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# The Development of Electromobility and the Increase in Electricity Consumption in EU Countries

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***Abstract:***

***Purpose:*** *The purpose of this paper is to estimate the increase in electricity consumption in EU countries following the mass introduction of electric passenger cars.*
***Design/Methodology/Approach:*** *Based on data on the number of passenger cars and electricity consumption in the base year, as well as assumptions regarding the share of electric cars, annual mileage, and average energy consumption, we simulated the increase in electricity demand in the target year. Various scenarios for the development of electromobility were considered.*
***Findings:*** *In a scenario of 100% transition of passenger cars to electric propulsion, the increase in energy consumption for the entire EU compared to the base year 2023 would be approximately 25.2% under more favorable assumptions regarding mileage and energy consumption per 100 km and 34.6% under a less favorable scenario. For Scandinavian countries, this increase would be much smaller, while for Eastern and Southern European countries it would be larger.*
***Practical implications:*** *The increase in electricity consumption in the event of mass introduction of electric cars could pose a significant barrier to the implementation of EU climate policy. A substantive discussion should be undertaken as to whether it is possible to ensure stable electricity sources in this situation, especially since energy demand exhibits significant seasonal fluctuations (monthly, weekly, and daily), so the increase in generating capacity of conventional power plants would have to be even greater than the estimates presented in the paper.*
***Originality/Value:*** *The topic discussed in this paper, concerning forecasting electricity consumption in the context of electromobility, is crucial to ensure the stability of the energy system and supporting national energy transitions, as well as for the proper organization of infrastructure. The paper ignores the justification for the EU's expansive climate policy and does not delve into environmental issues, as this is a very broad topic that would require a separate study.*

***Keywords:*** *Electromobility, energy consumption, energy efficiency, energy management.*

***JEL codes:*** *R41, Q41, Q48*
***Paper type:*** *Research article.*

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## 1. Introduction

Passenger cars provide not only freedom of travel but also comfort and convenience. With rising living standards and technological advancements, the number of passenger cars in Europe is steadily increasing. This increase in vehicle numbers has also fueled industrial development. Besides the obvious benefits, motorization also brings negative environmental impacts through emissions of nitrogen oxides, sulfur dioxide, carbon monoxide, and particulate matter (Kumar *et al.,* 2024; Zhong *et al.,* 2024; Kazancoglu *et al.,* 2021).

However, it should be emphasized that emissions in European countries were already decreasing before the introduction of electric cars, as internal combustion engines are increasingly efficient and less harmful to the environment. Furthermore, industry and households are significant emitters of air pollutants, but in many European countries, including Poland, air pollutant emissions are also decreasing.

The European Union's (EU) climate policy is focused on reducing greenhouse gas emissions while simultaneously increasing the share of renewable energy and improving energy efficiency to combat climate change. The EU initiates various programs and directives whose primary goal is to reduce negative human impact on the environment. EU climate policy includes, among other things, setting ambitious targets for reducing environmental pollutant emissions, developing strategies for adapting to climate change, and implementing and supporting research on sustainable energy.

Key stages of climate policy and energy transition:

- 2008 – The EU climate and energy package introduced that year assumed a 20% reduction in greenhouse gas emissions by 2020, a 20% increase in energy efficiency, and a 20% increase in the share of energy from renewable sources (Sanderski, 2008).
- 2011 – The White Paper called for a 50% reduction in the number of cars using conventional fuels in urban transport by 2030 and their complete phase-out by 2050 (European Commission, 2011).
- 2014 – An integrated framework for climate and energy policy until 2030 was created. The document assumed an increase in the share of energy from renewable sources and improved energy efficiency by 27%, as well as a reduction in greenhouse gas emissions by at least 40% compared to 2030 (European Commission, 2014).
- 2016 – Another strategy for low-emission mobility, a European Commission communication, proposed the use of political measures to accelerate the decarbonization of transport. The strategy outlined measures to achieve zero carbon dioxide emissions (European Commission, 2016).
- 2019 – The so-called European Green Deal was created, which aims to achieve climate neutrality by 2050. Initiatives include: a revision of the EU

Emissions Trading System, a regulation on carbon dioxide emissions from passenger cars and light commercial vehicles, and a directive on renewable energy and energy efficiency (Bocquillon, 2024; Dupont *et al.,* 2024, European Commission, 2019).

