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Proceedings of the 6th International Conference on Economics and Social Sciences (2023), ISSN 2704-6524, pp. 498-506

The 6th International Conference on Economics and Social Sciences
Geopolitical Perspectives and Technological Challenges for Sustainable Growth in the 21st Century
June 15-16, 2023
Bucharest University of Economic Studies, Romania

Electricity Production from Renewable Sources and the Adoption of Electric Vehicles in the European Union

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DOI: 10.24789788367405546-045

Abstract

In the context of climate change and the EU's common goal of reducing carbon dioxide emissions for high air quality, we ask whether electric cars will bring environmental benefits and what these will be, and whether they will continue to grow as Europe uses more renewable energy in the future, creating a new prospect for the circular economy. The use of renewable energy plays an essential role in reducing pollution and replacing diesel or petrol vehicles with electric vehicles contributes to the same goal by reducing emissions.

The aim of the current research is to determine and analyse the relationship between the uptake of electric vehicles in Member States, in terms of the share of newly registered electric cars, and the share of electricity generated from renewable sources. The Pearson correlation coefficient will be used to determine the type and strength of the correlation between the share of renewable electricity and the share of electric cars registered in 2020 in EU Member States.

The estimated results of the correlation analysis show a small to moderate relationship between the two indicators, but we will analyse which external factors cause the variables to change in the same direction due to indirect causes or remote mechanisms, as both contribute to the EU's ambition to reduce greenhouse gas emissions and become climate neutral by 2050.

Keywords: renewable energy; electric vehicles; energy sector.

JEL Classification: L94, Q27, Q42, Q56.

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1. Introduction

Renewable energy sources cover solar thermal and photovoltaic energy, hydro, wind, geothermal energy, and all forms of biomass, including biological waste and liquid biofuels. The use of renewable energy reduces the dependency on fossil fuel markets while lowering greenhouse gas emissions and creating new jobs in the process. Europe aims to become the world's first climate-neutral continent by 2050 through a complex package of measures for a sustainable green transition. With the ambitious Climate Target Plan, the European Union plans to reduce the greenhouse gas emissions by 2030 to at least 55 % below 1990 levels (European Commission, 2020).

A critical element for the green transition is the progressive reduction of fossil fuel use. The switch to renewable energy will reduce, but not eliminate the environmental damage completely. The current technology in use for producing renewable energy, like solar cells or wind turbines, does far less damage than mining and oil rigs, but is not completely harmless to the environment due to technological limitations. Battery cells require lithium and other rare metals that require mining, while solar cells use toxic substances in the manufacturing process. European plans to reduce greenhouse gas emissions should, therefore, be accompanied by considerable research and development efforts into environmentally friendly technologies used to produce and store energy. The European Union has pursued an active climate policy by facilitating the integration of renewable technologies into Member States' energy infrastructure. Most of the technologies needed for a full transition to renewables are currently available at low implementation costs. In the long term, the cost of transition would be similar to that of maintaining the existing system if appropriate policies and regulations are continued and improved (Tagliapietra et al., 2019).

2. Problem Statement

The European Union is a signatory to the 2015 Paris Agreement and is helping to achieve the goal of keeping global warming within safe limits for people. The targets developed further through the Green Deal for each member state lead to a competitive and resource-efficient economy. And the most important decision is that of decarbonisation, zero greenhouse gas emissions in the EU. This can be achieved by increasing the share of renewables in the energy mix (Rybak et al., 2022).

The electric car industry is an important element in achieving the EU's targets to reach climate neutrality by 2050, which is encouraged by the fact that electric cars, driven by an independent power source or an internal combustion engine, are growing globally, with low transport costs, are becoming increasingly popular (Markowska et al., 2023). Model specified by most literature sources as the best transport alternative. The International Energy Agency (IEA) reported that electric vehicle sales reached 6.6 million in 2032, doubling from the previous year. The success of electric vehicle development depends largely on factors such as

consumer acceptance of electric vehicles, price and charging time, and charging infrastructure (Razmjoo, 2022).

According to Grzesiak and Sulich (2022), the COP26 declaration, signed in Glasglow in 2021 at the United Nations Climate Change Conference, bans the production and sale of internal combustion vehicles, i.e. diesel, petrol, and hybrid cars, by 2035. As an interim commitment, an average car emission reduction of 55% by 2030 is required (European Commission, 2022).

