European Alternative Fuels Observatory

On the electrification path: Europe's progress towards clean transportation

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Study performed by the European Alternative Fuels Observatory on request of the European Commission

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Introduction

The European Green Deal is Europe's key roadmap to make the continent carbon-neutral by 2050. The Deal, published by the European Commission in December 2019, states that by 2025, about 1 million public recharging points will be needed for the 13 million zero- and low-emission vehicles expected on the roads of the European Union (EU).[1] The European Green Deal is also an important pillar of the EU's recovery strategy in response to the COVID-19 outbreak in early 2020, "Next Generation EU," which confirmed the need for 1 million recharging points as part of a plan for a cleaner transport system in the EU.[2]

The EU's expectations for electric vehicle uptake and recharging infrastructure deployment are ambitious. By the end of 2020, there were 2.24 million battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) in the 27 EU Member States.[3] Of these, the highest share were passenger cars (94.3%), followed by light commercial vehicles with a share of 5.4%. Buses and trucks accounted for 0.3% and 0.03% of the total electric vehicle fleet, respectively. In other words, by 2025 the European Commission expects an almost sixfold increase in BEVs and PHEVs.

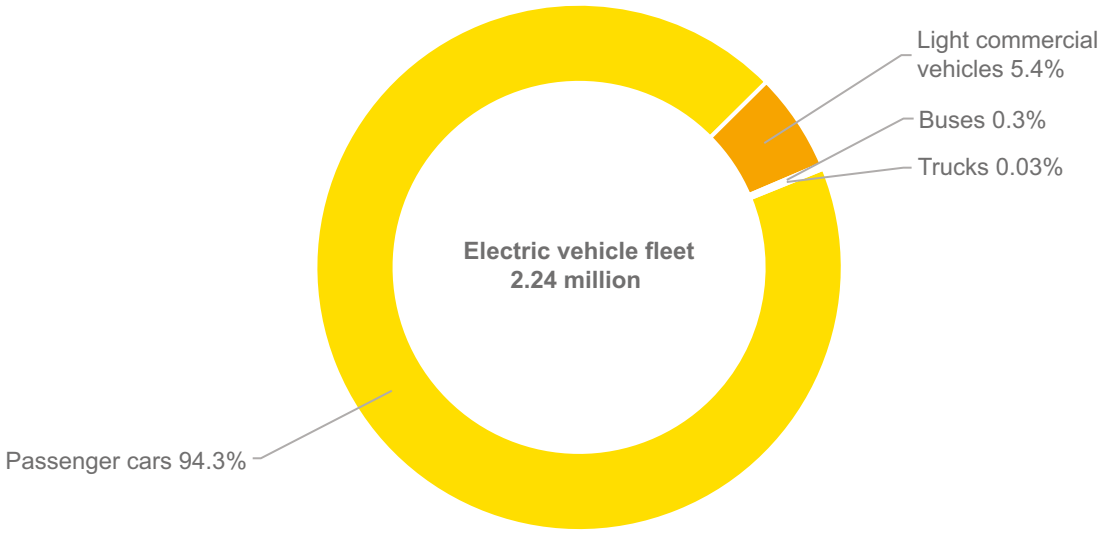

Figure 1. Electric vehicle fleet in the 27 EU Member States by December 2020.

A similar increase is needed to reach the 1 million public recharging points expected necessary by the European Commission to serve such growth in the electric vehicle fleet by 2025. By the end of December 2020, there were over 226,000 publicly accessible recharging points across the EU-27 Member States, 89% of which were normal power recharging points (with power equal to or less than 22 kilowatts) and 11% high power recharging points (with power greater than 22 kilowatts). The current total accounts for 23% of the public recharging infrastructure that would be required by 2025.

Great efforts will be necessary by the EU as well as the Member States and regional and local governments to accelerate the transition towards electric vehicles. This policy paper illustrates the current uptake of electric vehicles with a focus on passenger cars, which account for 94.3% of the electric vehicle fleet in the EU-27 Member States. In addition, the paper analyses the rollout of the public recharging infrastructure network

for electric vehicles. The policy paper also investigates key regulations at the EU level to drive electric passenger car uptake and the necessary public recharging infrastructure. Furthermore, key national and local levels policies in markets with high electric vehicle volumes are highlighted. The paper concludes with recommendations for future policy making at EU level. The geographical scope focuses on the EU-27 Members States, the United Kingdom, and the countries of the European Free Trade Association (EFTA,) including Iceland, Liechtenstein, Norway, and Switzerland.[4] Data is obtained from the European Alternative Fuels Observatory (EAFO).[5]

Analysis of electric passenger car deployment in Europe

The electric passenger car market has grown continuously over the past years. Yet, the growth is still concentrated in a few European markets. Nevertheless, despite the global COVID-19 pandemic, the share of electric vehicles rose significantly in most European countries in 2020. This is not least due to EU regulation which set stricter carbon dioxide (CO_2) emission performance standards for passenger cars and light commercial vehicles from January 2020.[6]

THE ELECTRIC PASSENGER CAR UPTAKE IN EUROPE IS DRIVEN BY A FEW MARKETS

By the end of 2020, 1% of passenger cars driving on European roads were electric, both in the 27 European Member States and also if including the United Kingdom and the EFTA countries. The majority of electric passenger cars on European roads were concentrated in Germany, Norway, the United Kingdom, France, and the Netherlands with a combined share of 70% of Europe's electric passenger car fleet (Figure 2). By the end of 2020, the German electric car fleet consisted of almost 600,000 vehicles. Following Germany by total fleet numbers were Norway with over 450,000 electric cars on the road by end-2020, the United Kingdom with just under 450,000 electric cars, France (almost 410,000) and the Netherlands (almost 280,000 electric cars). Eleven countries recorded electric fleet numbers below 5,000 vehicles, ranging between over 200 in Liechtenstein to almost 4,500 in Slovenia. Next to Liechtenstein and Slovenia, countries with small electric passenger car fleets included Bulgaria, Croatia, Cyprus, Estonia, Greece, Latvia, Lithuania, Malta, and Slovakia, which are smaller vehicle markets compared to the leading electric vehicle markets by passenger car sales. Figure 2 also reveals that in 24 of the 32 markets, the share of BEVs on the road exceeded that of PHEVs. Exceptions were Belgium, Cyprus, Finland, Greece, Iceland, Luxembourg, Sweden and the United Kingdom, where PHEVs dominated the electric passenger car fleet by the end of 2020.

By fleet shares, Norway was leading with 16% of the total passenger car fleet being either a BEV or PHEV by the end of 2020. This was followed by Iceland with a fleet share of 6%, Sweden (4%), the Netherlands (3%), and Denmark where just over 2% of the total passenger car fleet on the road were electric vehicles. In the remaining 27 countries, the electric passenger car fleet share was 2% or less. On the bottom were Greece and Poland with 0.06% and 0.05% of their car fleet being a BEV or PHEV, respectively.