- 2021 – The European Commission announced a package of legislative proposals called "Fit for 55." The "Fit for 55" package aims to align EU standards with climate goals (European Commission, 2021; European Commission, 2024). European climate law assumes a reduction in greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. The European Union has provisionally approved a greenhouse gas emission reduction target of 90% by 2040 compared to 1990 levels. This decision was reached after intense negotiations, although it is not yet final.

It should be emphasized that the European Union has issued a directive prohibiting the registration of new passenger cars and vans equipped with internal combustion engines after 2035 (European Parliament, 2022; Birel *et al.,* 2024). Therefore, the EU is aiming to eliminate internal combustion engine cars (as well as hybrid and gas-powered cars, even though hybrid and gas-powered cars produce fewer emissions than internal combustion engines).

Furthermore, the EU is taking steps to promote electric cars, including regulations encouraging the purchase and use of electric cars, subsidizing the purchase and creation of appropriate infrastructure for vehicles, including charging infrastructure (Szumska, 2023; Csiszár *et al.,* 2020). The aim of these regulations is to increase the availability of charging points to facilitate travel within the EU (Dahl, 2021; Szpak, 2020; Jeżowski, 2011, Oberthür *et al.,* 2008; Council of the European Union. Climate change: What the EU is doing, 2025).

Therefore, with the current policy, the European Union will soon face a number of changes that will significantly impact the development of electromobility, environmental protection, and the energy sector itself. The need to align with EU sustainability goals is a response to the climate crisis and the energy transition.

Effective January 1, 2025, the stricter carbon dioxide emission standards for registered new commercial vehicles and passenger cars are 153.9 g $CO_2$ per kilometer and 93.6 g $CO_2$ per kilometer, respectively, representing a 15% reduction. By 2035, this reduction is expected to reach 100%. However, it should be emphasized that to achieve the target, it will be necessary to increase the number of zero- and low-emission vehicles in the entire fleet (Energy, Environmental Protection, 2024).

Due to the ambitious climate plans implemented in European Union countries, including the transformation of road transport and the related shift from traditional combustion engines to electric vehicles, there is a need for analyses to estimate the demand for electricity generated by electric vehicles. Increasing the share of electric vehicles will inevitably lead to an increased load on the energy system.

In the case of vehicles charged at home, energy demand in buildings will grow. Meanwhile, many European countries (particularly Eastern European countries) have outdated and inflexible power systems. The aim of this paper is to estimate the increase in electricity consumption compared to 2023 levels, taking into account various scenarios for the development of electromobility.

## 2. Literature Review

To estimate the amount of energy consumed by electric cars, certain assumptions must be made regarding the average electricity consumption per 100 km. The factors influencing the energy consumption of electric vehicles include (Li *et al.,* 2016; Younes *et al.,* 2013; Miri *et al.,* 2021; Kremzow-Tennie *et al.,* 2020):

- driving maneuvers, as rapid acceleration followed by heavy braking increases energy consumption, thus driving style and smoothness affect energy consumption;
- too low or too high temperatures reduce battery efficiency by cooling or heating the cabin;
- tire pressure, as increased energy consumption occurs when tires are underinflated due to increased rolling resistance;
- tehicle efficiency, determined by the distance the vehicle can travel on one kWh of energy;
- payload and weight, as energy consumption may be higher with a heavily loaded vehicle;
- speed – greater aerodynamic drag caused by higher speeds results in higher energy consumption;
- terrain and altitude will also determine consumption levels;
- assistive features, such as infotainment systems, can also increase energy consumption levels.

