The Wroclaw School of Banking
Research Journal
ISSN 1643-7772 I eISSN 2392-1153
Vol. 15 I No. 7
Zeszyty Naukowe Wyższej Szkoły
Bankowej we Wrocławiu
ISSN 1643-7772 I eISSN 2392-1153
R. 15 I Nr 7

Wyższa Szkoła Bankowa
we Wrocławiu

The Wroclaw School of Banking
RESEARCH
JOURNAL

# Eco-efficiency in creating the ecological safety

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**Abstract**

The issue of eco-efficiency is associated with actions aimed at increasing the productivity of raw materials, natural resources and energy savings in production and at the same time offering environmentally friendly products and services. This kind of action is beneficial to businesses and the environment, as well as the society. By reducing the pressure on the environment, caused by production processes, consumption and investment, it is possible to reduce impact of anthropological risks and simultaneously ensuring ecological safety. This article addresses the explanation of the possible connection of eco-efficiency and ecological safety. Considerations include the issue of terminology, as well as key elements of both concepts. The main thesis is: creating solutions for eco-efficiency is associated with ecological safety.

**Keywords:** environment, efficiency, eco-efficiency, ecological safety, mankind
**JEL:** O14, O44, Q52, Q54, Q56, Q57

**Historia:** otrzymano 2015.04.30, poprawiono 2015.07.17, zaakceptowano 2015.07.17

## The issue of efficiency in economic development

The concept of efficiency is a subject analyzed in multidimensional. This issue is taken up in the area of management. It is aimed to reduce all forms of waste and ensuring a degree of customer satisfaction. Simultaneously efficiency is an economic measure of the production efficiency, relating to the size of used resources to produce of it (Griffin 2004: 696). The most important objective is to achieve the maximum of utility, whose sources are the main factors of production: labour, capital as well as land and natural resources.

The first one corresponds to the increase in labor productivity, associated with the achievement of greater quantities of manufactured goods or services in a shorter period of time. OECD defined it "as a ratio of a volume measure of output to a volume measure of input use (OECD 2001: 11)". In turn, according to the Central Statistical Office of Poland, the term is explained as the size of production effects resulting from human labor per unit of labor, i.e., work spent on production in the enterprise (Central Statistical Office of Poland, http). According to Andreas Möller and Stefan Schaltegger "efficiency expresses a relationship between positive and negative effects of a decision (Möller, Schaltegger 2005: 78)", which can interact on different areas of human activity. For example, investments related to the implementation of modern technological solutions might result in limiting the number of persons employed in conjunction with an increase in machines productivity. This might lead in an unemployment increase, especially when there are a few enterprises on the local market. At the same time the enterprise can achieve a positive result connected with increase the production capacity and reduce the costs of employees' salaries.

In turn rising the efficiency of capital consists in shaping the return on equity (ROE). The higher the return of business activity, the more effective this activity is considered. However, in this area there is a moot point for which of the entity the rate of return is already satisfactory.

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This in turn depends on the properties of the capital and its owners, as well as administrators. For example, in banks, according to European Central Bank "although the "traditional" decomposition of the ROE measure (i.e., looking at banks' operational performance, risk profile and leverage) may have been useful to assess banks' performance during benign times, this approach has clearly not proven adequate in an environment of much higher volatility – such as during the global financial crisis, where ROE fluctuations have been caused entirely by operational performance, which does not aid our understanding of the potential trade-off between risk and return in performance (EBC 2010: 5)."
The last factor of production is land and natural resources. In this respect it is worth to refer to theory of environmental economics, particularly the concept of sustainable development. Sustainable development concerns intergenerational equity, emphasizing the requirement of meeting the needs of the present generation, without the possibilities for future generations to satisfy their needs (Our common future, http). Professor Tomasz Żylicz points at two terms of sustainability, which is the major controversy both in translation and explanation (Górka 2010: 17-19; Jeżowski 2007: 12-16). He points to the consideration in terms of a "strong" and weak "sustainability. The first one means "leaving the next generation at least the same capital, which has inherited from their ancestors." However, there are difficulties in restoring the same state of capital. That is the reason to compensate the loss of one capital by another (there are three types of capital: natural, man-made and human). But this solution is also controversial and no supplements incurred losses due to the use of one type of capital. "Weak" sustainability assumes compensation of one type of capital by increasing another type of capital (Żylicz 2014: 283, 286-288). Therefore, efficiency in the "strong" meaning of sustainability relates to minimize the use of capital-access. Whereas in the "weak" definition it should be emphasize increase of the productivity of capital in order to complement one another loss. Therefore, one can speak of a multiplication of the remaining capital to supplement the deficiency of another. In a similar way, the concept of eco-efficiency and its connotation regarding a "strong" or "weak" sustainability. However, in both cases it must be emphasized the role of environment to crate each type of capital.
Analyzing the issue of production processes inputs should be considered, which can have an impact, either positive or negative, on the environment and environmental efficiency (Graham 2004). To create environmental efficiency there is the need for another type of efficiency – technical. In this area Reinhard et al. (1999: 48) adopted the following definition: "environmental efficiency is the ratio of minimum feasible to observed use of an environmentally detrimental input , conditional on observed levels of the desirable output and the conventional inputs." The issue of environmental efficiency concerns the control of sources of environmental risks such as emissions of harmful substances by using technology (Song et al. 2014: 894). In literature the term "environmental impact efficiency" has been developed (Iribarren 2015: 707), pointing at qualitative and quantitative aspects of inputs and outputs in production processes and their impact on the environment. "Environmental impact efficiency" is a tool to measure the eco-efficiency by indicating the impact category (Lozano 2010: 1272-1274).

