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The Evaluation of Circular Economy in the Slovak Republic Based on Selected Indicators

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Abstract: *At present, we are increasingly aware of the need to move towards a sustainable and ecologically friendly economy. An innovative approach to a sustainable and ecological economy that is gaining in importance is the concept of circular economy. The circular economy is a systemic approach to economic development and a paradigm shift from the traditional concept of the linear economy model "extraction - production - consumption - disposal - depletion". The circular economy is characterized by zero waste through resource conservation, as a changed concept of production processes design, production process and selected materials for a higher life cycle and preservation of all kinds of resources, material and/or energy recovery during all processes and at the end of the life cycle. The products could be used as an input material in a new production process in a value chain with a closed cycle of materials that improves efficiency resources, and resource productivity, benefits businesses and society, creates job opportunities and ensures environmental sustainability.*

1. INTRODUCTION

The European Commission (2023), in the communication Sustainable products as a standard of 30/03/2022 COM (2022) emphasized the need to analyse how the prosperity of citizens can be increased and the sustainable growth ensured thanks to better use of resources and materials that make up the products of daily consumption and thanks to the improvement of the products, by focusing on the production of products with less energy consumption, efficient and long-term use in consumption, and the use of recycled materials instead of primary resources and the spread of circular economy models. The circular economy is a model of production and consumption in which the lifetime of products is increased, and waste is reduced. It represents a model of a changed concept of designing production processes, the selection of resources, their material and energy valorisation in a value chain in a closed cycle, which benefits businesses and society, creates job opportunities and ensures environmental sustainability.

The paper aims to identify the links that exist between economic growth and the use of natural resources or environmental degradation and to implement circular models in such a way that they create and capture the value of products throughout the reproductive process, while at the same time helping to optimize and limit the use of resources and the creation of waste and unusable product residues. It is not just regulatory requirements that are specific to specific products, but also the right market signals for circular models to incentivize manufacturers to better design products, extend the life of products and preserve their value during and after their use.

2. RENEWABLE ENERGY SOURCES

The Slovak Republic is an open economy, the condition of which is primarily influenced by exports, mainly from the automotive sector. On the other hand, it belongs to the countries that have a high

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dependence on the import of key raw materials and energy. Slovakia has varied reserves of minerals, but only a few of them are mined. About a third of the total number of mapped deposits is actively used. From the aspect of natural conditions and current technological possibilities of the country, the Slovak Republic is not rich in terms of primary energy resources. Energy raw materials make up 7% of the total amount of reserves registered on the territory of the country. From the aspect of total extraction within Slovakia, the extraction of energy raw materials represents 6%. As of January 1, 2009, a total of 82 exclusive deposits of energy raw materials (anthracite, bituminous rocks, gasoline, brown coal, lignite, non-petroleum gases, non-paraffinic oil, semi-paraffinic oil, uranium, natural gas) in the amount of 1,147,217 kt were recorded in the territory of the Slovak Republic. The overview does not include underground natural gas reservoirs. The most important part is represented by reserves of brown coal and lignite (altogether 94% of the total reserves of energy raw materials).

In the EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources, binding targets for the year 2020 were set, in the form of a 20% share of energy from renewable sources in the total energy consumption in the EU and a 10% share of energy from renewable sources in the transport sector. In 2018, as in previous years, a high proportion of electricity produced in the Slovak Republic originated from nuclear fuel (54.7%), despite the year-on-year decrease in the production of nuclear power plants by 1.6%, as published by the Slovak Electricity Transmission System (SEPS). Fossil fuels accounted for the second largest share of electricity (21.7%) produced in 2022. Natural gas (32.6%), brown coal (26.4%) and black coal (23.2%) accounted for the largest share of electricity production from fossil fuels. According to SEPS data, green energy in Slovakia recorded a decline. As in the years 2015 to 2017, electricity from renewable energy sources in 2018 was produced predominantly from biomass (49.4%). Biogas and photovoltaic power plants continued to have a quarter share in the production of electricity from renewable sources (24.9% and 24.4%). According to Eurostat, the share of renewable energy sources (RES) in final energy consumption in the Slovak Republic has been falling for two years in a row.

Slovakia thus moved away from the EU average by 5%. For the year 2020, Slovakia has committed to increasing the use of RES in proportion to gross final energy consumption to 14%.