Average vehicle energy consumption per 100 km is the average consumption based on various driving conditions (e.g., city, suburban, and highway), an average value determined based on actual users. Maximum actual energy consumption (kWh/100 km) is the highest energy consumption observed in actual driving conditions, typically the most challenging ones (e.g., intense city traffic, extremely cold temperatures, uphill driving).

The article (Weiss *et al.,* 2024) analyzed data on the energy consumption and range of electric vehicles available on the European market. A comparison of certified values (according to the WLTP procedure[4]) with actual values for energy consumption and range reveals significant discrepancies between the values. Actual energy consumption is 7% higher than declared in WLTP tests. These differences result from more dynamic driving, weather conditions, driving style, and vehicle load.

[4]*Worldwide Harmonized Light Vehicle Test Procedure*

The applicable type-approval procedures do not indicate the actual energy consumption of electric vehicles on the road. Therefore, regulators should update their test methods to better reflect real-world operating conditions. The comparison results (including parameter values for energy consumption) are included in Table 1.

***Table 1.*** *Energy consumption and EV range factsheet*

| Parameter | Average | Standard deviation |
|---|---|---|
| **Energy consumption (WLTP)** | 19.0 kWh/100 km | ±4.0 kWh/100 km |
| **Energy consumption (real)** | 21.0 kWh/100 km | ±4.0 kWh/100 km |
| **Range (WLTP)** | 440.0 km | ±120.0 km |
| **Range (real)** | 380.0 km | ±110.0 km |
| **Battery capacity** | 76.0 kWh | ±22.0 kWh |

***Source:*** *Based on Weiss et al., 2024.*

The presented parameters were also confirmed by the results of the analyses presented in the article (Madziel and Campisi, 2023; Weiss *et al.,* 2024). According to these studies, the actual range values are lower than those declared by the manufacturers.

## 3. Research Methodology

Scenario forecasting was used to model energy consumption. Based on assumptions regarding the level of electromobility development (the number of electric cars), energy consumption per 100 km, and annual mileage, along with data on current energy consumption and the number of passenger cars, the total electricity consumption associated with the introduction of a corresponding number of new electric cars into road traffic was calculated. The reference year for the projected increase in electricity consumption was 2023.

To assess the variation in the electrification of transport relative to electricity consumption across European Union countries, this paper applies a quantitative approach based on indicator analysis and determines correlations between the share of electric cars in 2023 and energy consumption at the time of their introduction to the market in 2013.

## 4. Results

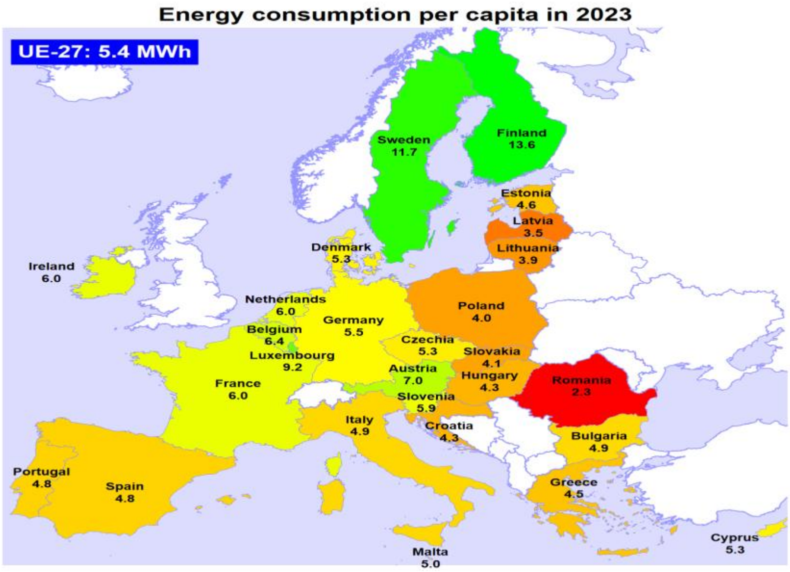
### 4.1 Electricity Consumption

The energy sector is one of the pillars of growth, competitiveness, and development of businesses, as well as modern economies. The increase in energy demand is a consequence of dynamic economic development. Economies addressing the challenges of sustainable development are focused on environmental protection and achieving energy security (Cherry *et al.,* 2018).

