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SUSTAINABLE PRODUCTION: REVIEW OF EUROPEAN TRENDS

Keywords: *ecology; production; sustainability.*

Abstract

The article presents problems of sustainable production against the idea of sustainable development, which means a comprehensive and harmonious socio-economic development that does not disturb the natural environment. An aim of the article is to show the importance of initiatives in the field of sustainable production connected with practice of implementing the principles of sustainable development. In search of quantitative measures to assess the basic pillars of eco-development, as well as social, economic and natural resources and their relationships, the Eurostat and European Commission databases from 2010 and 2016 were analysed. These data made it possible to visualise the behavior of the European countries with a dynamic approach.

1. Introduction

Sustainable development aims to improve the quality of life while maintaining social equality, biodiversity and variety of natural resources [1].

The program document, which presents the method of developing and implementing sustainable development strategies in local life, is Agenda 21, adopted at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, June 1992.

Agenda 21 contains basic recommendations regarding the protection and shaping of the human life environment. It pays attention to a number of its social and economic conditions as well as the protection of natural resources, as well as their rational management in order to establish stable and sustainable development. Effective solving of problems of eco-development requires a holistic approach. For instance, considerations of economic issues must take into account their impact on social aspects and the natural environment. For this purpose serves the currently developed concept of the Circular Economy modeling [2,3].

Sustainable production is defined as an environmental protection strategy, based on continuous, integrated, preventive action in relation to processes, goods and services, aimed at increasing the efficiency of production and services and reducing the risk for people and the natural environment. The basis for sustainable production consists in linking the production process with the concept of reducing the use of resources and the environmental impact of the product. This concept therefore applies to all stages of the product life cycle - from cradle to grave, from design to disposal [4].

In many countries ecological activities play an important role in balanced development of the society. Sustainable systems get more and more popular. Industrial companies hire professionals to their research and development (R&D) departments who search for new or more efficient technologies. However, there are many problems waiting to be solved.

Nowadays, more and more people realize that limited resources are not only a matter of the limited money they have, but also - and maybe primarily - it is a matter of the resource limitation itself. Moreover, a rapid development of urban areas all over the world causes some serious environmental problems including pollution, floods, smog etc. These occurrences still evoke a need for immediate changes. Today, a concept of the ecological perspective gets more and more popular and for many, and sustainable development is the only way to get rid of this problem.

A preliminary observation of attitudes focused on the environmental protection brings a presumed relationship between a wealth of the unit and its propensity to behave in more ecological way. A presumption of a correlation between Gross Domestic Product and a scale of the environmental actions, in majority of European countries, caused an interest to take this matter into consideration. Quite interesting study results are obtained by comparing a level of the resource productivity and a pursuit of investing in integrated and thus cleaner technologies in individual European countries.

The study was motivated by curiosity of the possibilities to visualise the behavior of European states against the available data. In order to find quantitative measures enabling for creation of basic pillars of sustainable production in a country a detailed analysis of the Eurostat's and European Commission's databases along with a deep consideration of the factors concentrated on the sustainability was performed. The following indicators were pointed as important for this study.

- Gross domestic product (GDP) represents a nation´s economic situation. It shows the total value of all goods and services produced in the particular area less the value of goods and services used for intermediate consumption in their production.
- Number of ecolabel licenses is an indicator which is defined as the number of Ecolabel or "EU Flower" licenses in Europe. Products

including services with reduced environmental impacts are awarded by the Community Ecolabel. The event is administered by the European Commission and is supported by all EU Member States and the European Free Trade Association (EFTA). Furthermore, ecolabel criteria are discussed in the European Union Ecolabelling Board (EUEB) which representatives come from industry, consumer organizations or environmental protection groups.