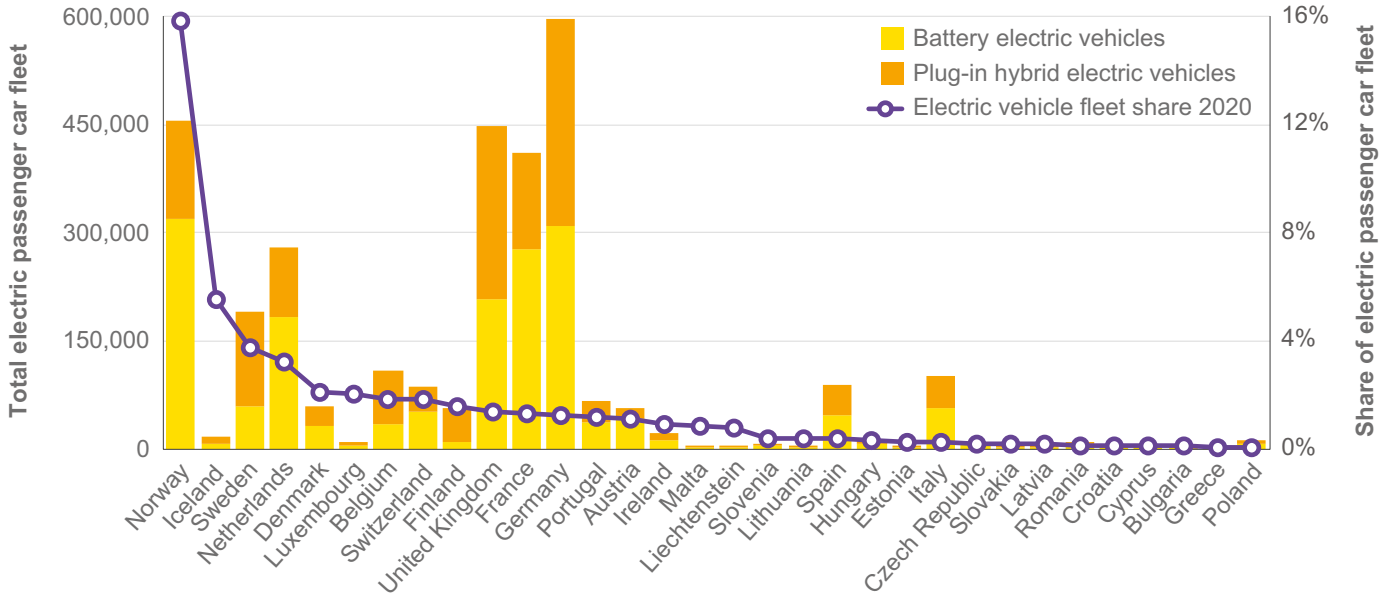

Figure 2. Total and share of electric passenger car fleet in European markets by December 2020.

The fleet composition is also reflected in new passenger car registrations in 2020, as shown in Figure 3. Overall, 1.36 million electric passenger cars were registered across the 27-EU Member States, the United Kingdom, and EFTA countries in 2020, a share of 11% of all new passenger car registrations. By absolute numbers, most electric passenger cars were registered in Germany (over 390,000), followed by France with over 185,000 new registrations, the United Kingdom (almost 175,000), Norway (over 105,000), and Sweden (almost 94,000). These five countries recorded 70% of all new electric passenger car registrations across the EU-27 Member States, the United Kingdom, and the EFTA countries in 2020. Differentiated by BEV and PHEV registrations, in 21 out the 32 markets analysed, new BEV registrations outpaced those of PHEVs. In Belgium, Cyprus, Denmark, Finland, Germany, Greece, Hungary, Luxembourg, Portugal, Spain, and Sweden a larger proportion of consumers opted for a PHEV if deciding for an electric car.

By registration shares in 2020, Norway was again far ahead of other European countries (Figure 3) with 75% of all new passenger car registrations a BEV or PHEV. This was followed by Iceland with an electric passenger car registration share of 51%, which is a small market with 4,800 new electric vehicle registrations (Norway over 105,000) and a fleet of 15,000 electric passenger cars (Norway almost 454,000). Following Iceland were Sweden, the Netherlands, and Finland with shares of new BEVs and PHEVs registered of 32%, 25%, and 18% respectively. The lowest registration shares below 2% were recorded in five countries: Cyprus, Croatia, Lithuania, Malta, and Poland.

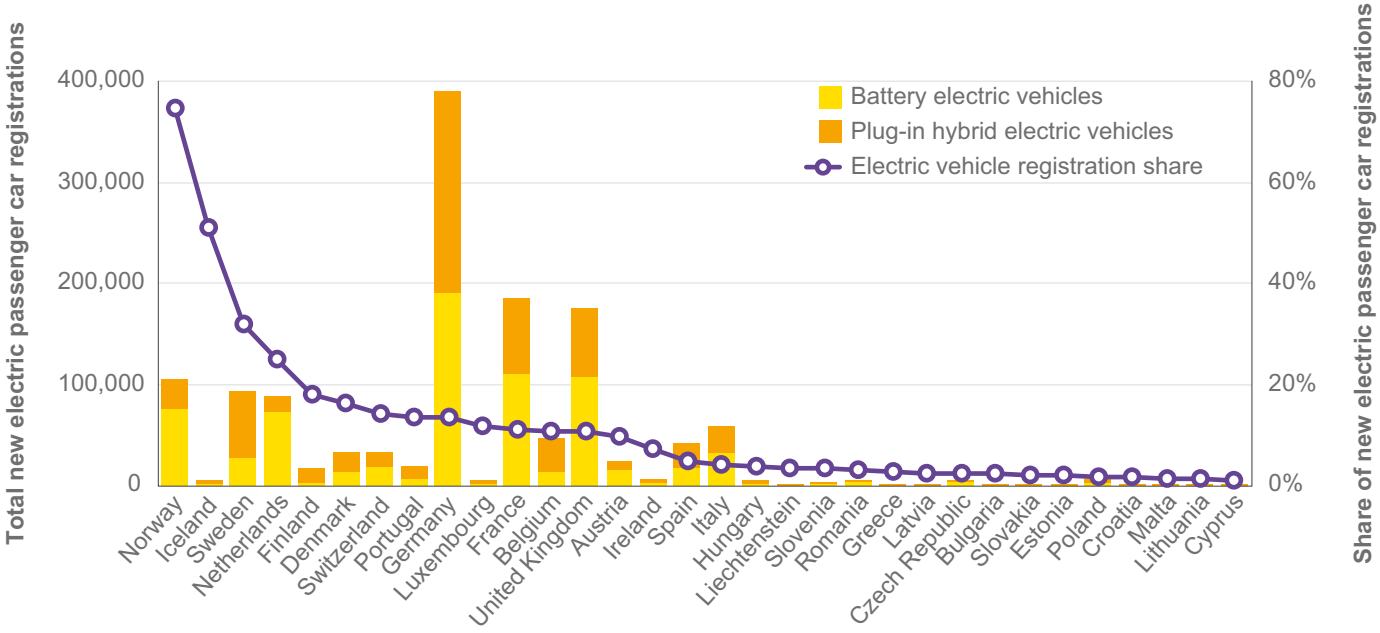

Figure 3. Total and share of new electric passenger car registrations in European markets in 2020.

Table 1 summarises the results, showing the top five countries by 2020 electric car fleet total and share as well as registration total and share. The table also displays the leading EU-27 Member State countries. In the European Member States, 75% of the electric vehicle fleet was concentrated in Germany, France, the Netherlands (which at the same time had the second-highest electric car fleet share at 3%), Sweden (with the highest fleet share of 4%) and Belgium (fifth-highest fleet share of 2%). In terms of total new 2020 electric car registrations, Germany, France, Sweden, and the Netherlands were also leading. Together with Italy, these five markets recorded 79% of total new electric passenger car registrations across the EU-27 countries.

Table 1. Top five countries by 2020 electric car fleet total and share as well as registration total and share.

Geographical area	Electric passenger car fleet total 2020	Electric passenger car fleet share 2020	Electric passenger car registrations total 2020	Electric passenger car registration share 2020
EU-27 Member States, United Kingdom, Norway, Iceland, Liechtenstein, Switzerland	1. Germany 2. Norway 3. United Kingdom 4. France 5. Netherlands *Covering 70% of the electric car fleet*	1. Norway 16% 2. Iceland 6% 3. Sweden 4% 4. Netherlands 3% 5. Denmark 2%	1. Germany 2. France 3. United Kingdom 4. Norway 5. Sweden *Covering 70% of electric car registrations*	1. Norway 75% 2. Iceland 51% 3. Sweden 32% 4. Netherlands 25% 5. Finland 18%
EU-27 Member States	1. Germany 2. France 3. Netherlands 4. Sweden 5. Belgium *Covering 75% of the electric car fleet*	1. Sweden 4% 2. Netherlands 3% 3. Denmark 2% 4. Luxembourg 2% 5. Belgium 2%	1. Germany 2. France 3. Sweden 4. Netherlands 5. Italy *Covering 79% of electric car registrations*	1. Sweden 32% 2. Netherlands 25% 3. Finland 18% 4. Denmark 16% 5. Portugal 14%

THE COVID-19 OUTBREAK IN EARLY 2020 ONLY TEMPORARILY SLOWED DOWN ELECTRIC PASSENGER CAR REGISTRATIONS

In 2020, the development of the electric passenger car market was highly influenced by stricter CO_2 emission performance standards for new passenger cars and vans set by the European Commission. Since January 2020, the EU fleet-wide average emission target for new cars is 95 g CO_2/km (130 g CO_2/km between 2015 and 2019). The worldwide COVID-19 pandemic, affecting the mobility behaviour and purchase decisions of consumers starting in March 2020, has temporarily slowed down electric vehicle adoption but the market quickly recovered.