**Eco-efficiency**

Definitions of eco-efficiency indicate two elements: economic benefits and reduction of the unfavorable impact on the environment. According to Möller and Schaltegger (2005: 78) it is "the ratio, or a causal relationship, between economic value creation and environmental impact added." Others write about "a ratio between environmental impact and economic cost or value (Huppes, Ishikawa 2005: 43)" or increase economic benefits while also lowering ecological burdens (Levidow et al. 2014: 2113)."
In each of the listed definitions there are additional elements: values, costs, benefits, which we can consider in three areas, connected with concept of sustainable development (Figure 1).
In economy the role of limited costs in production and services obtained through increase of productivity and rational material use should be emphasized. Helpful in this respect are modern technologies. Their role is considered through Factor Five, which emphasizes, according to authors: "real potential to cost-effectively achieve 80 per cent, or fivefold, improvements in resource productivity across most of the major sectors of the economy – that is building, industry, agriculture and transport". Activities in these areas should be also pointed to the key eight strategies: energy efficiency, fuel switching, heat and power recovery, renewable energy, feedstock change, product change, materials efficiency, reducing non-CO2 greenhouse gases (Weizsäcker et al. 2009: 30, 36-37). Changes in mentioned

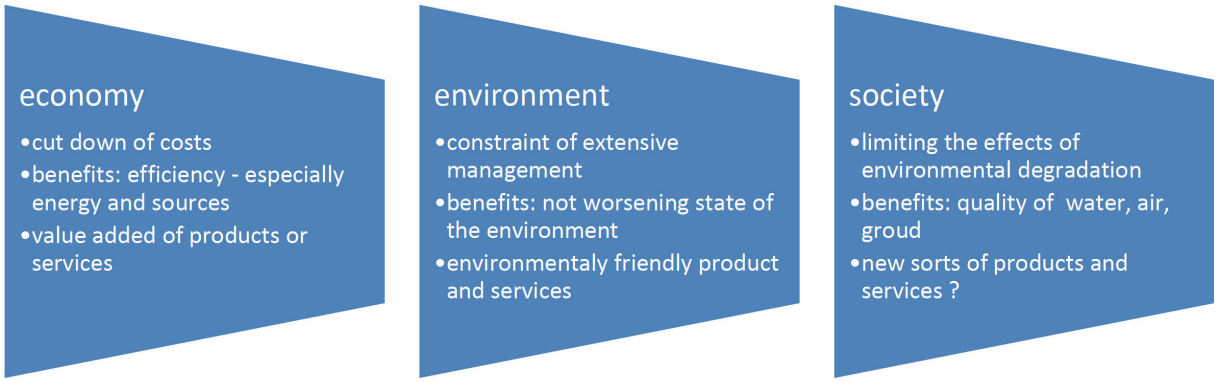



**Figure 1. The role of values, costs and benefits in elements of sustainable development**

Source: Author's own thoughts based on the three pillars of sustainability

sectors bring new products and services, not limited only to clean vehicles or green building. But high expenses associated with their implementation and long payback period present a significant barrier while different trade-offs may appear (Platje 2014; Will et al. 2015). However, at the same time, it becomes necessary to undertake the issue of structural changes due to the effects, for example caused by the last crisis in the economy (2008-2010). These include, for example, the industrial sector (Szyja 2014), and changes related to the opportunities that generate productivity growth in manufacturing processes by using environmentally friendly technological solutions (Edwards 2010) related to developing new types of energy and improving energy efficiency (Ptak 2014; Bartniczak 2014).

In turn, meaningful for the environment is the limitation of extensive management, which contributes to serious losses in terms of biodiversity, the level of non-renewable natural resources, limiting the capacity of the environment to absorb the waste of human activity (see Rockström 2009). None of the above statement is included in the national accounts as costs that affect the profitability of the business ventures. According to Adam Cygan: "economy is now facing the challenge of development of the theory based on the new paradigm, in which the ecological balance is a fundamental axiom, and economic and environmental factors are equally eligible (Dach 2004: 70)." There are opinions that the market should be a tool for the allocation of externalities, which would facilitate the rationalization of economic decisions (Dach 2004: 71). Taking such allocation conditions the market failures must be simultaneously taken into account. However according to Lee and Clark (2013: 287) "externalities, both positive and negative, are the most common explanation" for the last one (Lee, Clark 2013: 287).

