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TREND OF GREEN GROWTH INDICATORS IN EU COUNTRIES AFTER ACCESSION

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Abstract: *This paper examines the latest advancements in green growth among EU member countries, with a focus on Serbia. It aims to compare green growth indicators across different countries by employing two defined hypotheses. This analysis utilizes data from the OECD statistics database, specifically focusing on annual data related to CO2 emissions and renewable energy. The choice of these indicators is based on their causal relationship to green growth. The research is based on the methodology of comparative analysis for selected indicators. The first section applies to CO2 emission indicators with trends, while the second section analyses the renewable energy situation. All considerations were made by creating groups of EU member countries by year of accession: 2004 (for 10 countries), 2007 (for 2 countries), and 2013 (for Croatia) for selected indicators. The utilization of combined datasets facilitated the evaluation of positive trend outcomes in Serbia.*

Keywords: *green growth / production / renewable energy / green economy / sustainable development / ecological economics.*

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INTRODUCTION

The burgeoning population and industrialization, coupled with escalating energy demands and consumption, coincide with a worrisome rise in pollution levels. Consequently, the pursuit of sustainable development and the mitigation of energy consumption, demand, and greenhouse gas (GHG) emissions represent paramount contemporary concerns (Jednak et al., 2020, pp. 459-477). The latest Net Zero + report from the OECD underscores the pressing urgency of the climate crisis, highlighting the imminent threat of surpassing critical tipping points within the climate system, which could trigger catastrophic consequences if global temperatures exceed 1.5°C (OECD, 2023a). Extant research by Zouandi (2017) and Koengkan et al. (2020) elucidates the intricate interplay between energy consumption from renewable sources, economic growth, and carbon dioxide emission levels. This paper seeks to scrutinize the green growth achievements of European Union (EU) member states categorized into three accession groups: those admitted in 2004 (Slovakia, Slovenia, Poland, Malta, Lithuania, Latvia, Hungary, the Czech Republic, Cyprus, and Estonia), those admitted in 2007 (Bulgaria and Romania), and those admitted in 2013 (Croatia). Additionally, it aims to juxtapose these achievements with the circumstances in Serbia, a nation that has been vying for EU membership since 2012. This comparative analysis will be conducted utilizing the Organization for Economic Co-operation and Development's (OECD) Green Growth indicators, particularly focusing on Group I indicators, encompassing environmental resource and productivity metrics, such as CO2 productivity and the provision of renewable energy.

Two hypotheses have been formulated to guide this research:

Hypothesis 1 – Following accession to the EU, member states exhibit an upward trajectory in the supply of renewable energy.

Hypothesis 2 – Following accession to the EU, member states demonstrate a downward trend in CO2 consumption.

LITERATURE REVIEW

The economic domain intertwined with the natural environment is directed towards the development of methodologies and protocols

designed to optimize the conversion of natural resources into goods and services essential for human sustenance (Riznić et al., 2022). The transition towards a green economy, albeit intricate, arduous, and imperative, is entwined not solely with unsustainable consumption and production patterns but also with forthcoming developmental paradigms. Consequently, the proposition of embracing and executing the 2030 Agenda for Sustainable Development (the 2030 Agenda) has arisen. In this context, Goal 12 for 2030 underscores the imperative of amalgamating ecological, social, and economic considerations to foster sustainable modalities of consumption and production (Dogaru, 2021). Green growth metrics, exemplified by the System of Environmental-Economic Accounting, provide invaluable assistance to nations in their endeavors to monitor progress towards the 2030 Agenda for sustainable development. Green growth epitomizes the acceleration of economic advancement whilst conserving natural reservoirs to sustain the provision of goods and environmental amenities fundamental to our well-being.

