehicles end up driving on our streets.

Currently, three million public charging points will be needed to meet the electric car fleet in 2030, following the European Green Deal ambition [10]. By encouraging efficiency in electric vehicles, the economic impact of expanding and reinforcing the electricity grid could be mitigated. This will save grid operators, taxpayers, and governments billions of euros in costs. Depending on the adoption rate of high efficient electric vehicles, the cost savings for the Dutch charging infrastructure is estimated to be up to 5 - 6 billion euro until 2050 [11].

The European Union plays a major role in setting the right targets over time when it comes to reducing CO2 emissions from transport. However, it is at a national level that the right incentives need to be created. Luxembourg recently implemented a subsidy system based on the efficiency of a vehicle instead of the price. All electric vehicles are entitled to a 3,000 Euro subsidy, while those EV with efficiency above 5.5km/kWh are entitled to 8,000 Euro.

Applying European-wide efficiency standards on electric vehicles through the use of energy labels or categories would encourage manufacturers and consumers to develop and buy energy efficient vehicles.

These European technological developments around high-efficiency solar electric vehicles ensure global competitiveness, avoid future dependence on other parts of the world, and maintain high-quality jobs in Europe. Therefore, it is ever so important that European policymakers stimulate these developments and give them a central place in the 'Fit for 55' package, that is currently negotiated.


# 4 Conclusion

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In light of climate change, the urgency of a shift in the mobility sector towards zero emission transport is evident. EV numbers are growing rapidly, which means that high demand for charging infrastructure is inevitable. Therefore, it is important to support the right technologies today. The goal is to avoid costs that would derive from having an unbalanced charging network and not create the need for unnecessary electricity grid reinforcements. Actions need to be taken **to promote low-power charging, paired with highly efficient electric vehicles.** This comprehensive, integrated and scalable solution should be considered for solving both urgent and future challenges. Implementing solutions that only focus on urgent challenges might create further problems in the future.

Hence, promoting the adoption of high efficiency EVs – that can drive more km/hour charging and provide widespread low-power public charging infrastructure – is important to reduce the overall impact on the power grid that large numbers of electric vehicles will certainly bring.

# Final remarks

Technology development does not happen linearly, but rather exponentially. And right now, we are at a tipping point in electric mobility.

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Involved in the energy sector since 1997 and worked for Shell in Germany, Malaysia, and the UK, lately as General Manager, Retail Engineering Solutions in London.

**CEO, Co-Founder — Lex Hoefsloot**
Founded two student teams, of which the achievements reached millions of people. Co-Founder Lightyear, Founder Solar Team Eindhoven.

We are witnessing a fast-tracked development of digitalization, green deal programs, and solutions for a carbon neutral future. E-mobility is no longer a research field, it is time to get invested. A growing number of EV models make e-mobility a thing for everyone and charging needs to be simple and convenient. Globally, EVs are exempted from taxes and, on top of that, there is a lot of public funding available for EVs and infrastructure because more and more people want sustainable mobility solutions. EVs paired with clever charging options play an important role for the decarbonisation.

The landscape has evolved massively and provides a much stronger foundation for mass adoption – a motivation for us at ubitricity to provide convenient charging solutions.

As electric vehicles are not just for the early adopters anymore, the efficiency of these vehicles is growing with every new model on the market. With more EVs on the streets, new technology and more use cases, there is more data available to understand user behavior, renewable energy supply and demand, grid capacity, and charging infrastructure.

Some elements like battery life and range become a differentiator in EV adoption and further aid infrastructure roll-out.

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