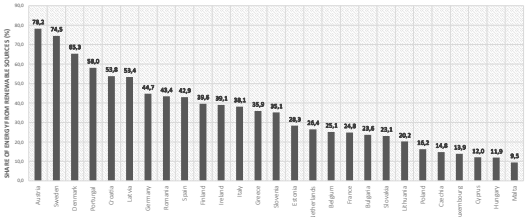
From the second half of 2021, the economic and energy contexts of the European Union have been marked by an exacerbated increase in the prices of energy products, negatively affecting both the population and businesses. Some studies reveal that these high prices were mainly due to the resumption of activities after the Covid-19 pandemic, production bottlenecks, but especially after the first quarter of 2022 due to the military conflict between Russia and Ukraine (Zamfir et al., 2022).

A McKinsey & Company study (2023) reveals that the European Union is the global leader in electric vehicle adoption, with more than a quarter of the world's production. This is also shown by figures published in September 2022 by the European Environment Agency, where the average carbon dioxide emissions of new cars registered in 2020 fell by 12% compared to the previous year, due to the high share of electric cars registered (European Environment Agency, 2023).

3. Methodological Approach

According to data published by Eurostat (b) (2022), the share of renewable electricity reached 37.5 % in 2021, an increase of only 0.1 % compared to 2020. The growth in electricity generated from renewable sources since 2011 (23,3 %) is mainly due to an increase in the wind and solar electricity sources, but also biofuels. Wind (36 %) and hydro (33 %) power generated more than two thirds of the total electricity from renewable sources, white the rest was generated by solar power (14 %), solid biofuels (8 %) and other sources (Eurostat (b), 2022). According to Eurostat (b) (2022), the share of electricity from renewable energy sources is defined as the ratio between electricity produced from renewable energy sources and gross national electricity consumption. The renewable energy sources include hydro power plants and electricity generated by wind, solar, biofuels, and geothermal installations.

Figure 1. 2020 European Union Member States share of electricity from renewable sources



Source: Eurostat (a), 2022.

Austria had by far the highest share among the EU Member States, with more than two-thirds (78,2 %) of the consumed electricity generated from renewable sources, followed by Sweden (74,5 %) and Denmark (65,3 %). The share of electricity from renewable sources was also high, accounting for more than half of the electricity consumed in Portugal (58 %), Croatia (53,8 %) and Latvia (53,4 %). On the opposite end of the scale, Malta (9,5 %), Hungary (11.9 %) and Cyprus (12.0 %) registered the lowest shares of electricity generated from renewable sources in 2020 (Eurostat (a), 2022). Only 12 of the 27 Member States were situated above the average EU value of 37,5 %.

Europe's long-term objective to a low-carbon environment requires a substantial change in the transportation sector, achievable by a large-scale adoption of electric vehicles charged with electricity produced from renewable sources. An increase in electric vehicle use will lower the carbon dioxide and air pollutants emissions from the road transport but generate higher emissions from associated electricity production and continued fossil use in the power sector. Therefore, the additional energy demand will need to be met by an increase in renewable energy production, integrated into the existing infrastructure across Europe. A large number of electric vehicles will require significant additional electricity that may put considerable pressure on the existing infrastructure without new investments. Countries with similar shares of renewable energy production might adopt different management strategies to accommodate the additional charging power needed, depending on their ratio of renewable energy to conventional power generation, the type of renewable energy source and the development of their electrical network infrastructure. According to Kasten et al. (2016), the demand share of electric cars to total electricity demand will reach levels of 4 % to 5 % in several European countries by 2030 and around 9,5 % by 2050 on EU average, with an electric car stock penetration of 80 %.

In 2020, more than half a million electric passenger cars were registered in the European Union, representing more than 5 % of the total number of new cars registered. Netherlands had the highest share of registered electric cars (20,52 %), followed at a considerable distance by Sweden (9,64 %), Denmark (7,17 %) and Germany (6,84 %). At the other end of the ranking are Cyprus (0,18 %), Poland (0,81 %), and Greece (0,84 %), with less than 1 % of the total new registered passenger cars being powered only by electricity.