To achieve this objective, significant investment and rejuvenation were requisite to underpin sustainable growth in a manner conducive to yielding novel economic advantages (OECD, 2011). The term 'green growth' heralds the prospect of economic progression in tandem with environmental conservation. A primary objective of esteemed international institutions such as the Organization for Economic Co-operation and Development (OECD), the World Bank, and various multilateral development banks, as well as the impetus behind the inception of a novel international body, the Global Green Growth Institute, is the pursuit of green growth. This notion frequently features in macroeconomic policy deliberations, as illustrated by the Managing Director of the International Monetary Fund (IMF) asserting in June 2012: “we must commence with the rudiments: from a foundation of reinstated economic stability and growth.” While diverse definitions of green development may persist with occasional ambiguity, they invariably encapsulate the notion of an expanding economy that conserves natural resources and commodities (Bowen & Hepburn, 2014). Owing to constraints in conventional energy reservoirs, the significance of renewable energy, capable of replenishment via specific processes, is burgeoning (Dilanchiev et al., 2023). Analysis findings by Bilan et al. (2019) indicate that the majority of EU nations had achieved

their 2020 objectives by 2019, with the proportion of renewables in final energy consumption exhibiting incremental growth over successive years.

In order to conduct a comparative analysis of green growth indicators at the international level, Joksimović et al. (2023) highlight significant disparities observed between developed and developing countries over the period spanning 1990 to 2021. Conversely, Balaban et al. (2023) conclude that heightened emissions of methane, nitrogen oxides, and CO2, alongside increased energy expenditures, do not exhibit a direct correlation with the quality and volume of agricultural production within the European Union. Stojanović et al. (2023) ascertain the profound impact of environmental taxation on ecological innovations. Their findings reveal that a 1% increase in eco-tax revenues per capita correlates with a 0.663 rise in the environmental innovation index. Building upon this, Balaban and Stoiljković (2023) argue that environmentally related taxes in Serbia contribute significantly to pollution reduction. Furthermore, Kovačević and Živanov Gardašević (2023) identify the foundational role of principles in environmental protection and their systematization, underscoring the imperative for further refinement. They advocate for heightened awareness among individuals and society at large, alongside concerted efforts to surmount individual interests.

RESEARCH AND DISCUSSION

The OECD's Green Growth indicators were initially introduced in the 2011 and 2014 editions, with the latest update occurring in 2017. These indicators, carefully selected based on rigorous criteria and integrated into a conceptual framework structured around four distinct groups, aim to comprehensively capture the essential characteristics of green growth (OECD, 2023b). In addition, Serbia presents significant potential in the realm of renewable energy sources, particularly when juxtaposed with European countries facing shortages in renewables (Žikić et al., 2022).

Selected indicators within the category of Environmental Resources and Productivity are used to assess how efficiently economic activities, including both production and consumption, utilize energy, natural resources, and environmental services. These chosen indicators offer

critical insights into various facets of the transition towards a low-carbon, resource-efficient economy. For instance, carbon and energy productivity metrics measure the output generated per unit of CO2 emitted or total primary energy supplied. Moreover, these indicators afford valuable insights into the overall net environmental impact, encompassing both direct and indirect environmental flows arising from household and government consumption and investment decisions (OECD, 2017).

CO_2 Productivity

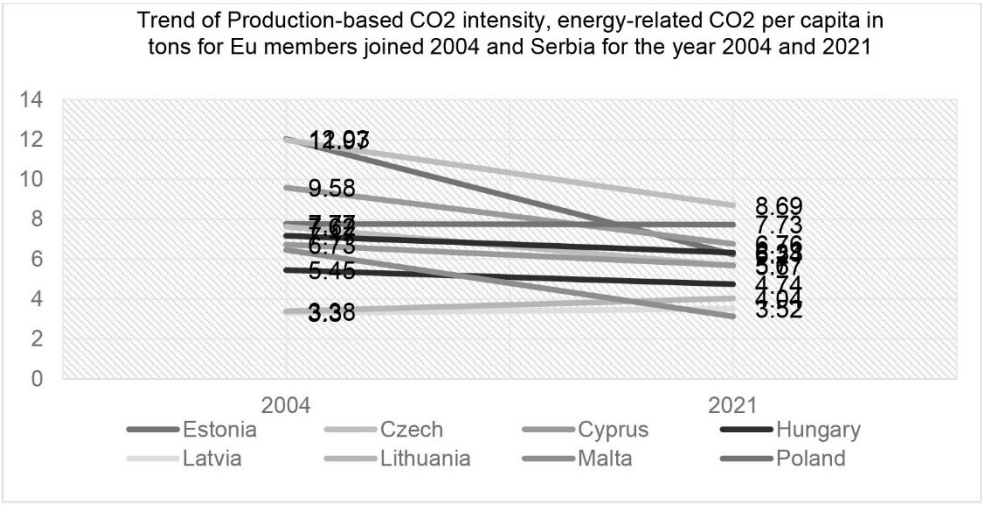
Table 1 presents green growth indicators for production-based CO2 productivity and energy-related CO2 emissions per capita (in tons) for EU members that joined in 2004, along with data for Serbia for the years 2004 and 2021.