- Resource productivity is gross domestic product (GDP) divided by domestic material consumption (DMC) which is considered as the total amount of materials directly used by an economy. For the calculation of resource productivity, Eurostat uses GDP either in unit 'EUR in chain-linked volumes' or in unit 'PPS' (Purchasing Power Standard). In this paper, the indicator was expressed in PPS per kg, for comparing different countries.
- Investment in equipment and plant linked to cleaner technology - so called "integrated technology" – is a part of the measures for environmental protection expenditure in industry (the paper takes into account a 'manufacturing' branch) by size class. According to its definition, the investment expenditure results from actions and activities whose objective is to prevent as well as reduce and eliminate pollution and any other degradation of environment. Moreover, a cleaner technology is an installation or a part of an installation that has been adapted in order to generate less pollution. The environmental equipment has been integrated into the production process, not like in case of the 'end-of-pipe' (pollution treatment) investment. In this particular situation, the investment in the environmental equipment consists of the extra cash flow due to the integration of the equipment. This type of environmental equipment is not a separated part of the production process therefore the costs should be estimated on the basis of e.g. available alternative environmentally harmful installations.

2. Environmental impact of production

2.1. Sustainability

A complexity of problems related to the sustainability in production systems makes the environment-friendly manufacturing quite complicated. Manufacturing of goods can be treated as a process of creating value added and environmental pollution is one of its risk factors. The construction industry, for example, is involved in creating physical assets (e.g. buildings treated as products) that are important drivers of development. On the other hand, the building sector, together with the building materials industries, is one of the largest exploiters of natural resources, both mineral and biological, as well as a significant producer of waste. Its activities cause irreversible

transformations of the natural environment. Moreover, it increases the accumulation of pollutants in the atmosphere.

Industry, in general, has been considered as a source of the environmental problems ranging from an excessive consumption of the global resources to a pollution of the surrounding environment. Thus, a research on 'green' technologies and their role to minimize an environmental impact has become recently very popular. A goal for the sustainability assessment goes even further than at the design stage of all production processes. The production planners have to consider an importance of the ecological approach at an early stage, before any detailed concept is made. This attitude ensures the organization of production that will be environmentally friendly throughout the production phase. Therefore, a debate on how to reconcile the needs of economic growth with a respect for the environment has been focused on the popular concept of the sustainable development.

2.2. Environmental impact of the production processes

Production systems, irrespectively of type of the products, are the prime source of the environmental risk due to the complex relationships with the environment. A probability of the serious impact on the environment can be treated as ecological risk.

The progress of civilization brings a number of potential environmental risks. Production plants, operating in the natural environment, consume natural resources and output emissions and waste. A problem for the environment is also the main product of manufacturing processes. A diagram (Fig. 1) presents relationships between the production system and the environment.