Table 1. European Union Member States share of electric passenger cars registered in 2020

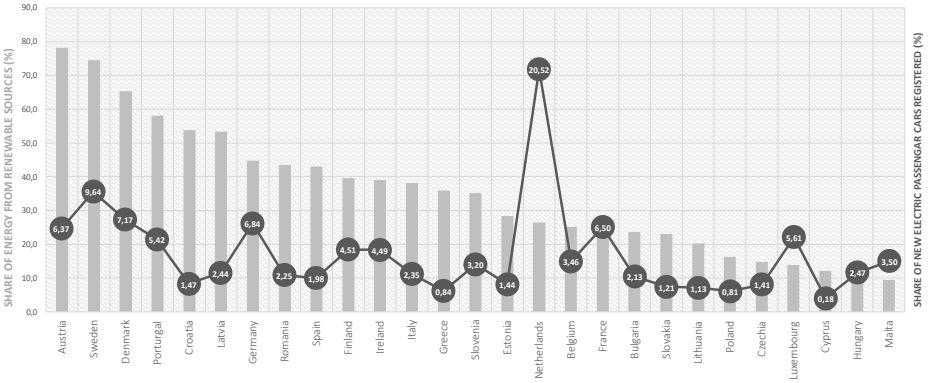
Country	No. of new electric passenger cars registered in 2020	No. of total new passenger cars registered in 2020	Share of electric cars of total new passenger cars registered in 2020 (%)
Netherlands	72.172	351.738	20,52
Sweden	27.661	286.797	9,64
Denmark	14.015	195.468	7,17

Country	**No. of new electric passenger cars registered in 2020**	**No. of total new passenger cars registered in 2020**	**Share of electric cars of total new passenger cars registered in 2020 (%)**
Germany	193.773	2.832.972	6,84
France	114.555	1.761.404	6,50
Austria	15.697	246.233	6,37
Luxembourg	2.455	43.735	5,61
Portugal	7.850	144.803	5,42
Finland	4.219	93.587	4,51
Ireland	4.009	89.295	4,49
Malta	154	4.403	3,50
Belgium	14.957	431.954	3,46
Slovenia	1.745	54.590	3,20
Hungary	3.185	128.896	2,47
Latvia	302	12.355	2,44
Italy	32.480	1.380.818	2,35
Romania	2.825	125.742	2,25
Bulgaria	471	22.158	2,13
Spain	18.232	919.334	1,98
Croatia	519	35.270	1,47
Estonia	265	18.453	1,44
Czechia	2.784	197.353	1,41
Slovakia	918	75.682	1,21
Lithuania	452	40.008	1,13
Greece	671	79.783	0,84
Poland	3.154	388.427	0,81
Cyprus	18	9.838	0,18
EU-27	**539.538**	**9.971.096**	**5,41**

Source: European Environment Agency, 2022.

The aim of the current study is to identify and analyse the relationship between the uptake of electric vehicles in Member States in terms of the share of newly registered electric vehicles and the share of electricity produced from renewable sources. Figure 2 provides a visual representation of the share of renewable electricity and the share of electric vehicles registered in all EU Member States in 2020. Sweden and Denmark ranked second and third in both rankings, while Netherlands (20,52 %) registered by far the highest share of electric cars, with almost 11 percentage points above Sweden (9,64) and 15 percentage points above the EU average of 5,41 %.

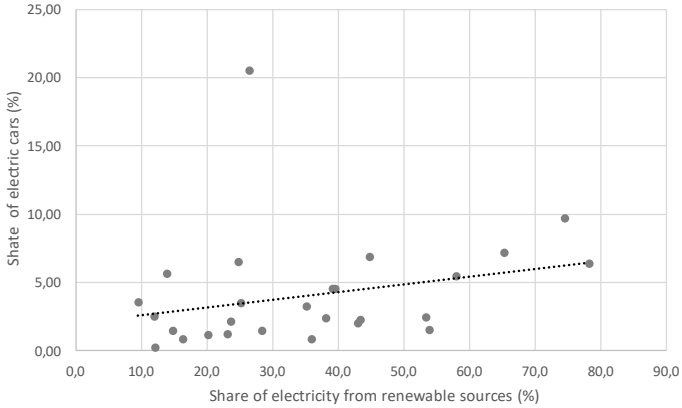
Figure 2. EU Member States share of electricity from renewable sources and share of electric passenger cars registered in 2020



Sources: Eurostat(a), 2022; European Environment Agency, 2022.