Table 1. *Trends in production-based CO2 intensity and energy-related CO2 emissions per capita in tons for EU members that joined in 2004, and for Serbia in 2004 and 2021, with trend analysis.*

Country	2004	2021	Trend
Estonia	12.03	6.24	-5.79
Czech Republic	11.97	8.69	-3.28
Cyprus	9.58	6.76	-2.82
Hungary	5.45	4.74	-0.71
Latvia	3.30	3.52	+0.22
Lithuania	3.38	4.04	+0.66
Malta	6.47	3.13	-3.34
Poland	7.77	7.73	-0.04
Slovenia	7.62	5.67	-1.95
Slovakia	6.73	5.70	-1.03
Serbia	7.17	6.33	-0.84

Source: Authors' calculation based on OECD Green Growth Indicators

Figure 1. *Trend of production-based CO_2 intensity, energy-related CO_2 per capita in tons for EU members that joined in 2004 and for Serbia for the years 2004 and 2021*



Source: Authors' calculation based on OECD Green Growth Indicators.

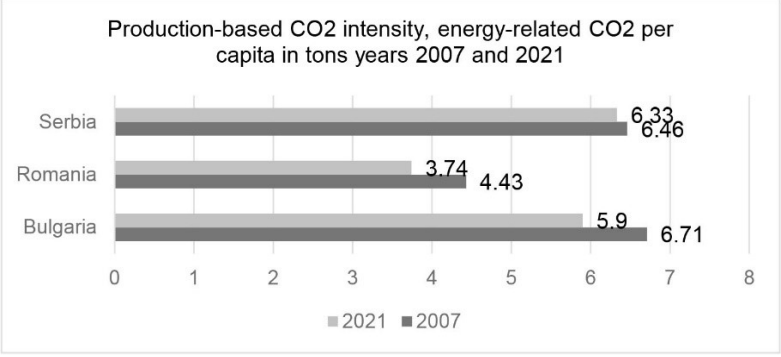
For EU members that joined in 2004, a range of reductions was observed, ranging from -5.79 (Estonia) to +0.66 (Lithuania). Increased production-based CO2 intensity and energy-related CO2 per unit of population were noted in Latvia and Lithuania, while all other countries that joined in 2004 experienced a reduction in CO2 intensity in tons. In comparison to the group of EU members that joined in 2004, Serbia has a slightly reduced value of -0.84, compared to an average of -1.80 for this group of members. A 1% increase in CO2 emissions leads to a decrease in renewable energy production by 1.65% (Dilanchiev A. et al., 2023).

Table 2 presents green growth indicators for production-based CO2 productivity and energy-related CO2 per unit of population in tons for EU members that joined in 2007, while also offering data for Serbia for the years 2007 and 2021, including trends.