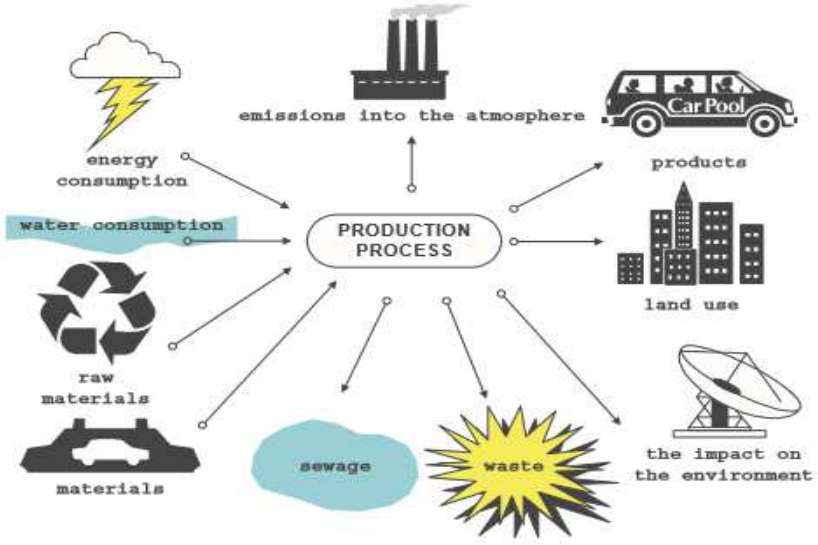


Fig. 1. Diagram of the environmental impact of the production process

Gerbens-Leenes, Moll and Schoot Uiterkamp (2003) underline that for the manufacture of a final product, many processes take place in several companies that form a production system. In addition, they generate a large variety of impacts. Although, existing sustainable business practices pay attention to the company performance rather than the performance of the production system as a whole, this attitude has several disadvantages. However, an important step towards sustainable business practices is the design and development of a system-based measuring tool providing information on the sustainability. It is necessary to take into consideration all companies that contribute to an end product. A technique for assessing the potential environmental impacts connected with the manufacture of a product in the whole life cycle is called Life Cycle Assessment (LCA) [5]. A meaning of this approach and its possible implementations in different industries are widely described in literature [6–8].

3. In search of sustainable production

There are clear reasons for changing a way the production is performed. The increasing pressure from manufacturing industry on the energy consumption calls for a more environmental-friendly production mode. Cleaner production has been hailed for the several economic, environmental and social benefits it can provide, and is considered as one of the most important means for manufacturing enterprises to realize sustainable production [9]. Manufacturers have become progressively more aware of their operations' impacts on the triple bottom line (people, planet and profit), with increasing pressure to account for their resource consumption and environmental footprint. Therefore, it is significant to explain what is sustainability from an operational perspective, and to understand the way in which it might be attained within manufacturing organizations [10].

Moreover, economic growth and the development of global markets are correlated with energy use, and they have caused an increase in global energy demand and created pressure on the energy resource supply. Many industries in different countries are highly energy-dependent, which is one of the reasons for the general recognition of the importance of energy in the economic growth of the societies. Governments concentrate on the secure and sustainable energy supplies. Awareness of public opinion about energy use, its environmental impact, and particularly the climate change and its adverse effects have become popular nowadays. Previous patterns of production and consumption styles have resulted in unsustainable outcomes and recent research concentrates on the sustainability of energy systems, including technological aspects, as well as environmental, economic and social aspects of energy [11].

Consequently, sustainable production can be defined as the creation of goods and services using processes and systems that do not pollute, the

conservation of energy and natural resources, the practice of economically viable operations, the maintenance of a safe and healthy environment for employees, communities and consumers, and socially and creatively rewarding all working people. The definition is consistent with the common understanding of sustainable development, because it emphasizes the environmental, social and economic aspects of a company's activities. Recently, a growing number of manufacturers are beginning to use environmental, health and safety, and social indicators to measure the sustainable production. Existing business-related sustainability indicators tend to emphasize the environmental aspects of production [12].

Various methods in different sectors are implemented in order to reduce negative environmental impacts of the production systems. In agriculture, for instance, to reduce the environmental and human health impacts of conventional agricultural production systems, alternative farming techniques have been developed, such as integrated and organic farming, which operate according to peculiar principles and rules. Integrated farming (as an example of the integrated technology) aims to minimize the use of the technical means normally adopted by conventional agriculture, relying on them only when necessary to optimize the balance between environmental and economic needs [13].

On the other hand, in building sector, the construction of any building, even a small-scale project, is a very complex process [14,15], utilizing tens of thousands of components. In order to effect efficient construction assembly, a number of resource flows need to be aligned, including the workforce, building information, plant and equipment hire, as well as the procurement and delivery of materials and components. These logistics need to be systematically managed and controlled in order to deliver projects that are efficient in waste and resource management. Undoubtedly, some innovations like a new way of the construction simulation (known as: Building Information Modelling) can be used to facilitate bottom up strategies for cleaner production in the construction industry [16]. Also new computational methods, including Big Data analysis [17–19] can be useful for managing construction waste, and reducing environmental impact. Moreover there are some efforts to implement an idea of the Circular Economy to the building sector. A proposal of measuring its scale can be found in the literature [3].

4. Visualising the European states' behaviour in terms of sustainability

The research covered European countries, members of the European Union. For these countries, all necessary data was available and complete. An extraction date was 2010 which was quite a memorable year especially due to the extreme weather conditions that forced to rethink past findings about

climate and reformulate recommendations about an impact of the industry on the environment.

