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Assessment of Environmental Performance and Development Sustainability of Systems Product

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ABSTRACT

The current stage of production development is marked by the search for more exact models ensuring its sustainability. This is perceived mainly as a balance of socio-economic and environmental pillars of development activities. The basis for managing the sustainability of socio-economic development and the development of the organization today and in the near future is the assessment of the environmental performance of product systems related to their overall socio-economic value improving the quality of life. In order to simultaneously solve the issue of creating and protecting the environment and ensuring the commercial and economic sustainability of products, it is possible to use the international standard ISO 14045, designed on the basis of the standards for LCA - ISO 1404 and 14044. In relation to sustainable production, it is currently proving to be a very effective addition methodically by linking to the framework green growth indicators from the OBCD level and their integration into the innovation model for assessing the environmental performance and development sustainability of product systems. As part of our research, variants of possible transition paths in the development of a sustainable product were modeled in relation to its future environmental profile.

Keywords: Sustainable development, green growth, product system, environmental performance, innovative model, integrating assessment.

INTRODUCTION

Assessing the environmental performance of product systems is a quantitative management tool that allows the interested party to study the environmental impacts of the life cycle in integration with its overall socio-economic value. For the assessment itself, a globally standardized guide is available today in the form of ISO 14045, which also uses the environmental assessment standards of the product life cycle (LCA – ISO 14040, 14044). However, it seems very useful to integrate these tools for improving economic-environmental behavior with the latest indicators for monitoring "green economic growth" from the OECD level and for evaluating the sustainability of production (Escrig-Olmedo et al. 2017).

Until now, traditional development focused mainly on economic growth based on materials in an effort to overcome such problems as poverty, hunger, disease and inequality. Despite impressive progress over the past century, particularly in OECD and middle-income countries, and even among poorer communities in the EU, the situation has not improved. New challenges such as dramatic environmental degradation, violent conflicts, climate change, energy crises and globalization could cause other unmanageable problems.

Old environmental burdens, environmentally inappropriate activities, greenhouse gas emissions lead to potentially catastrophic global warming. The constant decline of ecosystem services that support all life on the planet is also demonstrable.

It is therefore imperative to take immediate steps to reverse this alarming trend (Theyel 2016).

Preserving the balance between economic, social and environmental needs is the task and content of sustainable – "development that lasts" (TUR). It is also defined as a process for improving the scope and opportunity that will enable individual human beings and communities to achieve their ambitions and fulfill their long-term potential, while maintaining the resilience of both economic and environmental systems (Song et al. 2018).

Assessing environmental performance as a basis for managing development sustainability

Environmental performance is an aspect of socio-economic development sustainability regarding environmental impacts throughout the life cycle of a product that creates its value during economic growth. Environmental performance assessment is today an essential tool for reducing the overall negative impact of products on the environment. When using the international standard ISO 14045 through national standardization systems, users will be able to simultaneously solve the issue of creating and protecting the environment as well as the commercial and economic sustainability of their products.

The purpose and goal of environmental performance assessment is the optimal value of the performance of the product system, for example, its resources, production, delivery, efficiency of use, or a combination thereof (Lober, 1996). The result of these processes leads to the idea that less in the economy sometimes means more, or to confirm the thesis that what is not environmentally suitable cannot be economically efficient. In economic practice, environmental performance is achieved through the fulfillment of three main goals:

- Increasing the total value of products,
- Optimal use of resources within production,
- Reducing the negative impact of products on the environment and the health of the population.

Environmental performance is currently evaluated from a global perspective in several ways. To a certain extent, the international standard can also be influenced by the changing goals and scope of use in a specific organization. The international standard ISO 14045 globally harmonizes the assessment of the environmental performance of product systems, makes it more transparent, thereby increasing the credibility of the assessment, which until now has often been considered subjective or even misleading (Kloepffer, 2008).