Table 2. *Trends in production-based CO2 intensity and energy-related CO2 emissions per capita (in tons) for EU members that joined in 2007, and for Serbia for 2007 and 2021, with trend analysis*

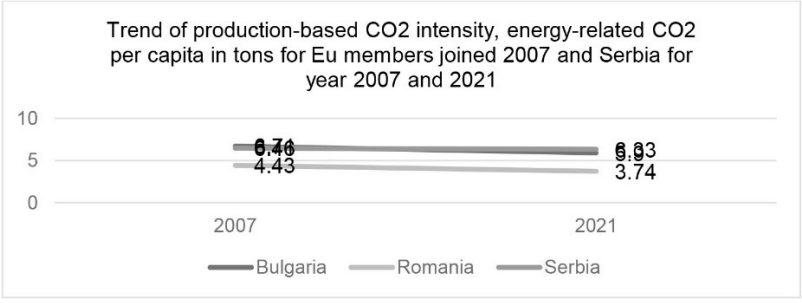
Country	2007	2021	Trend
Bulgaria	6.71	5.90	-0.81
Romania	4.43	3.74	-0.69
Serbia	6.46	6.33	-0.13

Figure 2. *Production-based CO_2 intensity, energy-related CO_2 per capita in tons for EU members that joined in 2004 and for Serbia for years 2007 and 2021*



Source: Authors' calculation based on OECD Green Growth Indicators

Figure 3. *Trend of production-based CO_2 intensity, energy-related CO_2 per capita in tons for EU members that joined in 2007 and for Serbia for the years 2007 and 2021*



Source: Authors' calculation based on OECD Green Growth Indicators

This group of EU members warrants consideration due to their proximity to Serbia. The analysis of production-based CO2 intensity and energy-related CO2 emissions per capita for EU members that joined in 2007, alongside data for Serbia spanning the years 2007 and 2021, reveals an average reduction rate of -0.75 for this group. Notably, Serbia demonstrates a comparatively lower reduction rate of -0.13.

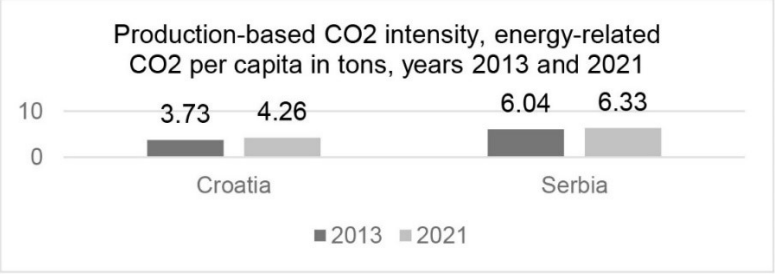
Serbia and Croatia, despite their shared historical background, are currently distinct sovereign states. Table 3 presents and analyses data for the EU member state Croatia for the year 2013, juxtaposed with the data for Serbia. This includes an examination of the trend in production-based CO2 intensity and energy-related CO2 emissions per capita for EU members that joined in 2013, alongside with the data for Serbia spanning the years 2013 and 2021, with accompanying trend analysis.

Table 3. *Trend of production-based CO_2 intensity, energy-related CO_2 per capita in tons for EU member that joined in 2013 and for Serbia for years 2013 and 2021, with trend analysis*

Country	2013	2021	Trend
Croatia	3.73	4.26	+0.53
Serbia	6.04	6.33	-0.29

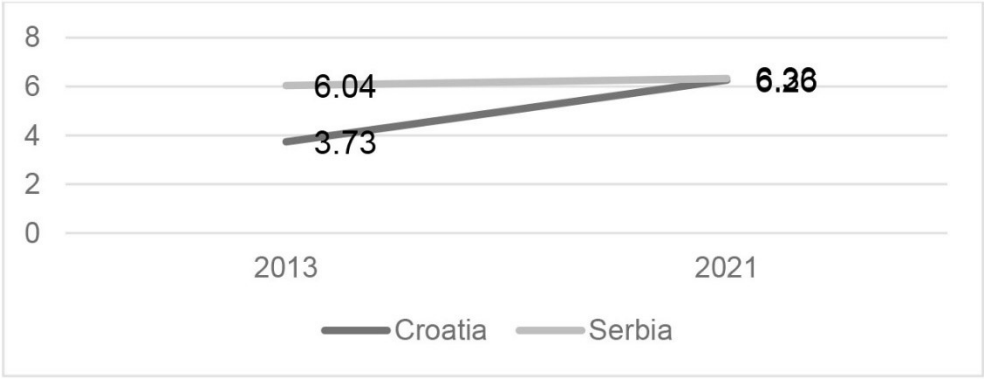
Source: Authors' calculation based on OECD Green Growth Indicators