Figure 4 compares total registration of new electric passenger cars for 2018, 2019, and 2020. Countries are displayed in the order of highest to lowest total new electric passenger car registrations in 2020. The figure reveals that electric passenger car registrations have surged in 2020 despite the COVID-19 pandemic. In 2020, all markets with the exception of Cyprus, Liechtenstein, and Malta recorded higher total electric passenger car registrations compared to the previous year. Just one year earlier, the number of countries which recorded lower total electric passenger car registrations in 2019 compared to 2018 was slightly higher. These countries included Estonia, Iceland, Latvia, Slovenia, and Slovakia. In the remaining 27 markets, total new electric passenger car registrations in 2019 surpassed those in 2018.

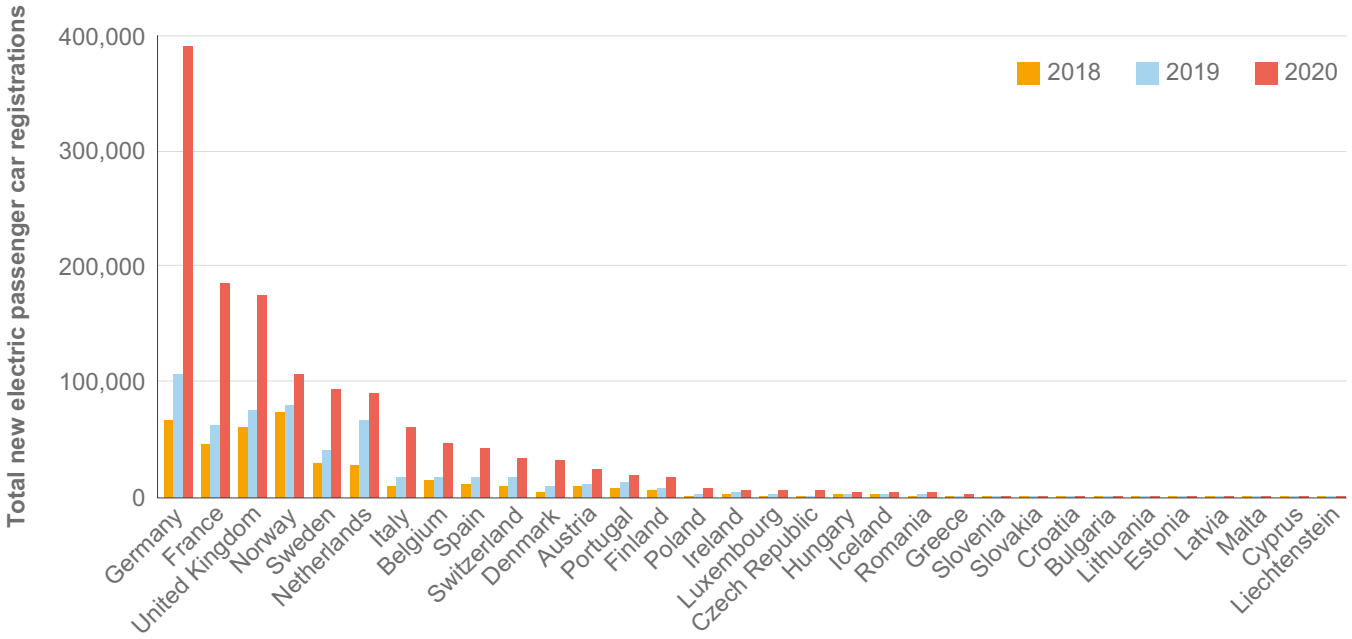

Figure 4. Total new electric passenger car registrations in European markets in 2018, 2019, and 2020.

By percentage change, Slovakia experienced the highest growth rate of electric passenger car registrations in 2020, increasing by 360% compared to 2019 (Figure 5). This was followed by Greece (+347%) and the Czech Republic (+310%), yet all three are smaller markets in terms of total registrations. Of the five leading European electric passenger car markets by total registrations, Germany recorded the highest growth rate with 270%, followed by France (+201%), the United Kingdom (+134%), Norway with +33% yet already an established electric vehicle market, and Sweden with +134%. In Cyprus, Liechtenstein, and Malta, electric passenger car registrations decreased by -26%,

-34%, and -51% respectively. One year earlier, Romania experienced the highest growth rate between 2018 and 2019 at + 231%, followed by Liechtenstein (+165%), Croatia (+164%), Ireland (+156%), and the Netherlands and Greece (both +149%). On average, the growth rate across the 27-EU Member States, the United Kingdom, and EFTA countries was 63% in 2019 and double the rate in 2020 at 136%.

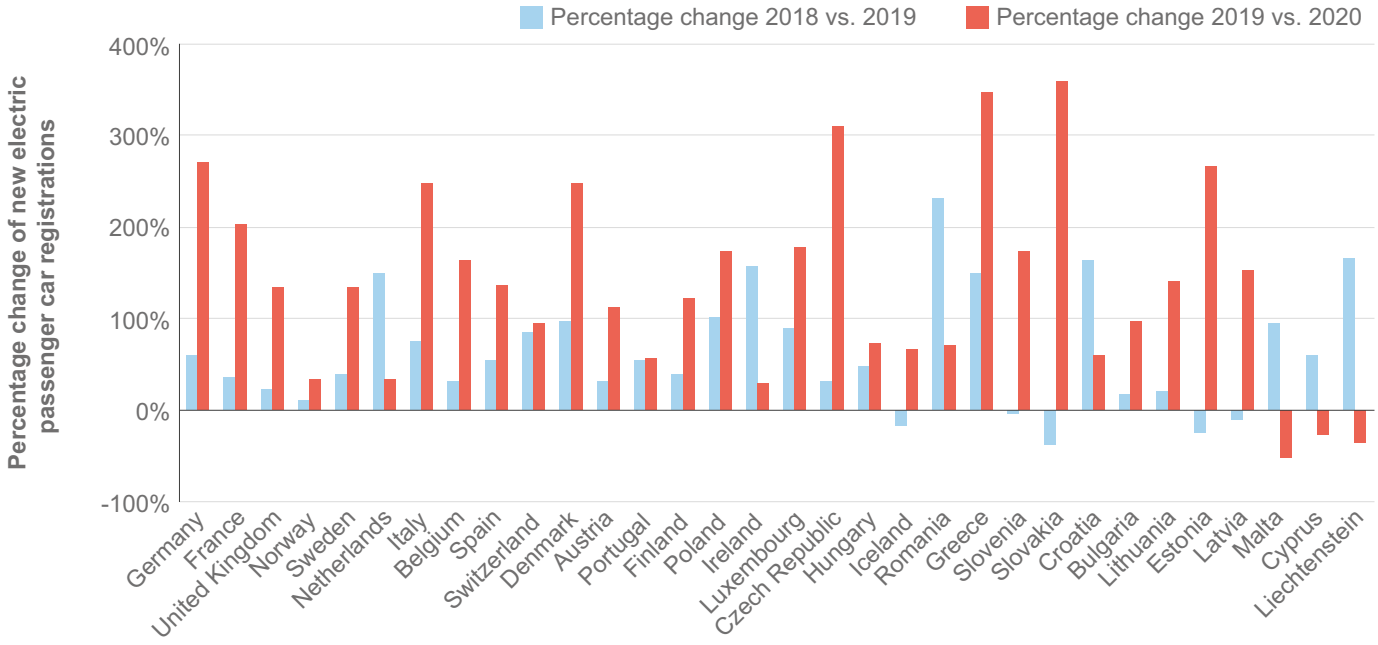

Figure 5. Percentage change of new electric passenger car registrations in European markets 2018 versus 2019 and 2019 versus 2020.