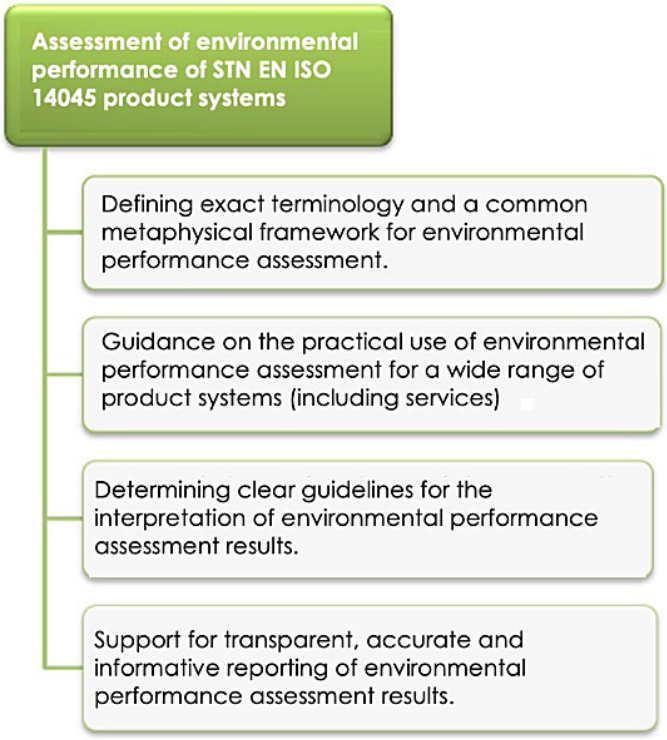

Figure 1. Purpose and objectives of standardized environmental performance assessment

Table 1. Tools usable in the assessment of environmental performance

Performance assessment tools	Characteristics and meaning
Environmental efficiency analysis	Achieving higher value with lower inputs (materials, energy and with a reduction in produced emissions when transforming business inputs into outputs).
Life Cycle Assessment (LCA)	Comparing products / activities with the same by function, identification of weak points within the life cycle of a product, service or process, identification of potential for improvement, labelling of environmental suitability.
Environmental Impact Assessment (EIA)	Analysis of potential positive and negative impacts on the environment and population health resulting from planned activities related to their location.
Strategic Environmental Impact Assessment (SEA)	Ensuring a high level of environmental protection, the health of the population and the integration of environmental and health aspects into the preparation and approval of development policies, plans and programs with the aim of supporting sustainable socio-economic development through their implementation.
Risk management	Quantification of the probability of the effects of the negative impact of a certain human and business activity on the components of the environment
Environmental audit	Evaluation of current environmental performance or profile, setting goals for the future in relation to the environmental performance of the company.

Human activities are generally also associated with a negative environmental impact, especially in such activities and processes as (Chen et al. 2015):

- Extraction and processing of raw materials.
- Transport and handling.
- Technological production processes.
- Phase of product use and renewal.
- Production and processing of waste, etc.

As part of the assessment of environmental performance and environmental impact systems of product systems, products are assessed using an environmental management tool-life cycle assessment (LCA), as specified in international standards (ISO 14040, ISO 14044).

Standardized environmental performance assessment (Figure 1) is a methodological procedure that ensures that the environmental impacts of business activities have been taken into account before decisions are made (Michelsen et al. 2006). This ensures that plans, programs and projects that could have significant impacts on the environment and public health are subject to an environmental performance assessment before they are approved. Other currently used and progressive tools for assessing environmental performance are characterized in Table 1.

An innovative model for assessing the environmental performance of product systems

Environmental efficiency is a philosophy that focuses on minimizing environmental damage while maximizing the efficiency of production systems and processes, such as lower consumption of energy, materials and water, better recyclability, and the elimination of hazardous emissions or by-products.