Figure 4. *Production-based CO_2 intensity, energy-related CO_2 per capita in tons for EU member that joined in 2013 and for Serbia for years 2013 and 2021*



Source: Authors' calculation based on OECD Green Growth Indicators

Figure 5. *Trend of production-based CO_2 intensity, energy-related CO_2 per capita in tons for EU member that joined in 2013 and for Serbia for years 2013 and 2021*



Source: Authors' calculation based on OECD Green Growth Indicators

Croatia and Serbia, as two neighboring countries, have undergone notable changes since the commencement of Croatia's EU membership in 2013 up to 2021. Croatia has experienced an increment in value of +0.53, whereas Serbia's value has decreased by -0.29.

Table 4 presents the average values of country groups based on their EU membership years in 2004, 2007, and 2013, inclusive of values for Serbia, and their corresponding progress relative to Serbia.

As delineated in Table 4, the average indicator values for production-based CO2 intensity and energy-related CO2 emissions per capita, within a cohort of EU countries grouped by their year of membership, exhibited a reduction to -1.80 tons per capita in 2004. These indicators denote a deficit of -0.96 tons in production-based CO2 intensity and energy-related CO2 emissions per capita relative to Serbia over the corresponding period (from 2004 to 2021).

Table 4. *Average values of country groups according to their EU membership years in 2004, 2007, and 2013, alongside their advancement relative to Serbia from the onset of their membership until 2021*

Group by year of membership	EU members that joined in 2004	EU members that joined in 2007	EU members that joined in 2013
Average value for the indicator Production -based CO_2 intensity, energy-related CO_2 per capita in tons (group of EU members per year of membership)	-1.80	-0.75	+0.53
Value for indicator Production-based CO_2 intensity, energy-related CO_2 per capita in tons (Serbia)	-0.84	-0.13	-0.29
EU countries average value for indicator Production-based CO_2 intensity, energy-related CO_2 per capita in tons progress in relation to Serbia	-0.96	-0.62	+0.24

Source: Authors' calculation based on OECD Green Growth Indicators

Conversely, EU member countries admitted in 2007 displayed a reduction in production-based CO2 intensity and energy-related CO2 emissions by -0.75 tons per capita. The data suggests a disparity of -0.62 tons in production-based CO2 intensity and energy-related CO2 emissions per capita compared to Serbia over the same timeframe (from 2007 to 2021).

On the other hand, a distinct EU member state admitted in 2013 (Croatia) witnessed an increase in production-based CO2 intensity and energy-related CO2 emissions by +0.53 tons per capita. This observation signifies a surplus of +0.24 tons in production-based CO2 intensity and energy-related CO2 emissions per capita relative to Serbia during the period spanning from 2013 to 2021.

Renewable energy

Table 5 presents and analyses the green growth indicator of renewable energy supply as a percentage of total energy for EU members that joined in 2004, along with data for Serbia for the years 2004 and 2021, or the latest available data (2020) for selected countries.

Table 5. *Renewable energy supply as a percentage of total energy for EU members that joined in 2004 and for Serbia for the years 2004 and 2021, or the latest available data (2020).*

Country	2004	2021	Trend
Estonia	11.10	30.59	+19.49
Czech Republic	4.40	12.04	+7.64
Cyprus	2.41	10.76	+8.35
Hungary	3.62	11.32	+7.70
Latvia	32.73	42.46	+9.73
Lithuania	8.97	23.37	+14,40
Malta	0.05	6.21 (2020)	+6,16
Poland	4.75	11.80	+7.05
Slovenia	13.19	17.51	+4.32
Slovakia	3.98	11.69	+7.71
Serbia	9.50	15.82 (2020)	+6.32