It seems that one of the most adequate indicators, measuring a scale of the reduced environmental impacts of products and services, for the whole country is a number of ecolabel licenses distributed in a year. The EU Ecolabel is a third party certified Type I ISO 14024 established in 1992 to promote products and services which have a reduced environmental impact. The award helps European consumers distinguish more environmentally friendly practices in the production. Therefore, a data was extracted from the database [20] what describes fig. 2.

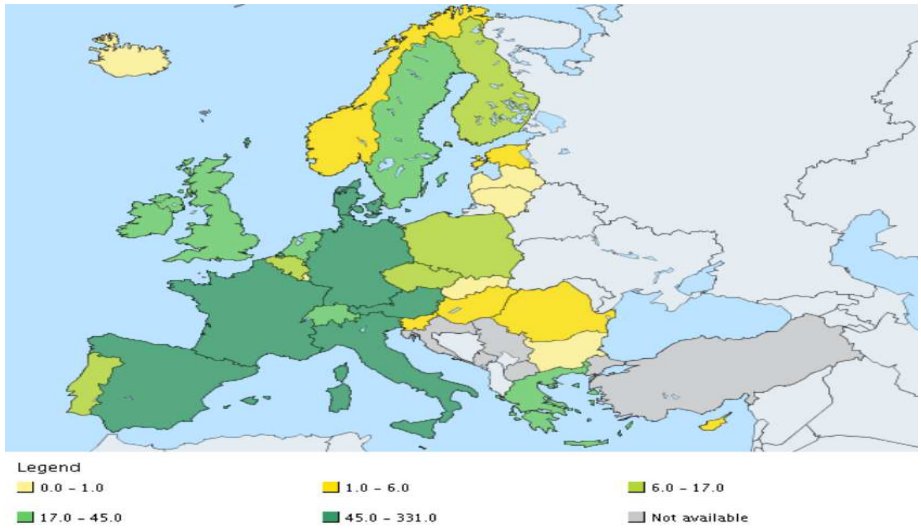


Fig. 2. Ecolabel licenses in Europe, 2010

This first indicator shows that there is an increasing interest in formalizing efforts related to the development of ecological production methods in Europe. Western states of the European Union (Germany, France, Spain, Italy) show a significant activity in this field – for example, 331 Ecolabel licenses were awarded in Italy in 2010, whereas Bulgaria, Latvia and Slovakia did not receive any. According to the European Commission (2018), since 2010, a total number of the licenses has almost doubled and reached 2130 in 2017 (comparing to 1152 in 2010). In September 2017, the largest number of EU Ecolabels was awarded in France (22%, 476 licenses), Italy (17%, 354 licenses), and Germany (15%, 315 licenses).

Another factor describing sustainability in individual countries is eco-innovation index (Fig. 3). This index is based on 16 indicators from eight contributors in five areas: eco-innovation inputs, eco-innovation activities, eco-innovation outputs, environmental outcomes and socio-economic outcomes. According to the Eurostat's methodology, the overall score of an

EU Member State is calculated by the unweighted mean of the 16 sub-indicators. It shows how well individual country perform in eco-innovation compared to the EU average, which is equated with 100.