European Union countries, despite similar levels of economic development, are characterized by significant variations in their per capita electricity consumption (Figure 1). This is primarily due to natural conditions – Scandinavian countries rely heavily on hydropower, which is a relatively cheap and, more importantly, stable energy source.

This issue is important in the context of further considerations, as both the price of electricity and its availability will drive the popularity of electric cars. It could be argued that the increasing use of electric cars in Scandinavian countries will continue spontaneously, as these countries can more easily generate energy reserves to meet the increased demand associated with the growing number of electric cars.

***Figure 1.*** *Energy consumption per capita in European Union countries in 2023*




***Source:*** *Own study based on EUROSTAT data.*

Electricity consumption per capita in the EU-27 ranges from 2.3 MWh, through 4.0 MWh in Poland, 5.5 in Germany, 6.0 in the Netherlands, 7.0 in Austria, 11.7 in Sweden, and as much as 13.6 MWh in Finland. Thus, consumption (per capita) in both Nordic EU countries is about twice that in Western Europe and almost three times that in Eastern Europe.

### 4.2 Share of Electric Passenger Cars

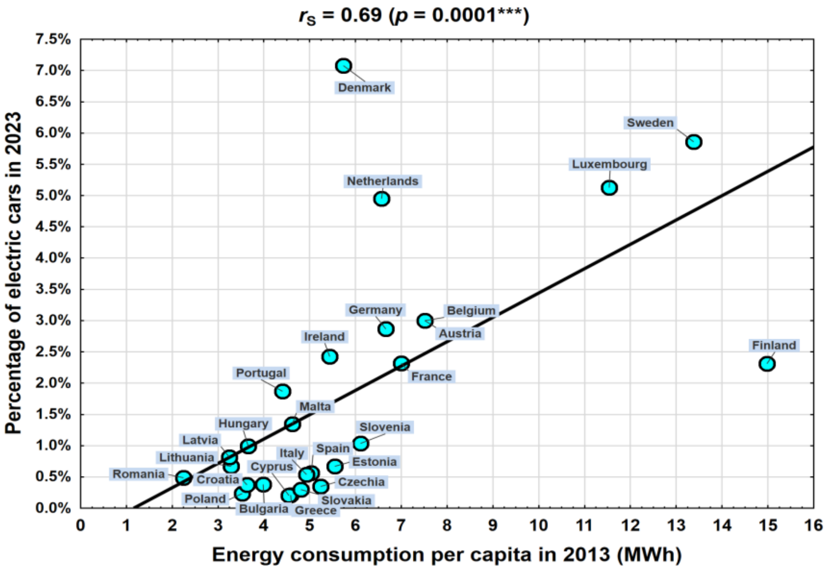
The deployment of electric vehicles in Europe faces infrastructure barriers. The primary problems include an insufficient number of public charging stations, limited power grid capacity, and long waiting times for grid expansion. Policy challenges include inconsistent financial incentives across EU countries and fragmented infrastructure licensing regulations. The charging sector struggles with investment gaps and difficulties achieving profitability without a stable policy framework. The high cost of purchasing an EV continues to deter many consumers, despite the potential long-term benefits (Broadbent *et al.,* 2021; Mesquita *et al.,* 2025; Guo *et al.,* 2025).