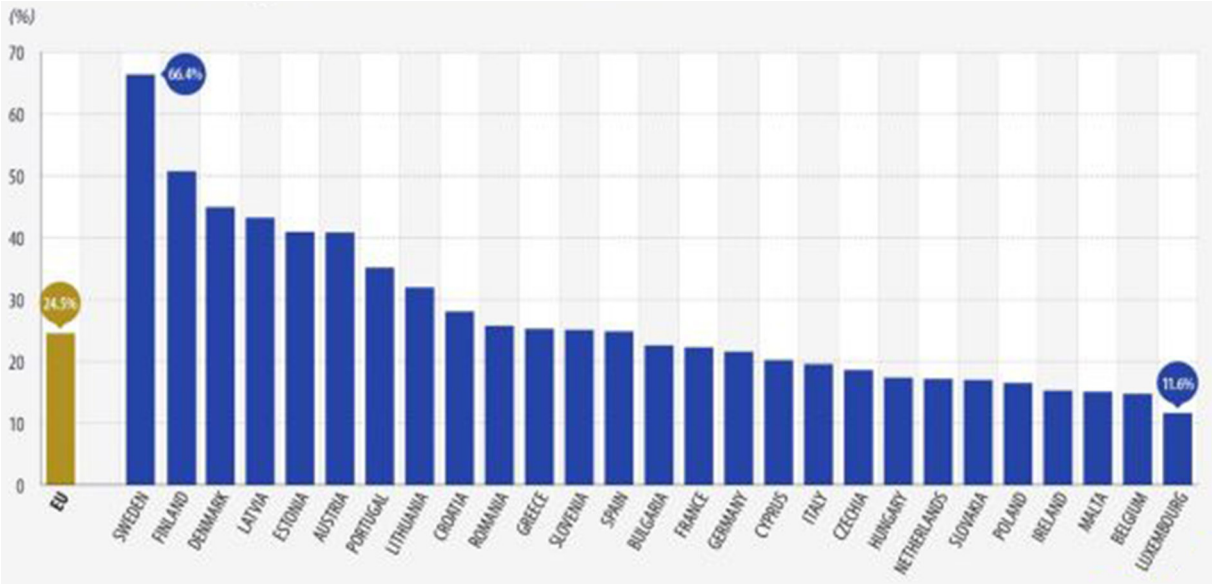

Figure 1. Overall share of energy from renewable sources in 2023

Source: Eurostat (2024)

The EU has reached a 23.0% share of its gross final energy consumption from renewable energy sources in 2022, which is approximately 1.1 percentage points (pp) more than in 2021. EU countries must therefore step up their efforts to jointly meet the new goal until 2030, which requires an increase in the share of renewable energy sources in the EU's gross final energy consumption by almost 20 percentage points. Figure 1 shows the latest available data on the share of renewable energies in gross final energy consumption in 2022. Figure 1 shows the data in 2023. Among the EU countries, Sweden has achieved the leading position, as almost two-thirds (66.0%) of its gross final energy consumption in 2022 comes from renewable sources. Sweden has relied primarily on water, wind, solid and liquid biofuels, as well as heat pumps. This was followed by Finland (47.9%), which also relied on hydro, wind and solid biofuels, and Latvia (43.3%), which depended mainly on hydropower. Both Denmark (41.6 %), followed by Estonia (38.5%), obtained most of their renewable resources from wind and solid biofuels. Portugal (34.7%) relied on solid biofuels, wind, water and heat pumps, while Austria (33.8%) mainly used water and solid biofuels. Slovakia reached the value (17.5%). The lowest shares of renewable energy sources were recorded in Ireland (13.1%), Malta (13.4%), Belgium (13.8%) and Luxembourg (14.4%).

3. SECTOR INDICATORS

Sector indicators are a means of evaluating progress in the implementation of sector policies in relation to the environment and the degree of integration of environmental aspects into sector policies. Based on the analysis of indicators developed and regularly evaluated by the European Environmental Agency (EEA), the Organization for Economic Development and Economic Cooperation (OECD, 2022), and the Statistical Office of the European Community (EUROSTAT) the evaluation based on indicators in the Slovak Republic has started, after the sets of sector indicators were created for the selected six sectors - industry, energy, transport, agriculture, forestry and tourism, as indicated by the Ministry of Environment of the Slovak Republic (2022). In each sector, individual indicators are organized into three groups. The first group consists of indicators describing the trends and development of the sector significant in relation to the environment. The second group of indicators is dedicated to the sector's interactions with the environment, including both the sector's demand for resources and its impact on the environment. The third group includes indicators reflecting political, economic and social aspects such as society's reactions to mitigation, or compensation for the negative consequences of the sector on the environment respectively. A reduction in the use of non-renewable resources may indicate an increase in efficiency or a transition to a more sustainable economy. Dependence on certain materials determines the vulnerability of the economy in relation to price changes in international commodity markets. Sectoral changes in the share of materials used may indicate structural changes in the economy, as observed by the Ministry of Environment of the Slovak Republic (2022). The share of imports per DMC is an important indicator of the sensitivity of the country's economy to fluctuations in international trade. The dependence of the Slovak economy on the import of raw materials increased from 64.4% in 2018 to 71.8% in 2022, which indicates an increase in dependence on these imports. The term "material import dependency" refers to the degree to which the economy is dependent on imports to meet its material needs. This indicator expresses the ratio of imports to direct material inputs (DMI) in percentage. Dependency on material imports cannot be negative or higher than 100%.