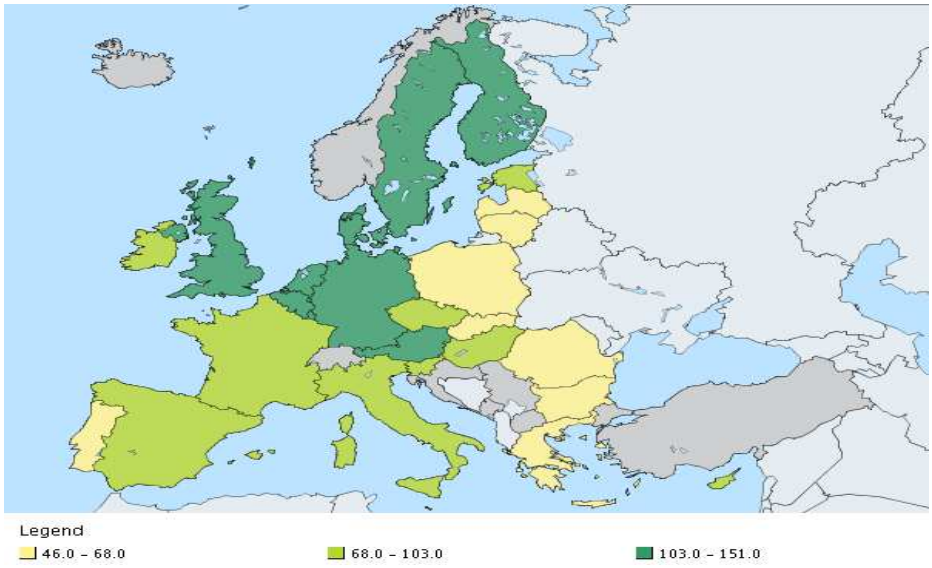


Fig. 3. Eco-innovation index, 2010

The data demonstrates that Denmark in 2010 had the highest level of eco-innovation index (151), whereas Latvia had the lowest (46). Top-three eco-leaders in 2010 are slightly different than in 2016, what can be observed in the