Figure 6 shows the development of new electric passenger car registrations in total numbers by month for the year 2020 to illustrate the effects of the COVID-19 pandemic. The eight countries which had more than 45,000 registrations in 2020 are shown individually while the remaining 24 European countries are added under "other". The figure depicts a significant downturn of total electric passenger car registrations in April 2020 after the lockdown of many European countries and cities in March 2020. Note that new electric passenger car registration figures were particularly high in the United Kingdom in March compared to the previous and following month with 33% of passenger cars registered being electric. This is likely a result of the reduction of the one-time grant for new electric car purchases introduced by the UK government mid-March.[7] Since May 2020, registrations of new electric cars have recovered across all markets with continuously growing numbers, with some markets showing even higher registrations than pre-COVID-19 months. A decline in new registrations for the summer months, particularly for the month of August, is not unusual and is shown in previous years.[8] Overall, in Europe the negative effect of the ongoing pandemic on electric passenger car registrations was only short-term.

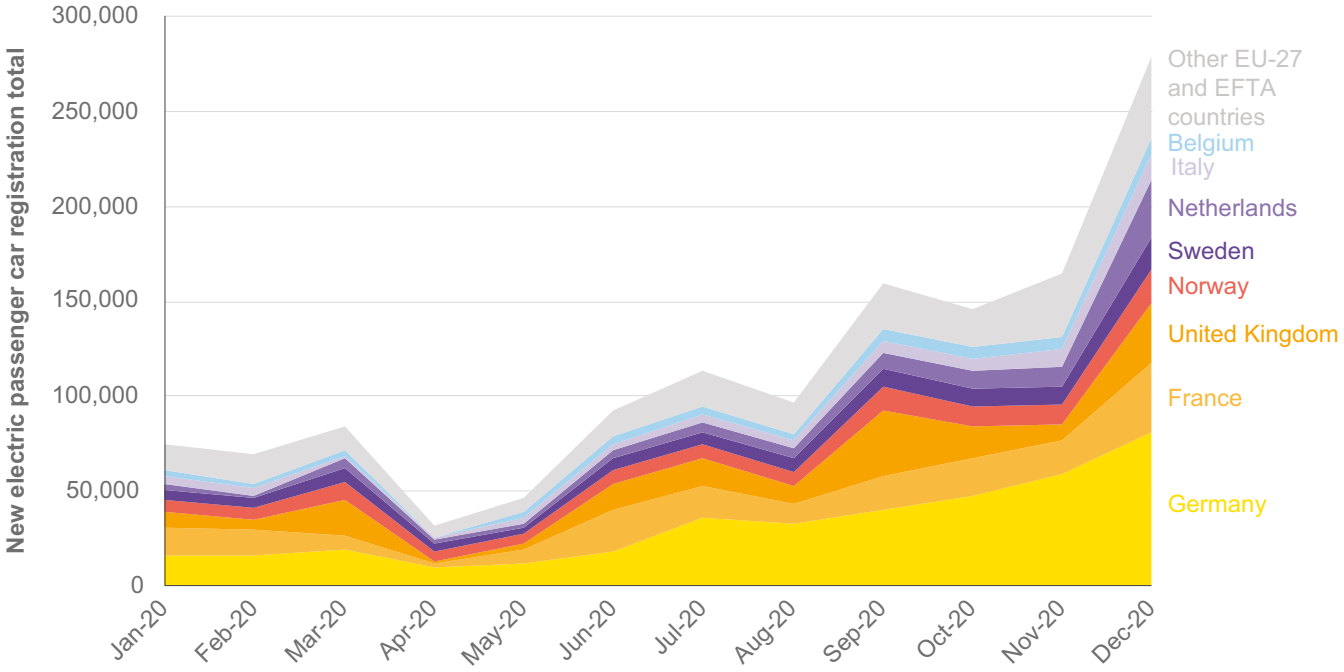

Figure 6. Total new electric passenger car registrations by month for European markets in 2020.

Analysis of recharging infrastructure deployment in Europe

Similar to the electric passenger car market, the public recharging infrastructure network has continued to grow over the past years, with strong concentration in a few European countries. Due to the different framework conditions, there is no "one-size-fits-all" solution for public recharging infrastructure deployment. According to the current Directive on the deployment of alternative fuels infrastructure (2019/94/EU; 'AFID'), "the number of recharging points should be established taking into account the number of electric vehicles estimated to be registered by the end of 2020 in each Member State. As an indication, the appropriate average number of recharging points should be equivalent to at least one recharging point per 10 cars, also taking into consideration the type of cars, charging technology and available private recharging points".[9]

ELECTRIC PASSENGER CAR FLEET AND PUBLIC RECHARGING INFRASTRUCTURE GROW IN PARALLEL

A key policy to stimulate electric vehicle growth in the years to come is the installation of sufficient recharging infrastructure.[10] Alongside the growing electrification of vehicle fleets, the public recharging infrastructure network has been rolled out in the major electric vehicle markets. Figure 7 shows the development of the electric passenger car fleet (left) and public recharging infrastructure (right) since 2015. The two figures display the countries with the largest electric passenger car fleet in absolute numbers by the end of 2020, i.e. with more than 100,000 BEVs and PHEVs on the road. This included, in descending order, Germany, Norway, the United Kingdom, France, the Netherlands, Sweden,

and Belgium. The remaining 25 countries are displayed under “others” in grey.

Figure 7 (left) illustrates that the electric passenger car fleet has grown continuously over the past years. While by the end of 2015 the electric passenger car fleet in the selected 32 European countries accounted for 376,000 vehicles, the number increased by eight-fold to over 3.1 million by the end of 2020. Figure 7 (right) illustrates that the public recharging infrastructure network has been simultaneously extended in Europe. While the number of total public recharging points accounted for 67,000 in 2015, the number increased by four-fold to almost 287,000 by the end of 2020.

The top seven European countries with more than 100,000 BEVs and PHEVs in their respective car fleet by the end of 2020 accounted for 80% of electric passenger cars on the road across the EU-27 Member States, the United Kingdom, and EFTA countries. At the same time, these seven countries had also 80% of Europe’s public recharging points in place by the end of 2020.

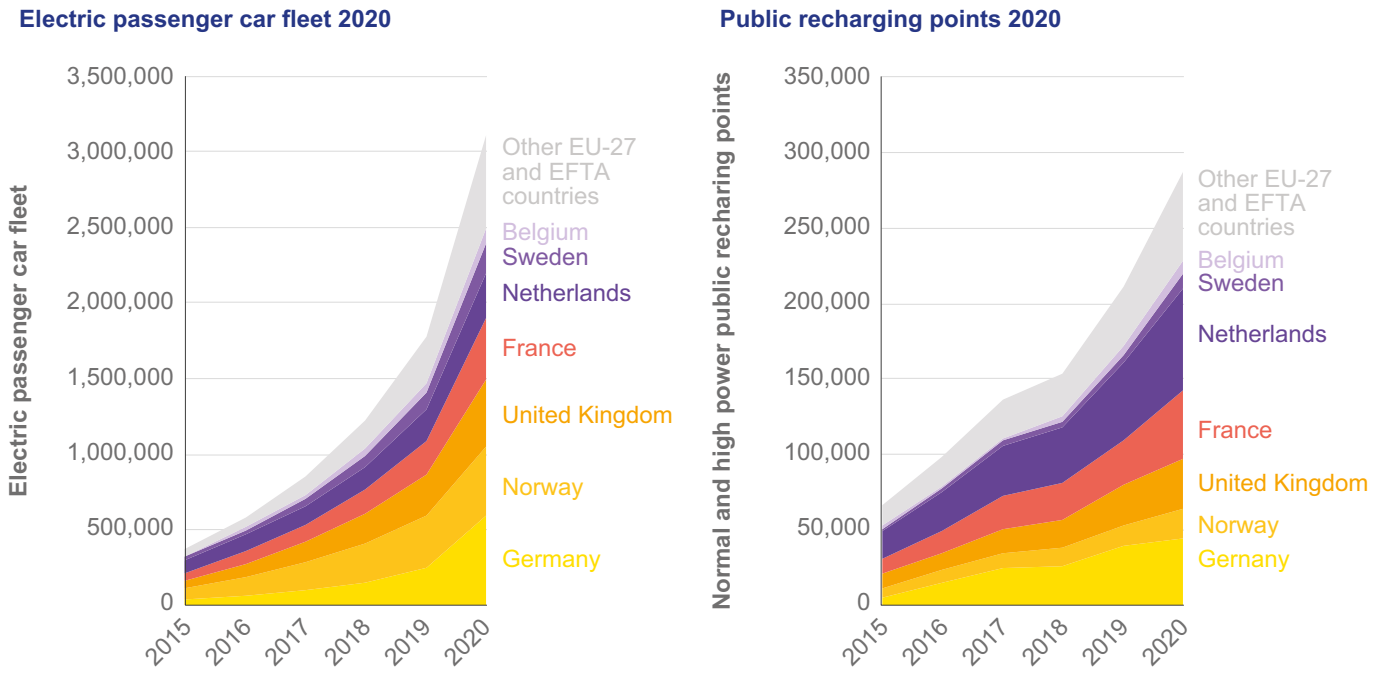

Figure 7. Development of the electric passenger car fleet and public recharging infrastructure in European markets between 2015 and 2020.