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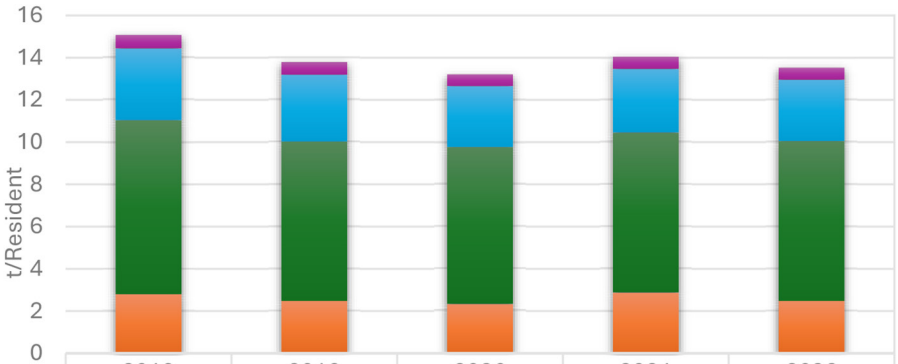
A value of 100% means that there is no domestic production in the base year. Slovakia is an open economy with economic growth and a lack of resources. Therefore, it is very dependent on the export of raw materials from other countries. The implementation of policies aimed at improving the efficient use of resources and achieving ecological growth is of fundamental importance for sustainable growth and prosperity. The growth of material consumption has a significant impact on the environment, including climate change. However, it is not the only impact on the environment. In 2022, the energy sector accounted for 57% of total emissions. The transition of businesses, especially the energy sector, to a circular economy is key to achieving climate goals in the Slovak Republic.



	2018	2019	2020	2021	2022
waste for final processing and disposal	0	0,002	0,002	0	0
other products	0,642	0,605	0,564	0,581	0,582
fossil energy materials/carriers	3,404	3,164	2,89	3,016	2,903
non-metallic raw materials	8,238	7,549	7,432	7,576	7,57
rudy the greatnon-metallic raw materials	2,795	2,478	2,332	2,873	2,477

Figure 2. Development of direct material inputs by material groups in Slovakia
Source: Eurostat (2023a)

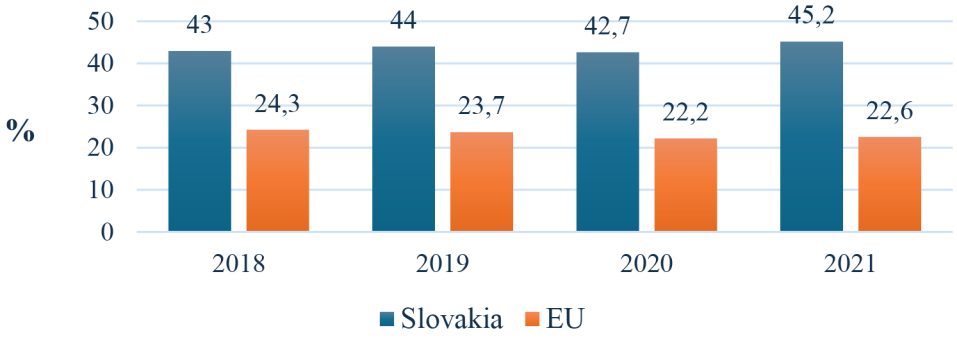


Figure 3. Dependence on material imports
Source: Eurostat (2023b)

4. ECO-INNOVATION PERFORMANCE OF SELECTED COUNTRIES

Enterprises are the carriers of change in each economy. Their innovative activities are key in achieving environmental goals. Regarding ecological innovations, information is provided by the survey on business innovation activities, which is carried out in EU member states. According to this survey, there are more innovating companies in Slovakia that have introduced an innovation with a benefit to

the environment than in the EU, the biggest difference is in the case of effects "recycling waste, water or materials for own use or sale within the company", which we can also consider as an indicator of the currently popular circular economy concept. According to Morvay (2023), this favourable situation is attributed to the high share of foreign-controlled enterprises in the corporate sphere in Slovakia.