The share of electric cars in the total number of passenger cars is growing rapidly, although it remains very low. According to EUROSTAT data, in 2024, approximately 4.5 million electric passenger cars were in use in the EU-27, representing only 1.7% of all passenger cars (256.5 million). It is important to remember that the electric car market wouldn't be developing dynamically without massive government support – subsidies and incentives for electric car owners, while simultaneously increasing the burden on owners of combustion-engined vehicles.

However, there's also a factor that can be described as rational and objective: as it turns out, electromobility depends quite clearly on the degree of electricity use in a given country.

The share of electric cars in 2023 is correlated with energy consumption at the time these vehicles first became available. Figure 2 shows the relationship between the share of electric cars in 2023 and energy consumption in 2013.

***Figure 2.*** *Level of electromobility in 2023 compared to electricity use in 2013*




***Note:*** *$r_S$ – Spearman's rank correlation coefficient, p – significance test results*
***Source:*** *Own study based on EUROSTAT data.*

The correlation assessed using the Spearman rank coefficient is quite strong ($r_S$ = 0.69) and statistically significant ($p < 0.05$). The share of electric cars in 2023 ranged from 0.2% in Poland, Cyprus, and Greece to over 5% in the Netherlands and Luxembourg, almost 6% in Sweden, and over 7% in Denmark.

A larger number of electric cars means greater energy demand. This relationship is direct, but it depends on many factors. The scale of future electricity consumption growth under different electromobility development scenarios varies across countries. The detailed results for all EU-27 countries will be presented for two scenarios, while for selected four countries, the results of four additional scenarios will be presented.

The scenarios include assumptions regarding: the estimated level of electromobility (the percentage of electric cars in the total number of passenger cars), electricity consumption per 100 km in kWh, and annual mileage. Of course, energy consumption parameters may vary depending on driving conditions. They will differ in countries with harsh winter conditions, and in those requiring frequent air conditioning.

Therefore, the presented scenarios will only provide estimates of the order of magnitude by which electricity production will need to increase in individual countries.

In the countries with high initial energy consumption, it may be easier to create some production reserves, so the scale of the challenges associated with the increase in the number of electric cars will be primarily indicated by the percentage increase in electricity consumption. Therefore, the results of the calculations will be presented in relative form, i.e. percentage increase in electricity consumption.

### 4.3 Scenario 1: 50% Share of Electric Cars

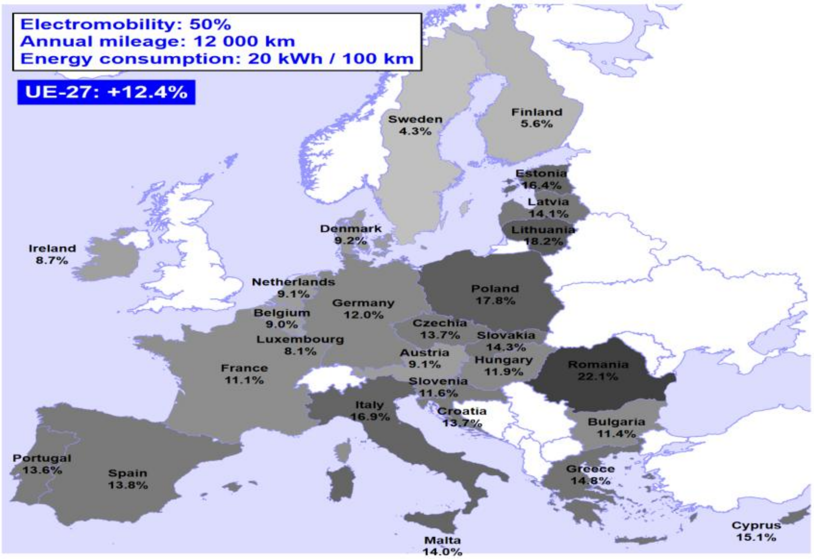
The first scenario presents the estimated increase in electricity consumption assuming that electric cars will account for 50% of passenger cars in use. The assumptions for this scenario are as follows:

- the number of electric cars is 50% of the total number of cars in 2023;
- average annual mileage is 12,000 km;
- average energy consumption is 20 kWh/100 km.