PUBLIC RECHARGING INFRASTRUCTURE IS CONCENTRATED IN A FEW EUROPEAN MARKETS

Among European countries in 2020, the most public recharging points were available in the Netherlands where drivers of an electric vehicle had access to over 64,000 normal and over 2,400 high power recharging points (Figure 8). This was followed by France with 42,000 normal and over 4,000 high power recharging points, Germany (over 37,000 and almost 7,500, respectively), the United Kingdom (over 27,000 and almost 6,300, respectively) and Norway where drivers of an electric car had access to over 13,500 normal and over 5,000 high power recharging points. Proportionally, 73% of public recharging points in the 32 studied countries were located in these five countries.

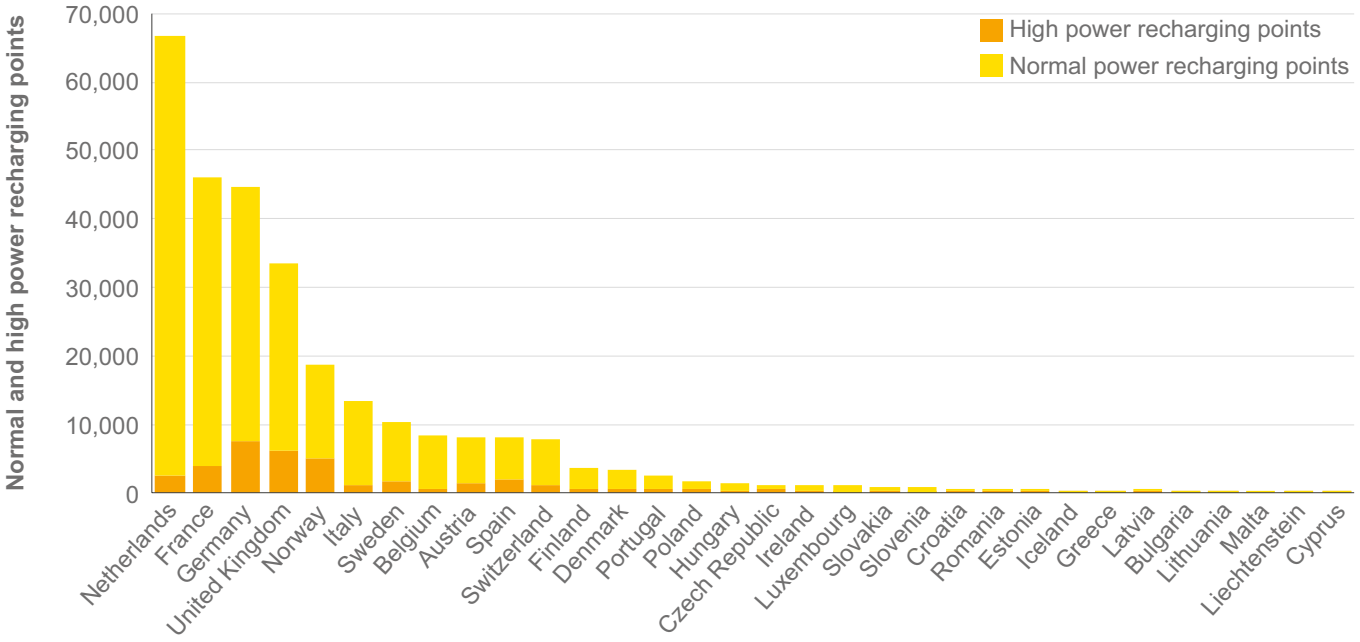

Figure 8. Electric vehicle public recharging infrastructure differentiated by normal and high power recharging points in European markets in 2020.

Figure 8 also illustrates that in absolute volumes, almost all countries have rolled out a higher number of normal power recharging points compared to high power recharging points. Overall, 87% of the public recharging infrastructure in the EU-27 Member States, the United Kingdom, and EFTA countries was normal power versus 13% high power. In the five leading countries, the share of normal power recharging points was the highest in the Netherlands with 96% of all public recharging points. In France 91% of all public recharging points were normal power recharging points in 2020, 83% in Germany, 81% in the United Kingdom, and 72% in Norway. There were, however, also some countries where high power recharging points dominated by the end of 2020. One example was Latvia where 75% of public recharging points were high power. This was followed by Lithuania (56%) and the Czech Republic (51%).

Overall, similar to the number of electric vehicles on the road and new registrations, the recharging infrastructure network is concentrated in a few markets in absolute numbers. Nevertheless, variations in the uptake exist, likely as a result of differing access to work and home recharging infrastructure, normal versus high power recharging infrastructure, and fleet composition. Table 2 summarises the distribution of the recharging points – normal power, high power, and total – differentiated for the EU-27 only and the EU-27 countries plus the United Kingdom and the EFTA countries by the end of 2020. Among the 27 EU Member States, 80% of all public recharging points were located in the Netherlands, France, Germany, Italy, and Sweden. High power recharging points were mainly located in Germany, France, the Netherlands, Spain, and Sweden, accounting for 69% of all high power recharging points in the 27 EU Member States.

Table 2. Top five countries by 2020 electric car public recharging points.

Geographical area	Normal power public recharging points 2020	High power public recharging points 2020	Total public recharging points 2020
EU-27 Member States, United Kingdom, Norway, Iceland, Switzerland	1. Netherlands 2. France 3. Germany 4. United Kingdom 5. Norway *Covering 74% of normal power public recharging points*	1. Germany 2. United Kingdom 3. Norway 4. France 5. Netherlands *Covering 66% of high power public recharging points*	1. Netherlands 2. France 3. Germany 4. United Kingdom 5. Norway *Covering 73% of total public recharging points*
EU-27 Member States	1. Netherlands 2. France 3. Germany 4. Italy 5. Sweden *Covering 82% of normal power public recharging points*	1. Germany 2. France 3. Netherlands 4. Spain 5. Sweden *Covering 69% of high power public recharging points*	1. Netherlands 2. France 3. Germany 4. Italy 5. Sweden *Covering 80% of total public recharging points*

DISTRIBUTION OF PUBLIC RECHARGING INFRASTRUCTURE VARIES GREATLY AMONG EUROPEAN COUNTRIES

An important metric for future planning is the density of the public recharging infrastructure network. The metric can be used to measure consumer convenience and accessibility to the public recharging network, which is particularly important for those without access to work and home recharging facilities. Figure 9 provides an idea of recharging infrastructure density, applying country size as a metric to reflect the spatial distribution and density of the recharging infrastructure network. The figure plots public recharging points as a function per 100 km^2 against the electric vehicle fleet by December 2020. It reveals great variations among countries. On average, the distribution across the 32 European countries was 13 public recharging points per 100 km^2. Germany, with the largest electric vehicle fleet, had 12 public recharging points per 100 km^2 available. In the Netherlands, with the fifth highest electric passenger car fleet in Europe, the concentration was the highest with 160 public recharging points per 100 km^2. This was followed by Liechtenstein and Luxembourg with 44 and 41 public recharging points per 100 km^2, yet these are smaller markets in terms of total electric vehicle fleet. By contrast, markets with a low electric vehicle fleet, i.e. less than 4,000 electric cars on the road, usually had a significantly lower distribution, with less than two public recharging point per 100 km^2 reported in Bulgaria, Croatia, Cyprus, Estonia, Greece, Latvia, Lithuania, and Slovakia. Exceptions were Malta and Liechtenstein with 32 and 44 public recharging points per 100 km^2, respectively.