An efficient way of using energy and materials, the selection of suitable sources of energy and materials creates economic growth, which is one of the main goals of the economic policy of the state, and business entities. Investments in research and development open new opportunities through which companies can achieve a competitive advantage. By implementing environmental measures, businesses can effectively respond to the effects of various factors with the impact of environmental disasters and environmental damage. The implemented environmental measures of legal entities in the current market economy, as well as the growth of business groups and partnerships and their decision-making regarding sustainability, as well as the fulfilment of strict standards are examples of preferring environmental solutions and sustainable products and services. The state of eco-innovation performance of various countries is indicated by the eco-innovation index, the essence of which is to measure the level and efficiency of ecological innovations in individual countries. It consists of several groups/components, which are eco-innovation inputs, activities, outputs, resource efficiency results and socio-economic results. Table 1 presents the evaluation of the ecological performance of the Slovak Republic and the EU through the eco-innovation index.

Table 1. Comparison of selected countries according to the ecological innovation index

Year	European Union	Slovak Republic	European Union	%-Increase	Slovak Republic	%-Increase
2016	106,16	82,04	95,21	104,66	30,71	47,34
2018	109,44	85,59	94,41	108,87	36,27	43,72
2019	111,05	79,08	89,46	114,25	19,40	40,50
2020	112,39	85,48	101,27	120,04	22,98	44,87
2021	115,84	88,05	96,70	126,28	29,66	49,18
2022	121,47	94,41	93,11	129,90	31,63	52,70

Source: Authors based on European Commission (n.d.)

Explanations: x = difference between the value of the eco-innovation index (2022, 2014) and the percentage growth/decrease from 2014 to 2022.

A synergistic, continuous approach to sustainability has a positive impact on the gradual growth of the European Union's eco-innovation index, which indicates that the European economy is focused on such initiatives and innovations that increase the level of environmental protection and contribute to sustainable growth. The European economy consists of the economies of the EU countries, among which there are countries with both higher and lower ecological activity. The data analysis in Table 2 presents the dynamics of changes in the eco-innovation index. Countries below the EU average are Poland (2022, 67.37), Hungary (2022, 81.15) and Slovakia (2022, 94.41). On the opposite side, there is an ecologically active country, Austria (year 2022, 173.86) with the most significant percentage growth of the index by the value of 10.58 in the period of 2021-2022. Figure 4 presents the development of Slovakia's eco-innovation index in the period 2013-2022. In the period under review, we note a gradual increase in the value of the index from 2013 (value 68.13) to 2022 (value 94.41). The exception is a decrease in value in 2019 (%-increase -7.61) and a slight stagnation in 2020 and 2021 compared to 2018.

The dynamics of changes were largely influenced by the epidemiological situation with the disease COVID-19.

Figure 4. The eco-innovation index of Slovakia in the time interval of 2013 – 2022

Source: Authors based on European Commission (n.d.)

Table 2 presents a comparison of two selected indicators, namely the indicator of government expenditures in the field of the environment and the indicator of the representation of personnel and science and research workers in the field of the environment. The data show that in the period from 2014 to 2022, all countries except Poland increased their performance in the group of eco-innovation inputs of the eco-innovation index. The only indicator that saw a decline in value during this period was government appropriations and expenditures.

Table 2. Comparison of the Slovak Republic and the EU based on 2 indicators of the group of eco-innovation inputs

Year	European Union		Slovak Republic	
	A	B	A	B
2014	95,21	104,66	30,71	47,34
2016	94,41	108,87	36,27	43,72
2018	89,46	114,25	19,40	40,50
2019	101,27	120,04	22,98	44,87
2020	96,70	126,28	29,66	49,18
2021	93,11	129,90	31,63	52,70
2022	108,59	135,43	45,46	59,79
x	14,05	29,40	48,03	26,30
y	1,25		1,32	

Explanations: A = Government appropriations and expenditure in the field of environment and energy; B = Total personnel and R&D personnel in the field of environment; x = Percentage growth/decrease from 2014 to 2022; y = Ratio between indicators B and A.

Source: Authors based on European Commission (n.d.)