Figure 3 shows the percentage increase in energy consumption under this scenario. With a 50% share of electric passenger cars (relative to the number of cars in 2023), electricity consumption across the European Union would increase by approximately 12.5%, or almost exactly one-eighth – with the highest increase in Eastern and Southern European countries (e.g., Romania – 22.1%, Poland – 17.8%, Italy – 16.9%), and the lowest in the Scandinavian countries (Sweden – 5.6%, Finland – 5.6%).

An increase of one-eighth may seem small, but remember that this only refers to consumption by passenger cars – buses, delivery vehicles, and alternative heating systems, such as heat pumps, are not included. Furthermore, electricity consumption shows significant seasonal fluctuations, and with limited storage capacity, generation capacity would have to increase significantly more.

***Figure 3.*** *Percentage increase in electricity consumption for the 50% electromobility scenario (assumptions are shown in the figure and described in the text)*




***Source:*** *Own calculations based on EUROSTAT data.*

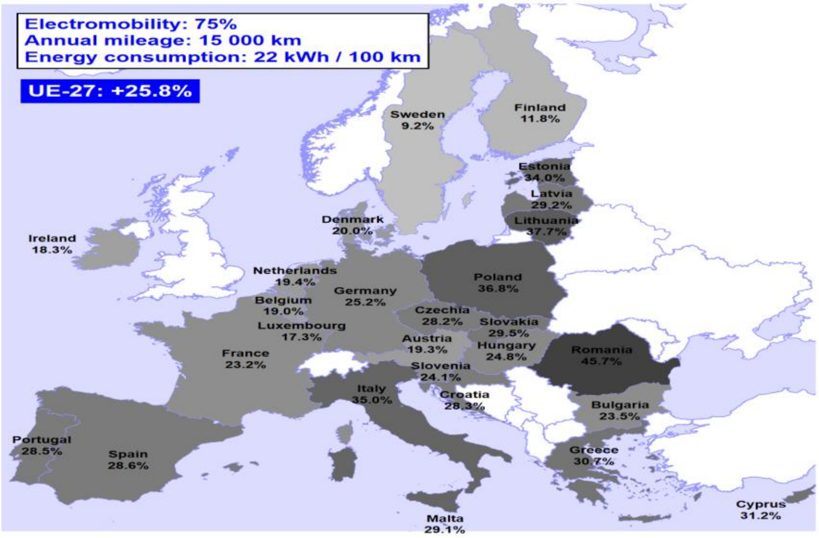
## 4.4 Scenario 2: 75% Share of Electric Cars

The second scenario assumes a 75% electric car share. The assumptions for this scenario are as follows:

- the number of electric cars is 75% of the total number of cars in 2023;
- average annual mileage is 15,000 km (it is assumed that at this level of share in the total number of vehicles, electric cars will be used more often on longer journeys and will no longer be the second or third car in a household);
- average energy consumption is 25 kWh/100 km (as above – longer journeys require more energy than city driving, requiring more frequent use of heating, air conditioning, high beams, windshield wipers, etc. – hence the assumed increase in energy consumption per 100 km).

Figure 4 presents the estimated percentage increase in energy consumption compared to 2023 levels if this scenario occurs. The average increase in energy consumption for the entire community is 25.8%. Considering the EU's plan to phase out combustion-powered cars by 2050, this would mean increasing electricity generation capacity across the EU by more than a quarter, which seems difficult to achieve over a 25-year period. In Romania, for example, the increase would be over 45%, while in Scandinavian countries, it would be only about 10%.

***Figure 4.*** *Percentage increase in electricity consumption for the 75% electromobility scenario (assumptions are shown in the figure and described in the text)*




***Source:*** *Own calculations based on EUROSTAT data.*

Table 2 presents the results for six scenarios for selected EU-27 countries (Germany, Greece, Poland, and Sweden), as well as for the entire EU.