The relationship between variables is usually obtained by assessing how specific measures that represent the variables are correlated (Shao et al., 2022). Correlation analysis determines the association or relationship between two or more quantitative variables by measuring the correlation coefficient. For the current analyses, under the assumptions that the variables are independent and normally distributed and the relationship is linear, the Pearson correlation coefficient will be used to determine the type and strength of the correlation between the share of electricity from renewable sources and the share of electric cars registered in 2020 across the European Union Member States. The Pearson correlation coefficient of the analysed data for the 27 Member States is r = 0,26. According to Asuero et al. (2006), a value of r between 0 and 0,29 indicates little or no correlation. Pearson correlation analysis is very sensitive to extreme points that do not fit the general trend of the data, which can have a large effect on the value of r. In the current analysis, Netherlands' share of electric cars is far above average, causing a significant alteration in the value of the correlation coefficient, as observed in the scatter plot diagram depicted in Figure 4. The Pearson correlation coefficient calculated for the adjusted data series, without the extreme value is $r_{adjusted}$ = 0,58, describing a moderate correlation. The results of a t-test suggest this is statistically significant, for an absolute test statistic value of 3,4994 and a corresponding *p-value* of 0,00184, lower than the standard significance level (α = 0,05).

Figure 3. Scatter Diagram - Correlation between EU Member States share of electricity from renewable sources and share of electric passenger cars registered in 2020



Source: Own calculations from Eurostat(a), 2022; European Environment Agency, 2022.

4. Results and Discussion

The results of the correlation analyses show a small to moderate relationship between the share of electricity from renewable sources and the share of newly registered electric cars among the EU Member States. However, this does not necessarily imply a causal relationship between the two variables. The correlation can as well be attributed to a sum of external factors causing the variables to change in the same direction due to indirect causes or remote mechanisms, since both contribute to the EU's ambition on reducing greenhouse gas emissions and become climate-neutral by 2050. Moreover, the relationship might also be affected by time lags. For example, a change in subsidy policies for electric cars at EU level may determine a rapid growth in the number of new electric cars registered, while the shift from fossil to renewable sources in terms of electricity production requires massive investments over long periods of time.

Since most of Europe's electricity still comes from fossil fuels, electric vehicles charged by that source of energy will indirectly generate greenhouse gases. As European countries will progressively transition to green, using fewer fossil fuels, it is reasonable to assume that the infrastructure of electric vehicles and charging stations will develop as well. The increasing number of electric vehicles will contribute to the reduction of greenhouse gases up to a certain limit. A large share of electric vehicles will have implications for the electricity production and distribution infrastructure in terms of investments, expansion efforts, and, possibly, innovation. Integration of EU policies and investment decisions across the energy and road transport sectors becomes very important. When electric car penetration reaches higher levels, the extra electricity demand will become a relevant factor within the energy systems, impacting the operation of power plants and energy infrastructure, at local, national, and European level, depending on the respective

status of the energy system (Kasten et al., 2016). The capability of electric vehicles to have a significant impact on the EU's ambition of reducing the greenhouse gas emissions and becoming a climate neutral economy by 2050 depends on the source of electricity used to charge the vehicles: renewable, nuclear power or fossil fuel sources. In the long run, in terms of total emission balances, electric mobility can lead to significant reductions in carbon dioxide and most air pollutant emissions and become a relevant part of a future sustainable transportation system.

5. Conclusion

The rather large differences in the development and adoption of electric or hybrid vehicles between the countries analysed may be the result of different implementations of support policies in the respective countries, but also of the level of development of the population.

Electric car technology is certainly the sustainable transport mode of the future in all EU Member States, due to its high energy efficiency, almost non-existent carbon emissions and low noise, it can be considered a viable solution for climate change mitigation, which is why each country encourages the population through various significant governmental actions, but also through charging infrastructure benefits.

Based on the results, we note that there are different drivers in the development of electric vehicles, e.g. the deployment of electric vehicles requires new technologies, especially batteries, fast charging stations, adequate investments, government support for manufacturers and government subsidies for buyers, affordable prices for consumers, funding for battery research, tax exemptions, and appropriate charging station infrastructure.

Moreover, when talking about the limitations of this study and the debate on the subject in possible future works, we can say that financial support for the development of electric vehicles is the most important factor that can create at European Union level policies to encourage and recover less developed countries in this respect, such as Cyprus, Poland, Greece, for a big step towards a faster transition to a green economy.

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