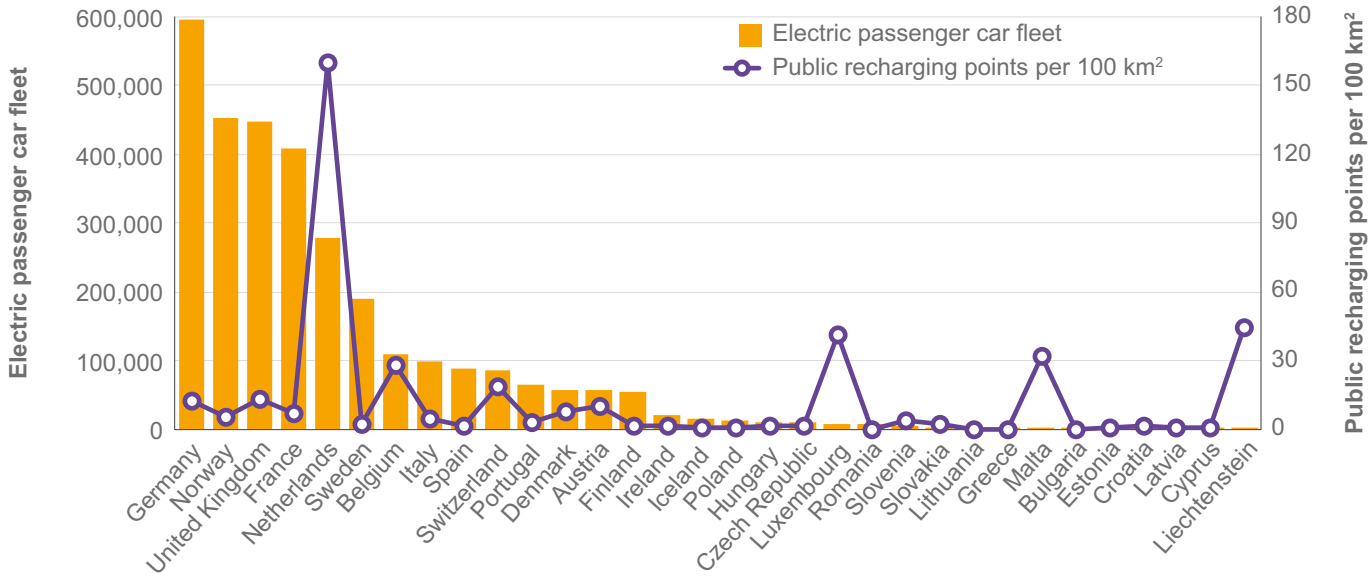

Figure 9. Electric passenger car fleet and public recharging points per 100 km² in European markets by December 2020.

Another metric to estimate the distribution of the public recharging infrastructure network is the number of electric vehicles per recharging point. As noted previously, the European Commission recommends one public recharging point per ten electric vehicles in the current AFID. Figure 10 illustrates the electric vehicle fleet by December 2020 plotted against the number of electric vehicles per public recharging point. Similarly, there is a wide variation among the European countries assessed. In Iceland, the ratio is the lowest, with 39 electric vehicles per public recharging point, followed by Portugal with a ratio of 26:1, Malta with 25:1, and Norway with 24:1. Countries such as France, Spain, and Switzerland approximate the AFID recommendation, with ranges from nine to eleven electric cars per public recharging point.

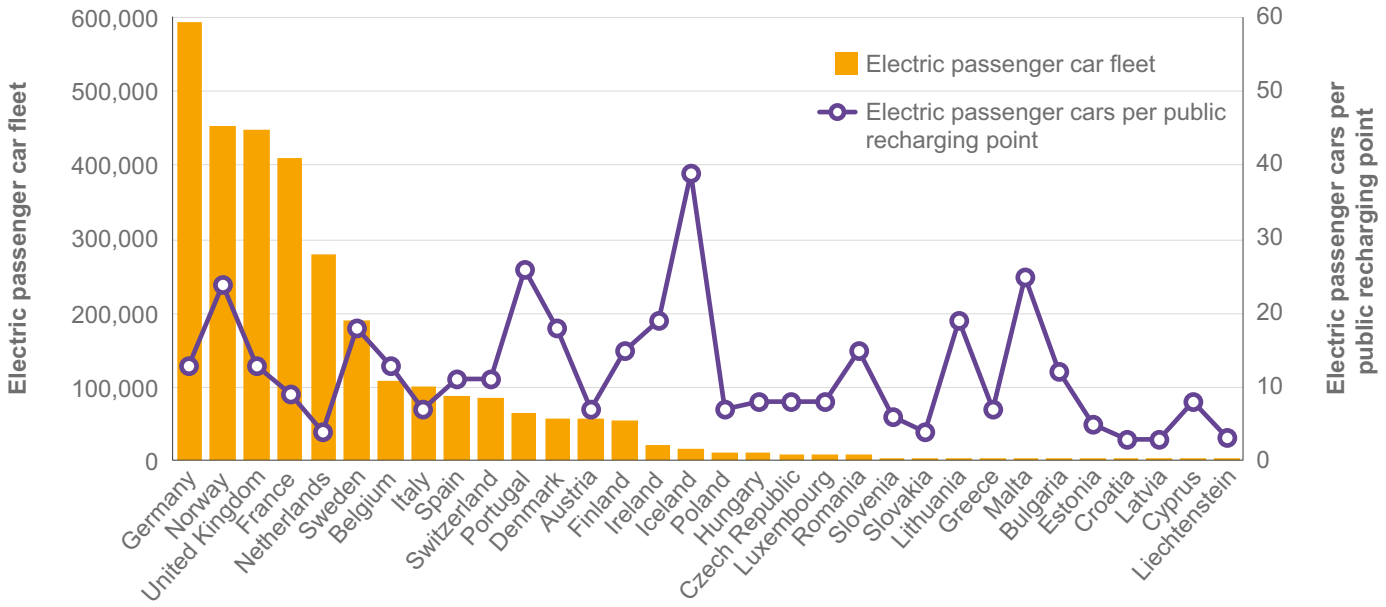

Figure 10. Electric passenger car fleet and public recharging points per electric vehicle in European markets by December 2020.

As PHEVs usually cannot use high power recharging points, the extension of the high power public recharging infrastructure network is closely linked to the number of BEVs on the roads. Figure 11 shows the distribution of public high power recharging points per 100 km highway, compared to the BEV fleet by December 2020. The density of high power recharging points along main highway corridors plotted against the BEV fleet shows no clear trend. On average, there were 81 high power public recharging points across 30 European countries (Malta and Liechtenstein excluded as they do not have highways). Particularly in Norway and Iceland, drivers of an electric vehicle had access to almost 1,000 respective 265 public high power recharging points per 100 km highway. Yet, the battery electric passenger car fleet in Iceland was much smaller compared to that of Norway by the end of 2020 (5,500 versus 320,000 BEVs on the road). The United Kingdom and Estonia have also rolled out an extensive high power recharging network along their highways over the past years, resulting in 164 and 131 high power recharging points per 100 km highway, respectively. Yet, similarly, both markets differ largely in terms of their battery electric passenger car fleet (207,000 versus 1,800 BEVs on the road).