The scale of energy consumption growth in the scenario of achieving full electromobility in the passenger car sector (100%) for the entire EU is over 25% for the more favorable assumptions regarding mileage and energy consumption per 100 km, and almost 35% for the less favorable scenario. This is a very significant increase, as it should be noted that this is an average value for the entire year, which will be subject to strong seasonal fluctuations – related to the season, day of the week, and time of day.

***Table 2.*** *Percentage increase in electricity consumption for 6 electromobility development scenarios in selected countries and the entire EU in relation to consumption in 2023.*

| **ELECTROMOBILITY** | **50%** | **50%** | **75%** | **75%** | **100%** | **100%** |
|---|---|---|---|---|---|---|
| **AVERAGE MILEAGE** | 12 000 | 15 000 | 12 000 | 15 000 | 12 000 | 15 000 |
| **CONSUMPTION PER 100 KM** | 20 kWh | 22 kWh | 20 kWh | 22 kWh | 20 kWh | 22 kWh |
| **GERMANY** | 12.0% | 16.5% | 18.3% | 25.2% | 24.7% | 34.0% |
| **GREECE** | 14.8% | 20.4% | 22.3% | 30.7% | 29.8% | 40.9% |
| **POLAND** | 17.8% | 24.5% | 26.7% | 36.8% | 35.7% | 49.1% |
| **SWEDEN** | 4.3% | 5.9% | 6.7% | 9.2% | 9.1% | 12.5% |
| **UE-27** | 12.4% | 17.0% | 18.8% | 25.8% | 25.2% | 34.6% |

***Source:*** *Own calculations based on EUROSTAT data.*

During periods of increased traffic, which often coincides with relatively worse weather (and lower energy production from renewable energy sources), production capacity will have to increase significantly more.

## 5. Conclusions

The implementation of the European Union's ambitious climate policy and the associated electrification of passenger cars will have consequences for the energy sector, particularly electricity consumption. Regardless of the adopted scenario, the increase in electricity consumption will be significant, reaching over 30% across the EU if full electromobility is implemented.

Furthermore, this process will not be uniform across countries, with the largest increases in electricity consumption due to transport electrification occurring in countries with relatively low per capita consumption. The fact that countries that joined the EU in 2004 and later have significantly higher projected growth in electricity consumption requires special attention, especially when designing instruments to support energy development in these countries.

Energy demand is not evenly distributed, with daily and seasonal fluctuations, and significant weather impacts. Therefore, the actual load on the energy system due to an increase in the number of electric cars will be greater than average calculations suggest. Just as flood embankments are built for maximum river flows, simulations of rising electricity demand should take this into account.

Therefore, the estimated increase in electricity consumption presented in this paper would require a significantly larger increase in production capacity – including, and even primarily, from stable conventional sources.

The paper only considers the increase in energy consumption associated with the increasing number of electric passenger cars. This is a significant limitation, but it does not render the results useless; it merely requires them to be considered a lower estimate of the scale of electricity consumption growth. The authors' next planned publication will also consider the EU's planned transformation of public transport, delivery vehicles, and trucks.

It is also worth mentioning the increasing use of heat pumps for heating, which will also generate a significant increase in electricity demand. Furthermore, many other factors that could drive electricity consumption growth (e.g., the development of AI, the construction of data collection and analysis centers) were not considered in the presented simulations. The increase in electricity consumption associated with the construction and operation of EV charging infrastructure was not taken into account. The challenges of maintaining and developing transmission and storage infrastructure, as well as the expansion of conventional and renewable energy power plants, were not taken into account.

In summary, the development of the electric vehicle market can contribute to environmental improvement, but it requires significant expansion and ensuring the stability of the energy system. Its implementation requires an integrated and multifaceted approach. Furthermore, significant technological challenges remain, such as battery wear and disposal, and the impact of weather conditions, which significantly limit the efficiency of electric vehicles.

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