Environmental efficiency is achieved by the supply at competitive prices of goods and services that satisfy human needs and increase the quality of life, while gradually reducing their impacts on the environment and health and the intensity of resource use throughout the life cycle at a level at least in accordance with the estimated "optimal" impact on the environment (Siebenhüner et al., 2006).

The World Business Council for Sustainable Development has identified seven elements that can be used to improve environmental performance:

- Reduction of material demand.
- Reduction of energy consumption.
- Reduction of dispersion of toxic substances.
- Increasing the share of recycling.
- Maximizing the use of renewable energy sources.
- Extension of the product's lifetime.
- Increasing the intensity of services.

The application of environmental performance indicators (Figure 2) in the business sector is generally expressed on the basis of the ratio of the value of the product and its impact on the environment and health.

The key difference in the analysis of environmental efficiency compared to e.g. with the LCA method is that the analysis of environmental efficiency is based on two pillars of the development of sustainability – evaluation of the environmental burden and economic costs, while LCA only evaluates the effects on the environment – the

$$\textbf{Environmental performance of production} = \frac{\text{Social value of the product}}{\text{Environmental impact of the product system}} = \frac{\text{Improving indicators of socio-economic quality of products}}{\text{Reduction or elimination of negative environmental effects of production}}$$

Figure 2. Quantification of environmental performance of product systems

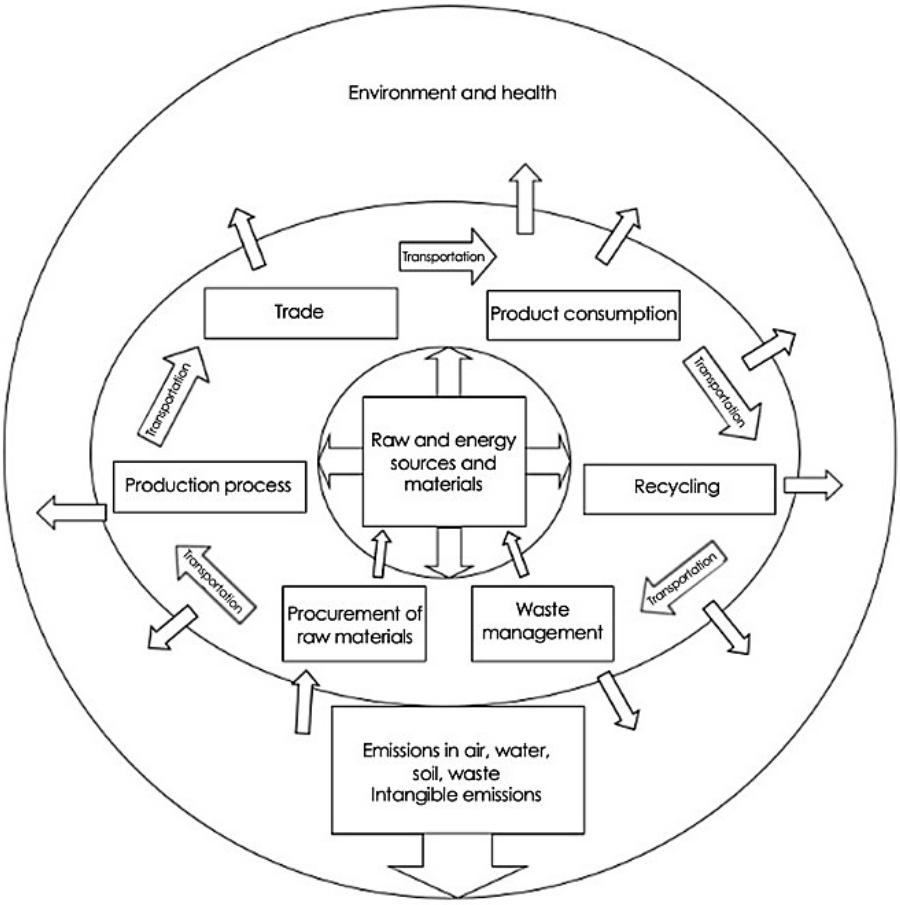

Figure 3. LCA in the product logistics system

environmental burden in the logistics system of the product and identifies weak points in this system, respectively. Phases of the product life cycle (Figure 3).