fig. 4. Western and Scandinavian countries are at the head of the rank (Germany – 140, Luxemburg – 139, Finland – 137) whereas Eastern Europe countries (especially Bulgaria – 41 and Hungary – 60) still have to improve.

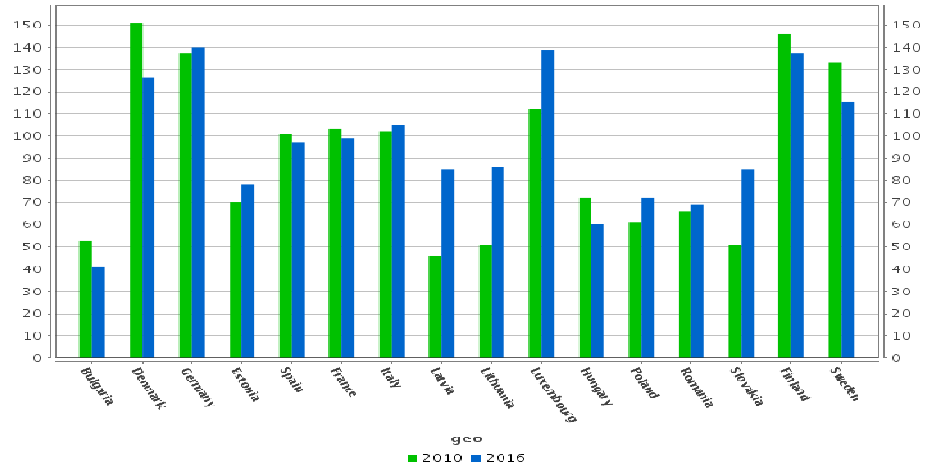
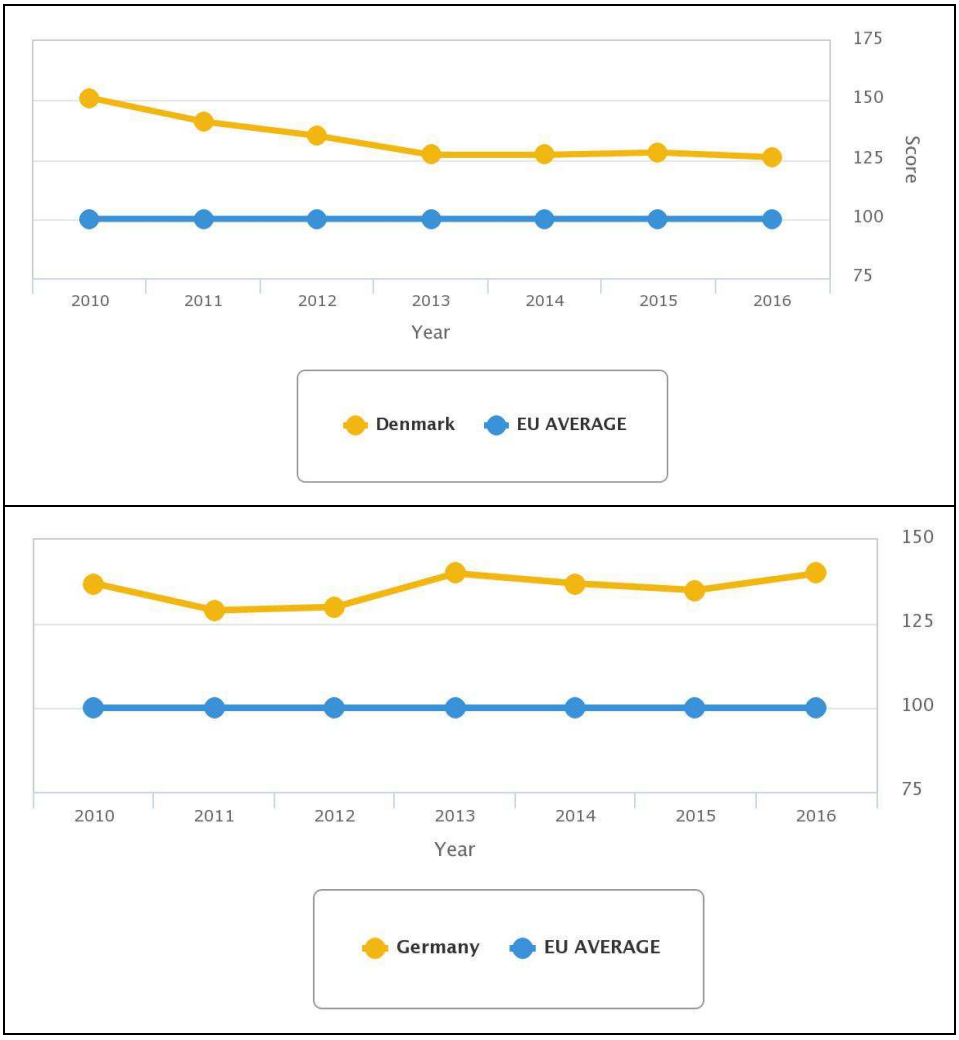