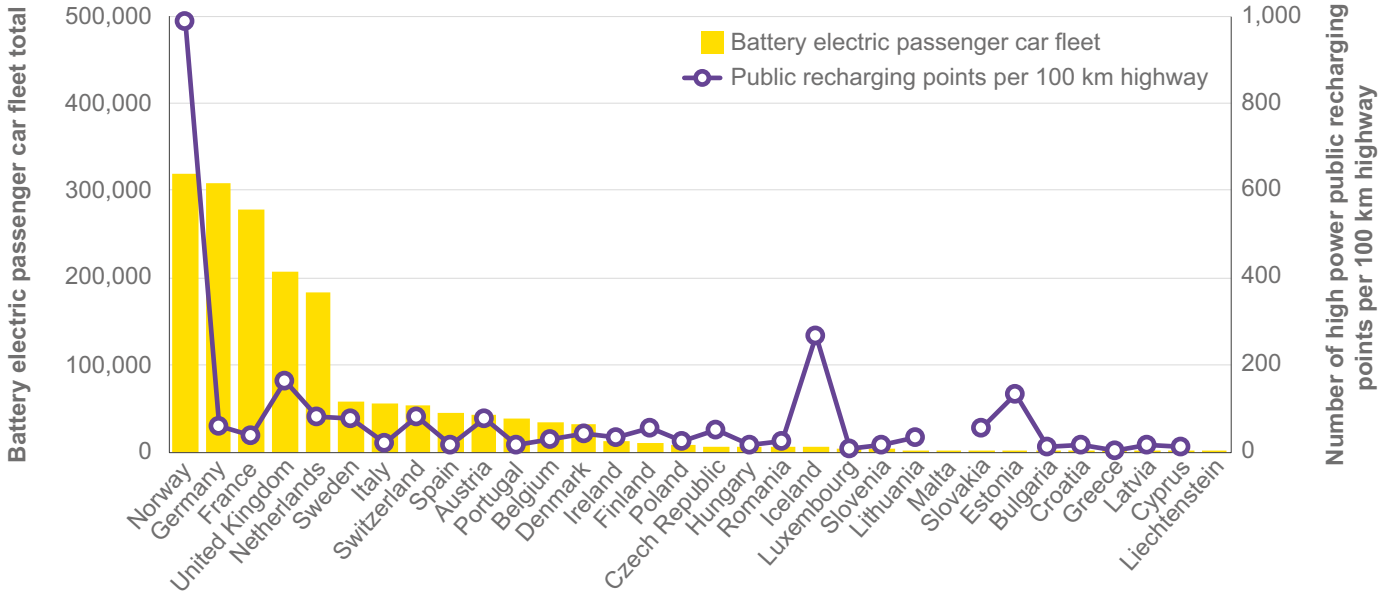

Figure 11. Number of public high power recharging points per 100 km highway and BEV fleet in European markets by December 2020. Malta and Liechtenstein are missing since they do not have highways.

THERE IS NO "ONE-SIZE-FITS-ALL" SOLUTION FOR PUBLIC RECHARGING INFRASTRUCTURE DEPLOYMENT

Figure 12 summarises some of the key findings outlined above to evaluate if there are patterns in electric vehicle uptake and public recharging infrastructure deployment. We compare 2020 figures to best reflect developments over the course of a full year. The column on the far left side displays European countries in descending order, based on 2020 new electric passenger car registration shares. The shares are differentiated by BEV and PHEV registrations. The second column shows the concentration of public recharging points and as a metric of recharging points per 100 km^2. The third column shows the percentage of high power recharging points, the fourth column public high power recharging points per 100 km highway, and the column on the far right the electric vehicle per public recharging point ratio.

The figure shows a wide disparity in registration shares and recharging point deployment among the different markets. The Netherlands had by far the highest concentration of public recharging points by December 2020 at 160 per 100 km^2. This was far higher than the European average of 13 public recharging points per 100 km^2. In the Czech Republic, Latvia, and Lithuania, more than half of all public recharging were high power recharging infrastructure, while in Malta, Luxembourg, and the Netherlands the share was very low, i.e. 0% to 4%. In all other countries, between 5% and 50% of public recharging points were high power and across Europe, and the average share was 25% in 2020. Norway had by far the highest number of high power recharging points on highways at almost 1,000 per 100 km. Yet, for most countries there were between 10 and 50 high power recharging points per 100 km highway available. The ratio of electric vehicles per recharging point varied widely as well by end-2020, from as low as 3 in Croatia, Latvia, and Liechtenstein to as high as 39 in Iceland. Half of the European countries were in the range of 7 to 14 electric vehicles per publicly accessible recharging point, and the average among all 32 countries was 12 electric cars per public recharging point.

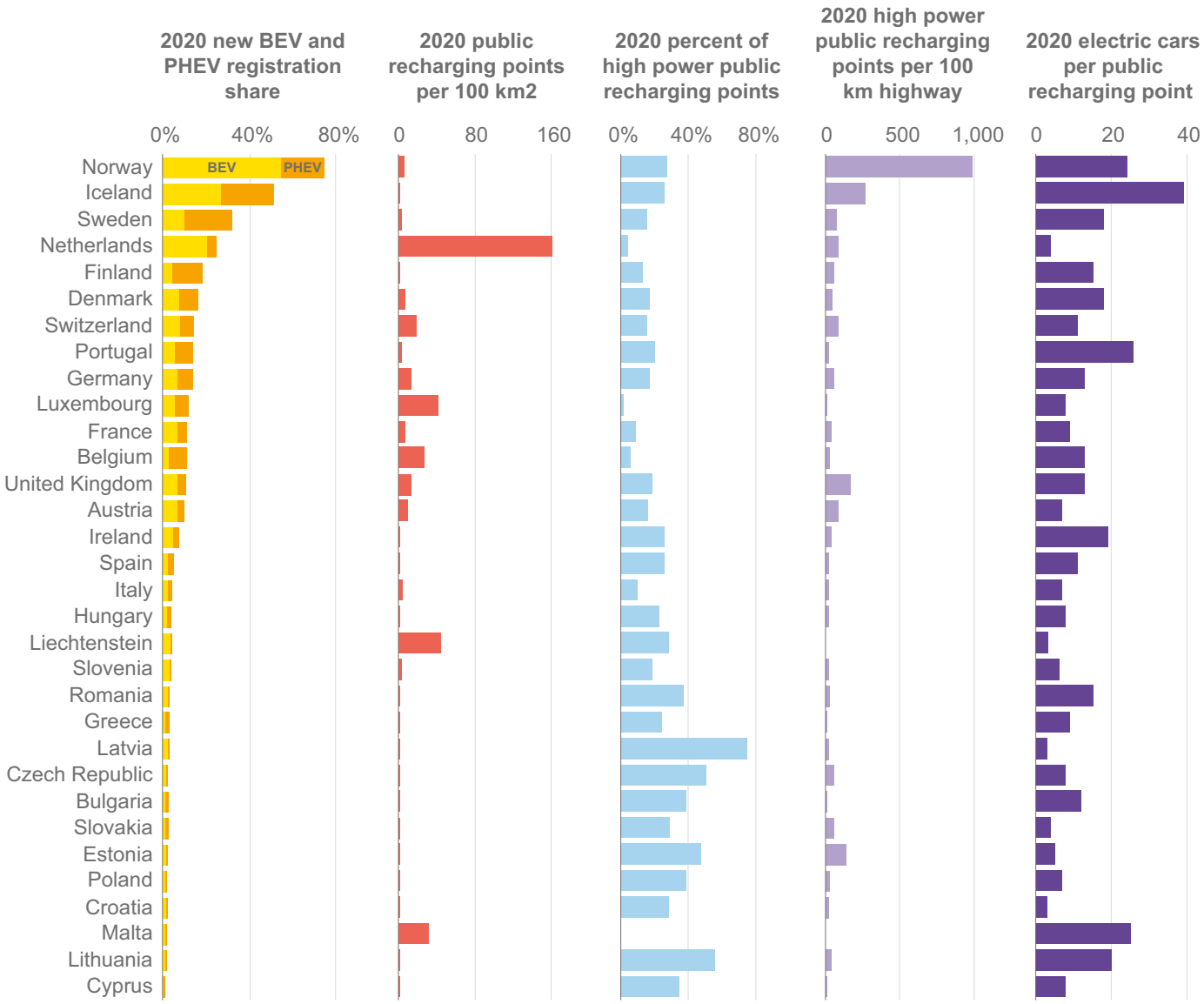

Figure 12. Electric passenger car uptake and key recharging metrics for European markets by December 2020.

The figure also reveals that there is no "one-size-fits-all" solution for the number of recharging points needed at country level. There are some factors which influence how much and what type of recharging infrastructure (e.g., normal versus high power recharging infrastructure) European countries will need in the years to come.[11]

One factor is the housing stock. While in less urbanised areas one- or two-family homes with the likelihood of access to private home recharging facilities dominate, multi-family condominiums are the typical dwelling type in dense urban areas. For example, in the Netherlands, residents living in city areas usually rely on kerbside public recharging. Therefore, a number of municipalities provide public recharging points on request of an electric vehicle owner in case he has no access to home or workplace recharging. This partially explains why high power recharging infrastructure plays a less important role in the Netherlands than it might be in other markets.