In the individual phases of environmental performance assessment (Figure 4), the results of the phases are used – an iterative procedure that contributes to complexity in each area and in the connection between areas and unifies the assessment of environmental performance and the obtained results. Life cycle assessment of products includes the investigation and evaluation of the impacts of given products or services caused by their existence on the components of the environment. It is a process of compiling and evaluating inputs, outputs, processes of transformation of inputs into outputs and possible impacts on the environmental components of the production system during its entire life cycle from "cradle to grave" or currently by including "cradle to cradle" recycling, when waste becomes a valuable raw material replacing exhaustible raw material – energy resources. The basis is the identification of environmental aspects, impacts and risks (IEAIaR) and their management system (EMS according to ISO or EMASIII - EU Regulations). Figure 4.

The definition of the objective and the scope, including the boundaries of the system and the level of detail of the LCA method, is also copied by the course of the environmental performance

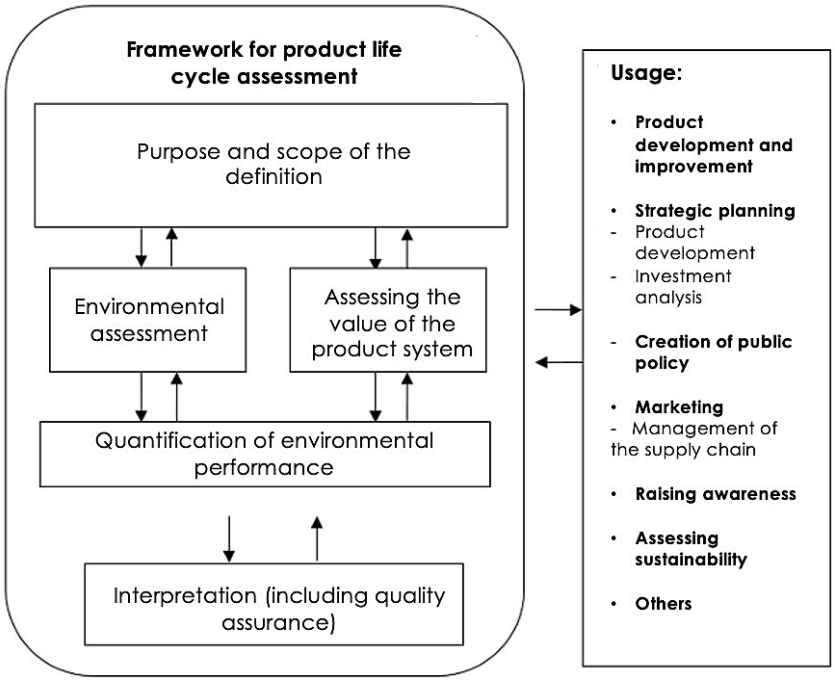

Figure 4. Model for evaluating product life cycle stages

assessment process according to ISO 14045 and depends on the subject and the scope of the intended study used. The depth and breadth of the LCA method can vary considerably depending on the specific objectives of the LCA method. The scope should be sufficiently well defined to ensure that the breadth, depth and detail of the study are compatible and sufficient to address the stated objective (Majerník et al. 2021, Dias-Sardinha et al. 2001).

Life cycle analysis attempts to quantify the range of environmental impacts associated with a product by considering all inputs of resources, materials and all outputs of waste and pollution at each stage of the product's life cycle, including raw material sourcing, product manufacturing and distribution, consumer use, maintenance product and its final disposal (Sahay et al. 2006).