Fig. 4. Eco-innovation index, in 2010 and 2016

Trends of the eco-innovation indexes of the first and the last countries on the list in 2010 and in 2016 (figures 5-8) do not show any significant change. However, Germany and Latvia have improved their initial performance in comparison to the EU average whereas Denmark and Bulgaria have gradually decreased their position. In case of Denmark the change may come from an increase of the European Union's performance but Bulgaria lost the distance to the rest of the countries.



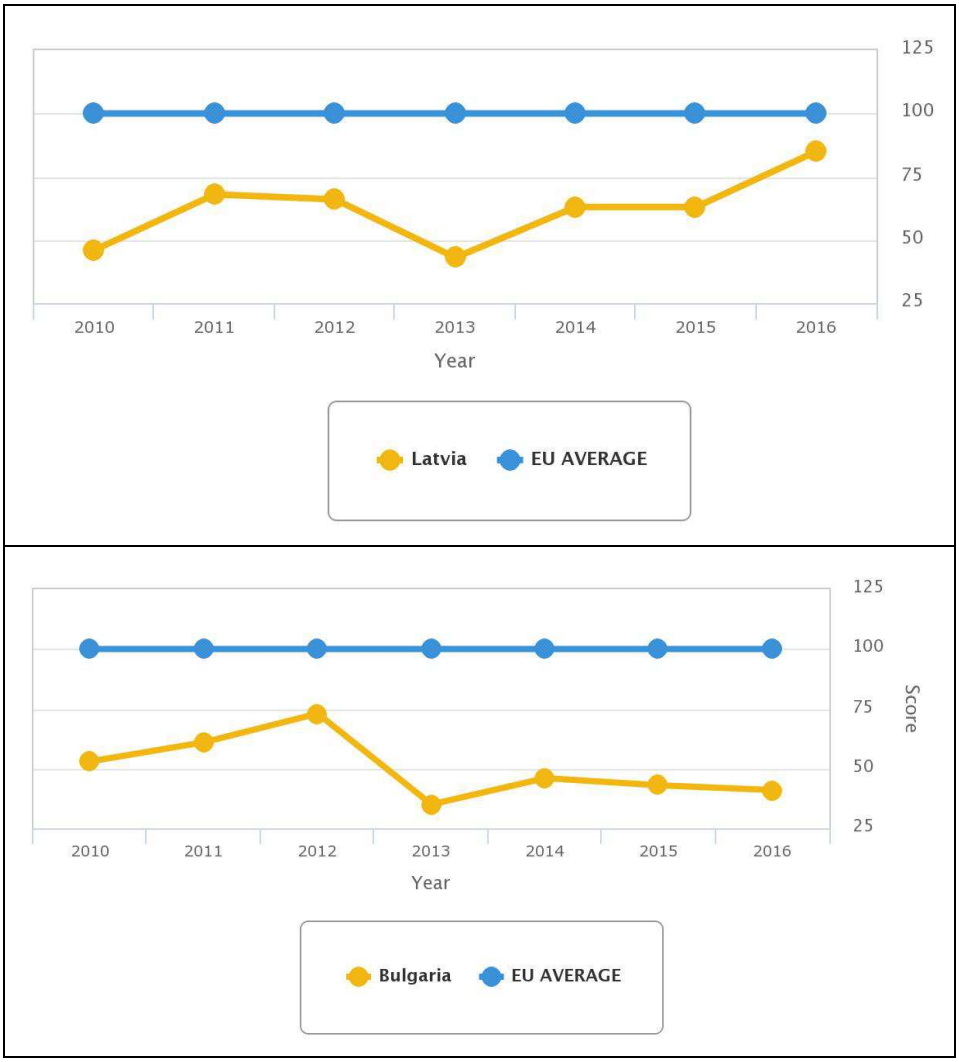


Fig. 5-8. Eco-innovation index trends (2010-2016) for leaders and laggards.

It should be noted that from 2013 onwards, the average used for indexing to 100 is calculated from the data for 28 EU Member States (after an accession of Croatia to the European Union). Units of the index are relative so it cannot indicate progress in absolute terms, however they give an overall view of Member State's positioning in eco-innovation performance against the European Union as a whole.

Fig. 9 presents a relationship between Gross Domestic Product in 2016 [21] for the individual country and its habitude to implement the innovations expressed by a number of the ecolabel licenses in 2017 [22]. It is clear that there is a direct coincidence of these parameters.

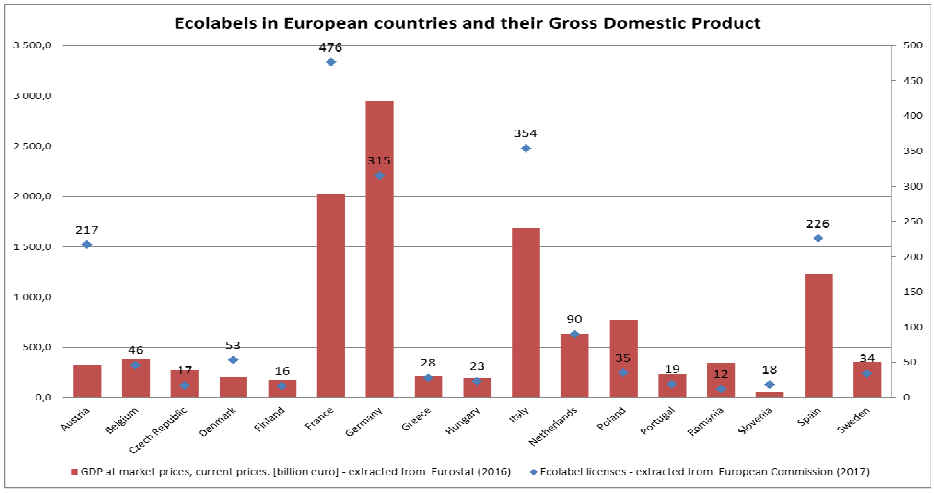


Fig. 9. Ecolabel licenses and GDP in chosen European countries

Almost in each country, one can observe that exists an impact of the investment in equipment and plant linked to cleaner technology [23] on the resource productivity [24], what can be observed in the fig. 10.