Another factor influencing the number and type of recharging infrastructure is the vehicle mix, i.e. the ratio of BEVs and PHEVs. While BEVs can make use of high power recharging infrastructure, this is generally

not the case for PHEVs, which might benefit to a higher degree from a policy focus on the deployment of home/workplace and normal power public recharging points. An example is Sweden, where 3% of the total passenger car fleet were PHEVs compared to 1% BEVs by December 2020. Coincidentally, Sweden had a low concentration of public recharging points at 2 per 100 km^2, a relatively low percentage of high power recharging points (15%), an average number of high power recharging points per 100 km highway (75), and an above European average number of electric vehicles per public recharging point (18:1 versus 12:1 across Europe).

Driving patterns also influence requirements for public recharging. Longer distances travelled might result in higher (power) public recharging infrastructure needs. Countries such as Germany, where more kilometres are travelled at higher speeds compared to other European countries, might need a higher number of inter-city (high power) recharging points.

Additional factors can influence the amount of high power recharging points overall. Some countries may pursue a deployment strategy focusing on the deployment of a higher concentration of high power recharging points, as high power recharging points can recharge more vehicles in a given timeframe than normal power recharging points. Those countries, with a resulting high density of high power recharging infrastructure, may also have a higher electric vehicle per recharging point ratio. For example, Iceland had the highest electric vehicle-per-public-recharging-point ratio compared to other European countries by end-2020 (39:1 versus 12:1 across Europe), but also had the second-highest number of public high power recharging points per 100 km highway (265 versus 76 per 100 km highway European average).

A POLICY MIX AT NATIONAL AND LOCAL LEVELS IS DRIVING THE ELECTRIFICATION AND INFRASTRUCTURE DEPLOYMENT

Beyond CO_2 emission standards for passenger cars at EU level, national and local measures also stimulate electric vehicle sales and the deployment of recharging infrastructure. Analyses show that a broad mix of electric vehicle promotion actions addressing consumer barriers of affordability, convenience and awareness are a key to accelerate electric vehicle uptake.[12]

In Germany, the government has funded a broad range of measures for the promotion of electric vehicles. A key financial measure is the one-time bonus for the purchase of an electric vehicle, introduced in 2016. An exemption for electric vehicles of the annual ownership tax and a lower taxable amount for electric company cars are additional benefits. The electric mobility law which came into force in June 2015 provides municipalities with the legal framework to implement local privileges for drivers of an electric vehicle, such as preferential parking, exemptions on parking fees, or driving in restricted areas. To further promote electric vehicles, the German government has set up various funding programs at the national level to build up the public recharging infrastructure network for electric vehicles.[13] At the end of 2019, the German government adopted the “Masterplan recharging infrastructure” which specifies targets and measures for the deployment of the recharging network – public and non-public – in Germany until 2030.[14] The government aims for 1 million public recharging points by 2030. To reach this goal, the government intends to invest over €3 billion in recharging infrastructure for cars and trucks by 2023. As part of the recovery plan in response to the COVID-19 outbreak, the German government has increased the one-time bonus on electric car

purchases and has secured an additional €500 million in funding for home recharging facilities.

Sweden also set ambitious targets for increasing the number of electric vehicles and public recharging infrastructure. The government intends to ban new gasoline and diesel car sales from 2030 onwards.[15] To reach that goal, the country implemented a number of incentives for the promotion of electric vehicles and the deployment of public recharging infrastructure. For example, as early as 2012, the government introduced a bonus for the purchase of an electric vehicle. Despite inconsistent funding, the electric vehicle market has grown steadily. Mid-2018, the government adopted a bonus-malus tax scheme, providing even higher incentives for the acquisition of an electric vehicle. Preferential taxes for the private use of an electric company car have also helped to grow the electric vehicle market, particularly of PHEVs. The government has also adopted various funding programs for the installation of public normal and high power recharging infrastructure over the past years, which has resulted in a steady deployment of public recharging points.

Conclusions

A set out in its Green Deal, the European Commission expects that about 1 million public recharging points will need to be deployed across the 27 European Member States to serve the 13 million electric vehicles expected on EU roads by 2025. The European Commission's expectation equals a more than six-fold increase of the electric passenger car and light commercial vehicle fleet registered at the end of 2020 within the next five years. Likewise, the public recharging infrastructure network will have to increase four-fold to serve the expected increase in the electric vehicle fleet.

To reach the number of electric vehicles and recharging points expected in the European Commission's Green Deal, a policy mix, investments, and the cooperation of various stakeholders are crucial to grow the electric passenger car market and extend the public recharging infrastructure network. Based on the analysis, the following high level aspects can be summarised:

- **The European electric passenger car market and recharging infrastructure is concentrated in few markets.** Germany, France, the Netherlands, Sweden, and Belgium accounted for 75% of the electric passenger car fleet among the 27 European Member States by the end of 2020. Of the total new electric passenger car registrations in 2020, 79% were recorded in Germany, France, Sweden, the Netherlands, and Italy, and 80% of the recharging infrastructure was concentrated in the Netherlands, France, Germany, Italy, and Sweden. If including the United Kingdom and the four EFTA countries, Germany, Norway, the United Kingdom, France, and the Netherlands covered 70% of the electric passenger car fleet. Moreover, in that scenario, 70% of the total new electric passenger car registrations were recorded in Germany, France, the United Kingdom, Norway, and Sweden in 2020. Of the total public recharging points, 73% could be found in the Netherlands, France, Germany, the United Kingdom, and Norway.
- **2020 was a breakthrough year for the electric passenger car market in most European markets.** In 2020, all countries with the exception of Cyprus, Liechtenstein, and Malta surpassed new

electric passenger car registration shares compared to 2019. Most new electric passenger cars by total numbers were registered in Germany (over 390,000), France (over 185,000), and the United Kingdom (almost 175,000). By shares, Norway kept its role as a frontrunner with 75% of all new passenger car registrations being a BEV or PHEV. This was followed by Iceland with an electric vehicle share of 51% of all new passenger car registrations and 32% in Sweden. Electric passenger car registrations grew since January and continued an upward trend in May 2020 after a significant drop in April 2020 due to the COVID-19 pandemic. Tighter CO_2 emission performance standards for passenger cars have successfully boosted the European electric passenger car market in 2020. Since January 2020, the European Commission requires stricter CO_2 emission performance standards from car manufacturers. As part of the European Green Deal, the European Commission announced an earlier revision of the CO_2 emission regulations for cars and vans by June 2021.

- **There is no silver bullet for the deployment of the public recharging infrastructure network.** The analysis of the public recharging infrastructure network in European countries indicates that there is no "one-size-fits-all" solution for the number of public recharging points needed at the country level. For example, the number of electric vehicles per public recharging point varied widely in 2020, ranging from 3:1 in Croatia, Latvia, and Liechtenstein to 39:1 in Iceland, highly diverging from the 10:1 ratio suggested by the European Commission's 2014 AFID. Despite its poor electric vehicle per charging point ratio (39:1) and low concentration of public recharging points (0.4 per 100 km^2), Iceland is one of the leading European electric passenger car markets by new registration shares (51% in 2020, of which were 27% BEV and 24% PHEV). This likely not least due to its second-highest concentration of high power public recharging points (265 per 100 km highway) and an average share of high power public recharging points (25%). Countering Iceland is the Netherlands, where 25% of new passenger cars registered in 2020 were either a BEV (21%) or PHEV (4%). The country had the highest number of public recharging points (160 per 100 km^2) and a favourable electric vehicle per public recharging point ratio (4:1). Yet, the percentage of high power public recharging points was one of the lowest in 2020 (4%). The analysis suggests that different national deployment strategies beyond policies that address costs and awareness can result in high electric vehicle uptakes. In addition, the extent to which home charging and workplace charging is available has a direct effect on the number of public recharging infrastructure needed. Therefore, legislators should consider that (potentially mandatory) fleet-based deployment ratios might force Member States into a "one-size-fits-all" solution that might not be suitable to all and might not meet the local requirements and different framework conditions. In the case of the extension of the public recharging network along highways, where continuity is needed to enable EU cross-border travel, the approach might be different. If highway deployment targets are considered, the focus should be on high power recharging points and linked to BEV uptake only, as owners of a BEV are the primary users of high power recharging infrastructure.

ENDNOTES

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