Green growth indicators according to OECD

In today's economy, supply-customer chains are often long and complex (sales and purchases also outside national borders) and decisions made by consumers in one region or countries can often have an impact on environmental aspects in another region as well as around the world. The direct connection between the sphere of the individual or the household and the natural environment is also evident (the use of environmental benefits and the resulting degradation or reduction of the quality of the environment, people's health and the overall quality of life). These aspects play a key role in environmental growth.

When monitoring activities towards or away from green growth, it is necessary to obtain information about the actions and behavior of governments, households and businesses as a reaction to the issue of creation and protection of environment - social response. In connection with the social response, there are also opportunities for growth resulting from environment (Raluy et al. 2005, Todd et al. 2001). If the indicators of green growth are connected with the state development policy, growth opportunities resulting from the environment also arise, e.g. new products, processes opening new markets, maintaining incomes and creating jobs. As with other evaluation methodologies and indicators, the green growth indicators are always limited in some areas and, especially in international comparisons, they must be interpreted depending on the specifics of the given country.

However, all indicators should reflect political relevance for green growth, analytical validity and measurability of the quality of the underlying data.

The established indicators must be politically relevant and must, in particular (Figure 5):

- Ensure equal coverage of the key elements of green growth with an emphasis on those that are in the common interest of OECD members and partner countries.

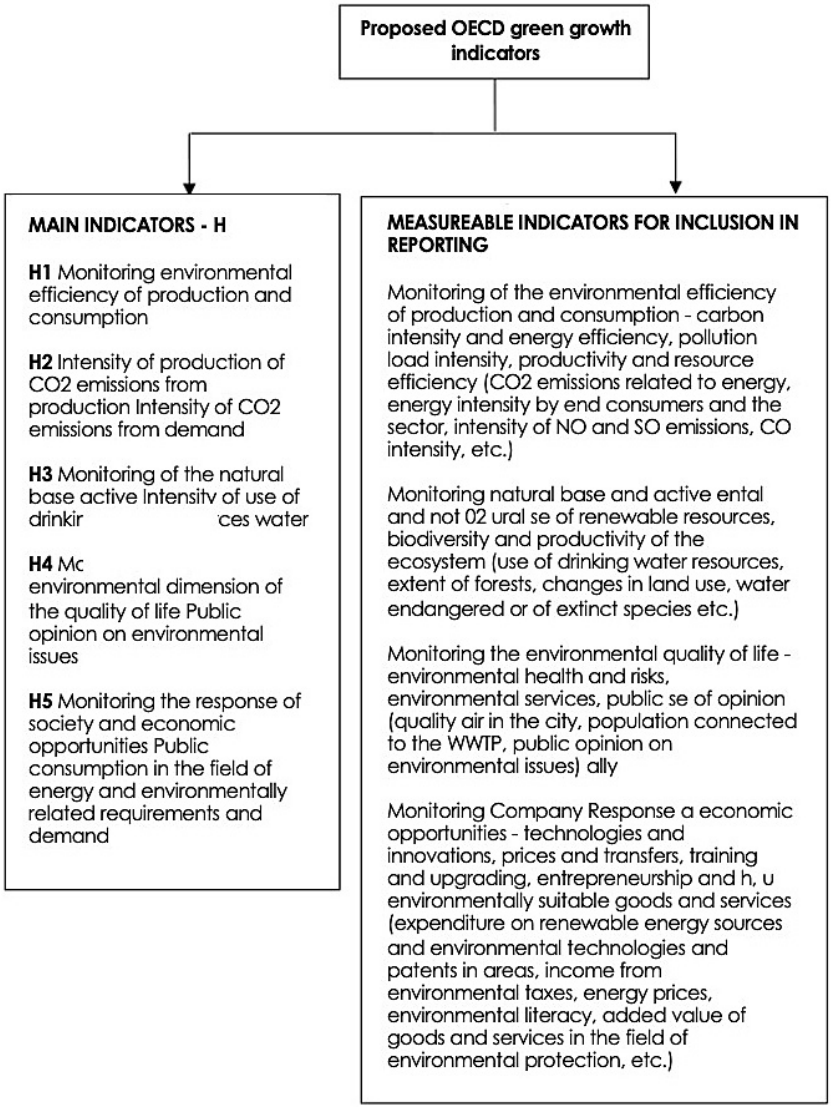

Figure 5. Framework OECD indicators of green growth and sustainability

- Guarantee clarity and clarity for users in terms of the meaning of the values associated with it and their changes over time.
- Serve as a basis for comparison between countries.
- Adapt to various national differences and analyze disproportions.