Source: Authors' calculation based on OECD Green Growth Indicators

Drawing upon available data, it is evident that in each selected EU member country that acceded in 2004, there exists a discernible positive trend in the proportion of renewable energy supply as a percentage of total energy consumption, a pattern also observed in Serbia. Noteworthy advancements from the 2004 membership cohort are evidenced in Estonia (+19.49%), Lithuania (+14.40%), and Latvia (+9.73%), while Serbia has notably increased its consumption percentage by (+6.32%) more substantially than Slovenia (+4.32%) and Malta (+6.16%), as indicated by the green growth indicator. The average increase in the proportion of renewable energy supply in total energy consumption among EU 2004 members stands at +9.25%, contrasting with data for Serbia which registers a 2.93% increment in renewable energy supply as a proportion of total energy consumption.

Figure 6. *Trend of augmented percentage share of consumption of renewable energy in total energy for EU members affiliated with the 2004 accession, juxtaposed with Serbia, relative to recent data*

Source: Authors' calculation based on OECD Green Growth Indicators

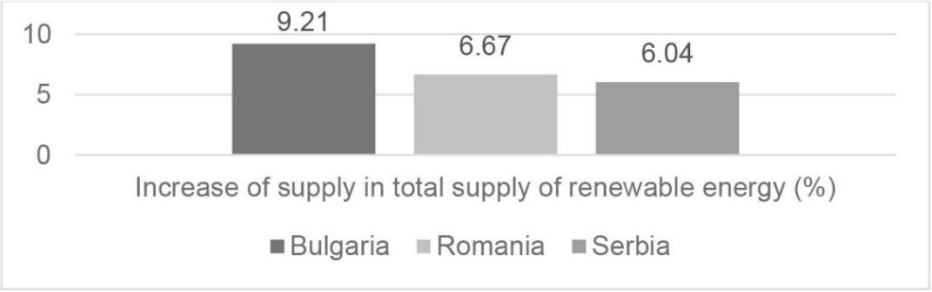
Table 6 presents the green growth indicator of renewable energy supply as a percentage of total energy for EU members that joined in 2007, along with data for Serbia for the years 2007 and 2021, or the latest available data (2020) for selected countries.

Table 6. *Share of renewable energy in total energy for EU members that joined in 2007 and for Serbia for years 2007 and 2021, or the latest available data (2020)*

Country	2007	2021	Trend
Bulgaria	4.76	13.97 (2020)	+9.21
Romania	11.96	18.63	+6.67
Serbia	9.78	15.82 (2020)	+6.04

Source: Authors' calculation based on OECD Green Growth Indicators

Figure 7. *Trend of increased consumption share of renewable energy in total energy for EU members that joined in 2007, alongside Serbia, compared to recent data*



Source: Authors' calculation based on OECD Green Growth Indicators

Drawing upon available data, it becomes apparent that in each selected EU member country in 2007, there was a discernible positive trend in the share of renewable energy in total energy consumption, a trend also evident in Serbia. The average current increase among EU 2007 members stands at 7.94%, compared to the data for Serbia which indicates a 6.04% increase in the share of renewable energy in total energy consumption.

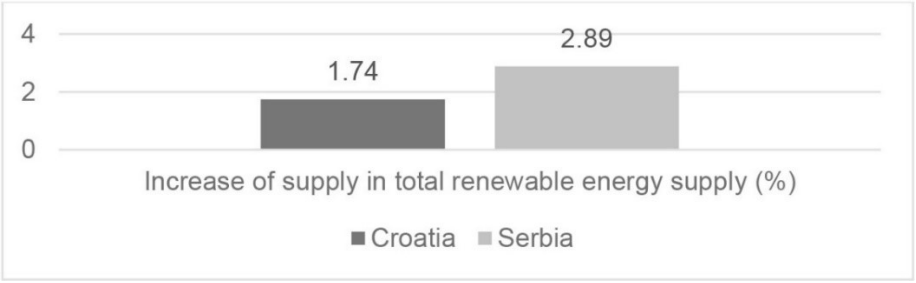
Table 7 presents the green growth indicators, specifically the proportion of renewable energy supply as a percentage of total energy, for EU members that joined in 2013 (Croatia), alongside data for Serbia for the years 2013 and 2020 (the latest available data) for selected countries.