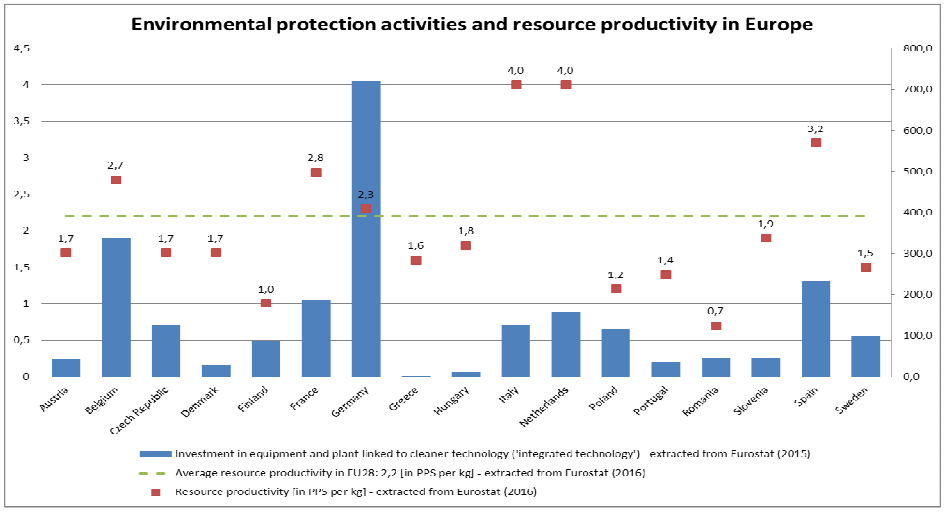


Fig. 10. Environmental protection and resource productivity in chosen European countries

Presented statistics show that European Union members are not homogeneous regarding an attitude towards sustainability. Wealth of particular country plays an important role in shaping eco-friendly actions. However, common policies should compensate the differences over time.

5. Conclusions

A preliminary observation of environmental protection activities in Europe brought a presumed relationship between a wealth and a propensity to behave in more ecological way in particular parts of the European Union. A relationship between Gross Domestic Product and a scale of the environmental actions was revealed in the study. Interesting study results, obtained by comparing a level of the resource productivity and a pursuit of investing in integrated and thus cleaner technologies in individual European countries, imply a need for promoting common European strategies based on the pursuit of reducing the environmental impact of the production systems. Unfortunately, so far there is no common European model of such behaviour. There are still significant differences in the economic level of particular member states. However, present and future policies created by the European Commission should take into consideration further strengthening the economic relationships, especially with less developed regions of the EU. This attitude enables for establishing a common policy of environmental protection and for an increase of the position of the European Union on the global market.

Nowadays, a concept of the ecological perspective in every human's activity gets more and more popular. People are starting to understand that their behaviour in terms of environmental protection is not insignificant. Conducted studies point out on a complexity of relationships between environmental actions and a variety of the economic indicators in the countries. A particular impact on the ecological behaviour has the Gross Domestic Product, whereas the environmental protection activities have an significant influence on the resource productivity on the other hand. It means that in rich countries usually there are more investments in pro-ecological production solutions what in turn influences on efficient use of the factors of production. Undoubtedly, the European Union plays a significant role in environmental protection. The impact is dual. First of all, it sets out strategies related to environmental protection. Secondly, it contributes to the economic growth of the member states. Each of these two paths leads to meeting needs of habitants while protecting natural resources.

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