The indicators included in the OECD list so far are intended to facilitate, or to coordinate national discussions also when formulating specific national indicators. At the same time, the basic indicators are considered measurable in a short time horizon.

The proposed indicators (H1 - H5) should capture the main trends and importance of green growth and point to development paths eliminating environmental damage and risks that could eventually become an obstacle to economic growth - the green economy. Remediation of environmental damages is often more expensive than the costs of their prevention. The purpose of the indicators and the assessment itself is also to find development paths providing opportunities for economic growth and prosperity.

Integration of assessment of environmental performance and development sustainability of products

Environmental performance is a practical tool for simultaneously managing environmental and value aspects. Environmental performance assessment is the assessment of the environmental profile of a product system in relation to its value.

The result of the environmental performance assessment concerns the product system, not the product itself. A product cannot be

environmentally efficient, only the system of this product, which includes production, use, disposal, i.e. the entire life cycle. Environmental performance is also a relative term and a product system is only more or less environmentally efficient in relation to another product system. When defining the environmental performance objective, the following must be taken into account and clearly described:

- The purpose of environmental performance assessment.
- Target group.
- Planned use of results.

When defining the scope, the following must be taken into account and clearly described:

- The assessed product system.
- Function and functional unit.
- Boundaries of the product system.
- Allocations to external systems.
- Method of environmental assessment and types of impacts.
- Value assessment method and product system value type.
- Selection of environmental performance indicator.
- Method of interpretation.
- Limitations.
- Reporting and announcing results.

The scope of environmental performance assessment must clearly specify the functions (profile characteristics) of the studied product system. The functional unit must be defined in accordance with the objective and scope of the environmental performance assessment. One of the primary purposes of a functional unit is to provide a basis for environmental assessment and for assessing the value of a product system (Pearce et al. 2013). There are several types of environmental performance indicators that can be used to express a quantitative figure of environmental performance. The environmental performance indicators to be used for assessment must be described (De Benedetto et al. 2009). The assessment methods and presentation format of the environmental performance assessment must be defined. The following requirements apply to the selection of environmental performance indicators:

- An increase in performance for the same value of the product system must represent an improved environment.
- An increase in performance with the same environmental impact must represent an increased value of the product system.

Figure 6 shows an example of a possible sustainable product development path. If the current product or service at the point "original product",