The data showcases that Slovakia is the 2nd worst development of the value of eco-innovation inputs. In 2022, the value increased by 27.46% to 51.34, but in 2018 and 2019 these values were very low (28.06 and 31.97), which was deeply below the EU average (2018 and 2019: 99.64 and 108 .98). The highest percentage increase in the value of inputs during the entire interval among the selected countries was achieved by Hungary in 2018 (increase by 44.77%) and Austria in 2022 (increase by 44.62% to a well above average value of 141.89). Countries as Austria and the Czech Republic and the EU have higher values of eco-innovation inputs, and countries as Hungary, Slovak Republic and Poland have lower values. Recorded data from Slovakia point to a low level of eco-innovation inputs for both indicators. The comparison of Slovakia and the EU for the year

2022: eco-innovation inputs (SR=51.34; EU=119.61), government appropriations and expenditures (SR=45.46; EU=108.59) and total staff and research workers and development (SR=59.79; EU=135.43).

When evaluating the country's eco-innovation performance, the indicators include energy productivity and greenhouse gas emission productivity (Table 3).

Table 3. Comparison of the Slovak Republic and the EU based on two indicators of resource efficiency results in 2014, 2016 and 2018-2022

Year	European Union		Slovak Republic	
	C	D	C	D
2014	100,99	104,16	44,29	85,21
2016	109,86	120,03	51,49	100,2
2018	112,86	129,37	54,58	96,12
2019	113,97	134,47	52,32	93,64
2020	117,97	144,75	56,93	97,26
2021	123,36	161,84	59,56	112,6
2022	127,23	172,74	58,57	118,6
x	25,98	65,84	32,24	39,16

Explanations: D = Energy productivity; C = Productivity of greenhouse gas emissions; x = Percentage growth/decrease from 2014 to 2022

Source: Authors based on European Commission (n.d.)

Energy productivity represents the level of economy in the use of energy. If it is used effectively, there is a decrease in costs, less environmental impact and high competitiveness. It is a key factor for sustainable development. The highest values in the indicator - energy productivity among the selected countries were recorded by Austria (year 2022=151.02) and at the same time it is above the average in comparison with the EU (127.23). Significantly below average values were recorded by Slovakia (58.57), Hungary (52.69), Poland (52.3) and the Czech Republic (50.28). Productivity of greenhouse gas emissions represents the relationship between the produced economic value (e.g. GDP) and the generated greenhouse gas emissions. A higher value indicates higher value productivity with lower emissions. A significantly above-average value was recorded by Austria (year 2022=241.4) compared to the EU (172.4). Deeply below average values were recorded by the Czech Republic (90.86) and Poland (65.88). Slovakia recorded a value of 118.6. The positive thing is that all selected countries and the EU show a relatively high % increase.

5. FUTURE RESEARCH DIRECTIONS

Slovakia's ecological performance is not yet at the required level compared to EU countries. To reach the European level, a wider scope of involvement of public institutions, business entities and the population throughout the country is necessary. The key tasks for the near future include better information of population, the creation of regional policies emphasising citizen's interest in the environment and sustainability, reducing the environmental burdens and increasing ecological performance. Measures to support the competitiveness of the Slovak Republic and its individual regions in the eco-innovation performance are of key significance for the future development of the country. Kollár and Matúšová (2023) stated that the transition to a circular economy and the reduction of regional disparities is determined by cooperation among European countries, effective use of resources in research and development of new ecological technologies and procedures. The exchange of best practices and experiences among countries could contribute to the effective implementation of eco-innovations and policies regarding the removal of regional disparities.

Coordination measures enable creation of harmonized policies that facilitate international entrepreneurship. Equally important is a high-quality coordination institutional framework setup supporting consistent and effective management of environmental policies. According to Kollár and Matúšová (2023), it also requires better quality monitoring of indicators that point to the real state of eco-innovation performance and circulation of the country and regions.

6. CONCLUSION

Effective use of resources has a significant impact on reducing the cost of raw materials, energy and other inputs. It is important for the increase of the profitability of businesses, better availability of products and services for consumers, and the increase of competitiveness at the national and international level. Effective use of resources may promote the transition from a linear model to a circular model of the economy, to the reduction of waste and, consequently, to the reduction of the environmental burden. From the aspect of long-term sustainability, it is important that currently available resources will be available also for future generations. The quality of indicator monitoring is crucial for an accurate assessment of the eco-innovation performance and the degree of circularity in the country and regions. Objective information on the positive and/or negative advancement in the implementation of eco-innovations and the transition to a circular economy is necessary for the consistency and transparency of the monitoring, the accountability in the implementation of environmental goals, which are necessary for the long-term sustainability and competitiveness of the country. Research and development support represent the most important pillars of sustainable development, the key to strengthening the environmental industry, and creating new ecological technologies and environmentally friendly processes. Research and development must be linked to education and training in the circular economy. Investments in education and should promote awareness of recycling, waste reduction and efficient use of resources. According to Kollár and Matúšová (2023), the implementation of educational programs prepares the next generations for relevant solutions.

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