Table 7. *Proportion of renewable energy supply as a percentage of total energy for EU members that joined in 2013 (Croatia) and for Serbia for the years 2013 and 2020 (the latest available data)*

Country	2013	2020	Trend
Croatia	24.70	26.44	+1.74
Serbia	12.93	15.82	+2.89

Source: Authors' calculation based on OECD Green Growth Indicators

Figure 8. *Trend of increased percent of consumption of renewable energy in total energy supply for EU members that joined in 2013 and for Serbia compared to recent data*



Source: Authors' calculation based on OECD Green Growth Indicators

Based on the available data, it is evident that in every selected EU member country in 2013, there was a positive trend in the share of renewable energy in total energy, a trend also observed in Serbia. The average increase among EU 2013 members (including Croatia) stands at 1.74%, contrasting with data for Serbia which indicates a 2.89% increase in the supply of renewable energy in total energy. However, notwithstanding the trend, Croatia, as an EU member country, contributes 26.44% to the total energy supply, in contrast to Serbia's contribution of 15.82%.

In terms of the overall outcome for the set hypotheses:

Hypothesis 1 – Following accession to the EU, countries demonstrate a trend of increasing renewable energy supply – This hypothesis is substantiated.

Hypothesis 2 – Following accession to the EU, countries exhibit a trend of reducing CO2 consumption – Among the 13 analyzed countries, 12 demonstrate a trend of reduction – This hypothesis is not substantiated.

CONCLUSION

Serbia, holding the status of a candidate for EU membership, adheres to EU regulations, where the ratio of renewable energy production to carbon dioxide emissions is deemed significant. Analyses of selected indicators pertaining to CO2 consumption and renewable energy supply, juxtaposed with data for Serbia, reveal no notable deviations from

average trends. Significant untapped potential for renewable energy sources (RES) in the region persists, warranting further exploitation. Data from Serbia suggest a proclivity and endeavors towards augmenting the utilization of these resources. Relative to EU member countries, the presented data for selected indicators in Serbia indicate that, on average, deviations are negligible. Moreover, concerning the established hypotheses, the data corroborate the acceptance of hypothesis 1.

The paper forms a component of the research outcomes from Project U 01/2023 titled "Green Economy in the Era of Digitization," undertaken by the Faculty of Finance, Banking, and Auditing at Alfa BK University in Belgrade, Serbia.

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TENDENCIJA RASTA INDIKATORA ZELENOG RAZVOJA U ZEMLJAMA EU NAKON PRIDRUŽIVANJA

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Sažetak: *U radu se analiziraju novija dešavanja u oblasti zelenog rasta u zemljama članicama EU u odnosu na Srbiju kako bi se uporedili indikatori zelenog rasta na međudržavnom nivou kroz dve postavljene hipoteze, korišćeni su podaci iz statistike OECD na godišnjem nivou – baza podataka za indikatore CO2 emisija i obnovljiva energija – zbog njihove uzročnosti. Rad se zasniva na metodologiji komparativne analize za pokazatelje podudaranja. Prvi deo se odnosi na indikatore emisije CO_2 sa trendovima, drugi deo analizira stanje indikatora obnovljive energije i sva razmatranja su urađena stvaranjem grupa zemalja članica EU po godini pristupanja 2004. (za 10 zemalja), 2007. (za 2 zemlje) i 2013. (za Hrvatsku) za izabrane indikatore. Trend je zasnovan na kombinovanim podacima.*

Na ovaj način je bilo moguće napraviti procenu sa pozitivnim trendovima u Srbiji.

Ključne reči: *zeleni rast / proizvodnja / obnovljiva energija / zelena ekonomija / održivi razvoj / ekološka ekonomija.*