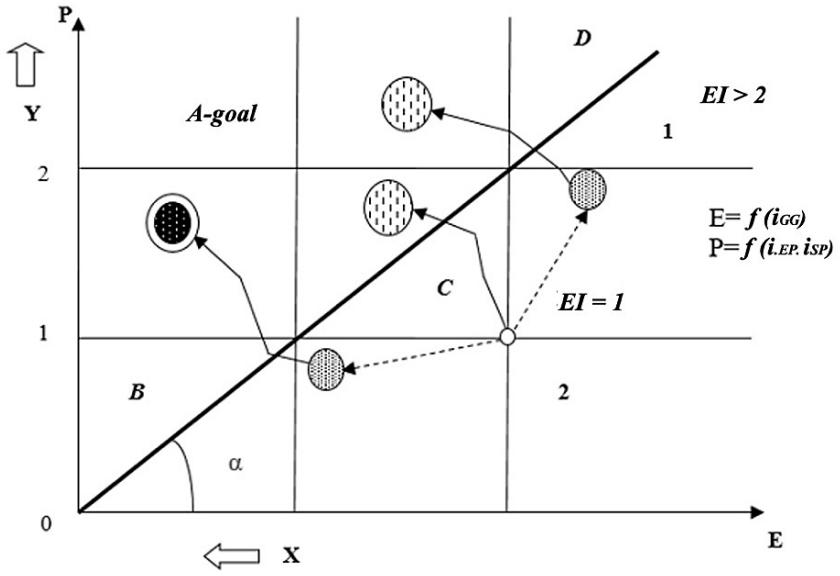

Figure 6. Development of a sustainable environmental performance product [According to international standard 14045:2013 and green growth indicators according to OECD].
Legend: E – environmental impact quantified by green growth indicators (H1–H5), P – value of product systems quantified by UR environmental and social indicators, GG – green growth, i – indicator, EP – economic pillar of SD, SP – social pillar of SD, 1 – new products – sustainable and environmentally efficient, 2 – compared product – before the environmental innovation, X – reduction of environmental impact – quantified by the change in the green growth indicator, Y – improvement of value functions of the product – presented by socio-economic indicators of SD.

its environmental performance (EP = P1E) is defined as 1. Towards the top left, the environmental performance increases and tgα expresses the environmental performance of the developed target. If the goal is environmental performance (EP) > 2, area A is the target and area B is better only in environmental aspects. Area C shows that the product is steadily evolving towards area A.

Advances in technology make it possible to take different paths, and this can sometimes involve a decrease in environmental profile along the way. Area D appears to be a poor area for environmental degradation, but moving through this area may be a necessary step towards the goal through the implementation of Best Available Technologies (BAT). In this context, when the value of the product system increases much more than the environmental impacts decrease, the environmental performance can be described as an improvement in the serial development of the product.

In order to be able to choose between variants A and B for a specific product, the environmental performance of these options needs to be compared with that which is currently current in the company. However, a necessary condition is that concrete measurable values, indicators - indicators are used within the framework of improvement.

In contemporary literature, the term "sustainability" represents development that meets the needs of the present generation without jeopardizing the ability of future generations to meet their own needs. It identifies economic, environmental, social and institutional issues which, given the characteristics of the sustainability model, are considered equally important and stand balanced next to each other. Whether it is a new product that needs to be designed or an existing one that needs to be improved, the process of creating more sustainable and environmentally efficient products must be constantly monitored and managed. In order to solve global problems and relevant processes, it is necessary to use appropriate methods and tools for assessing environmental performance in the context of socio-economic aspects of sustainable development.

The concept of environmental performance and development sustainability can function as an effective tool in companies, the environmental management system, and at the same time, by gradually measuring performance, it can help the organization's development sustainability. Successful organizations are beginning to use the assessment of the environmental performance of products in a systematic way by defining goals, collecting data, assessing impacts, controlling effects and finally providing information to interested parties through indicators of sustainable development (economic and social) and indicators of green growth from the OECD level and the green economy from UNEP (United Nations Environment Program) levels.

CONCLUSIONS

The growth of the world economy, as well as the world population, has maintained constantly increasing values for several decades. As demand grows, so does the consumption of all natural and material resources. The way our society is progressing is not sustainable in the long term, it limits opportunities for the less privileged, but especially threatens the quality and fullness of life of future generations. Nowadays, society is increasingly moving beyond the imaginary limit of sustainable environmental burden. Human life is spent in the pursuit of satisfying needs. However, it is not only about basic needs, but especially about various artificial needs created by the trend of consumer society. The natural environment is the source of almost all substances that not only satisfy human needs, but mainly enable the existence of life on Earth. Therefore, it is necessary that we take a more responsible approach to the use of natural resources when fulfilling these needs, and the development of our society can be characterized as sustainable.

Sustainable development is the direction in which our society must progress. Therefore, the international political board has been dealing with this issue since 1968, when the term sustainable development was first mentioned at the Paris Conference on the Biosphere. Despite the long-term efforts of various international organizations to implement the sustainability strategy and its rules in practice, its fulfillment is still insufficient. The majority of the responsibility for the implementation of the sustainable development strategy falls mainly on companies and organizations. The focus of the organization must not be limited only to their profitability, but must also take into account social responsibility. In the pursuit of growth and development of business activity, it is necessary to imply such tools and solutions

that will bring organizations sustainable progress, green growth and increased competitiveness in globalized markets.

The promotion of the idea of green behavior in Slovakia still does not reach the level of other European countries, mainly due to the establishment of green instruments on a voluntary basis, but it is clear that this trend will have a growing tendency in the future. We therefore consider it necessary that the awareness and activities of individuals, organizations and the entire human community in this direction are constantly increased and developed, and that green thinking becomes an integral part of the management of business processes.

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REFERENCES

1. De Benedetto, L., Klemeš, J. 2009. The Environmental Performance Strategy Map: an integrated LCA approach to support the strategic decision-making process. Journal of Cleaner Production, 17(10), 900-906.
2. Dias-Sardinha, I., Reijnders, L. 2001. Environmental performance evaluation and sustainability performance evaluation of organizations: an evolutionary framework. Eco-Management and Auditing: The Journal of Corporate Environmental Management, 8(2), 71-79.
3. Escrig-Olmedo, E., Muñoz-Torres, M. J., Fernández-Izquierdo, M. Á., & Rivera-Lirio, J. M. 2017. Measuring corporate environmental performance: A methodology for sustainable development. Business Strategy and the Environment, 26(2), 142-162.
4. Chen, Y., Tang, G., Jin, J., Li, J., & Paillé, P. 2015. Linking market orientation and environmental performance: The influence of environmental strategy, employee's environmental involvement, and environmental product quality. Journal of Business Ethics, 127(2), 479-500.
5. Kloepffer, W. 2008. Life cycle sustainability assessment of products. The International Journal of Life Cycle Assessment, 13(2), 89-95.
6. Lober, D. J. 1996. Evaluating the environmental performance of corporations. Journal of Managerial Issues, 184-205.
7. Majerník, M., Bednárová, L., Naščáková, J., Drábik, P., Malindžáková, M. 2021. Comprehensive management of natural resources: a holistic vision. In Sustainable Resource Management (pp. 221-240). Elsevier.
8. Michelsen, O., Fet, A. M., Dahlsrud, A. 2006. Eco-efficiency in extended supply chains: A case study of furniture production. Journal of environmental management, 79(3), 290-297.
9. Pearce, D., Markandya, A., Barbier, E. 2013. Blueprint 1: for a green economy. Routledge.
10. Raluy, R. G., Serra, L., Uche, J. 2005. Life cycle assessment of desalination technologies integrated with renewable energies. Desalination, 183(1-3), 81-93.
11. Sahay, B. S., Stough, R. R., Sohal, A., Goyal, S. 2006. Green business (Vol. 1). Allied Publishers.
12. Siebenhüner, B., Arnold, M., Hoffmann, E., Behrens, T., Heerwart, S., Beschorner, T. 2006. Organisationales Lernen und Nachhaltigkeit: Prozesse, Auswirkungen und Einflussfaktoren in sechs Unternehmensfallstudien (No. Bd. 65, p. 277). Metropolis-Verl.
13. Song, M. L., Fisher, R., Wang, J. L., & Cui, L. B. 2018. Environmental performance evaluation with big data: Theories and methods. Annals of Operations Research, 270(1), 459-472.
14. Theyel, G. 2006. Customer and supplier relations for environmental performance. In Greening the supply chain (pp. 139-149). Springer, London.
15. Todd, J. A., Crawley, D., Geissler, S., Lindsey, G. 2001. Comparative assessment of environmental performance tools and the role of the Green Building Challenge. Building Research & Information, 29(5), 324-335.