Kapp pointed at the following social costs in areas of ecological problems: air pollution, water pollution, the depletion and destruction of natural resources, premature depletion of energy sources, soil erosion and the destruction of forests and other costs like: the cost of technical progress, unemployment, or transport (as the cost of lost opportunities). Kapp argues that these costs are mainly caused by private companies (Matczak 2000: 79, 85).

Some of the social costs are associated with effects of market or government failures, which in turn contributes to the deterioration of environmental quality. The last one, especially, when the government supports groups or privileged sectors, and does not account for the benefit for all. In this regard, experts suggest subsidies for most polluting enterprises. According to Bartosz Bartniczak, public aid can have a positive, negative or neutral impact on each of the following areas: economy, society and environment. Granted aid can affect directly one of the areas, but at the same time the impact may it have on other but the impact of this may have on other (Bartniczak 2011: 8-9). Main obstacles of environmental subsidies is to direct them to these companies –which are the perpetrators of negative externalities. Meanwhile, in accordance with the "polluter pays" principle, they should be required to reduce of harmful activities through financial instruments. Despite the subsidy, marginal social cost is higher than the marginal cost of private one before receiving the endowment (Kożuch 2010: 417, 419).

Economic benefits are primarily business profits from the sale of products and services. However, the increasing role of profits obtained through

savings in the production and provision of services. Their benchmark is to rise the productivity - energy, water, raw materials, natural resources. Increasing productivity contributes to lower operating costs. Conservation can become a means for investments. It should also point out the positive externalities. The latter may have a dimension of both direct and indirect on society. Directly may involve job creation as a result of investment, and indirect by reduction the environmental burden, which help to improve quality of living.

Taking into account the extensive practices of economic activities, benefits for the environment can be examined by not worsening state of the environment. Such opinions are justified inter alia by studies indicating ecological footprint and its connection to countries' economic growth (Al-mulali 2015). Social benefits are associated with non-deterioration and improving the quality of water, air, soil. Both the benefits and the costs resulting from production processes, consumption or investment affect as well the environment as humans, direct and indirect (*picture 1*).

Simultaneously environmental friendly activities in economy sector contributes to the added value for both society and the environment, and they are identical – new sorts of products and services. But for the environment, this value is only a reduction of burden of goods this kind, in comparison with traditional non-environmental. And therefore there may be concerns about whether they actually add value. Indeed, the latter must be a significant advantage. Reduction of nuisance levels of human activity does not constitute such. This means maintaining the quality of the environment at the same level, but do not improve the quality of it.

The term of eco-efficiency term can be analyzed taking into account the subject criterion:

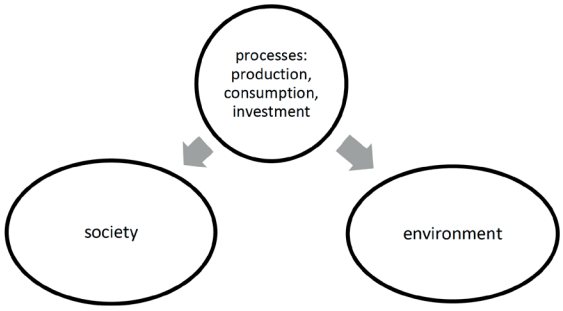
- production processes
- product (Möller, Schaltegger, include products and services to this category) (Möller, Schaltegger 2005:77),
- services,
- trade.

It is essential for creating socio-economic development to added value, which can be production, technology, product or service innovation. Such innovations form eco-efficient solutions in all mentioned area. However they need to comply with three requirements at the same time: performance in terms of efficiency, added environmental friendly value, less nuisance to the environment. In other words, these three elements are needed to shape the eco-efficiency (*picture 2*).

The first one we can define and measure, f.ex. labour productivity, as indicated by the equation:

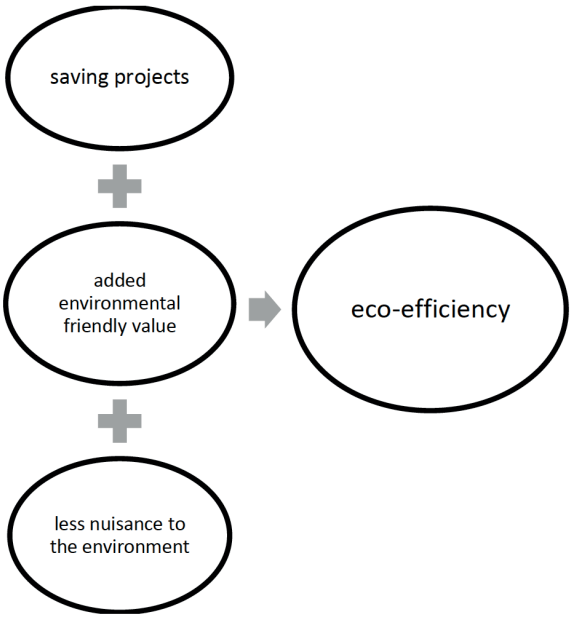
Labour productivity = volume measure of output / measure of input use

Therefore, measurement includes the effects of work and expenditures (OECD 2008: 5). Both in one and the last may cause costs, that arise




**Picture 1. The scope of the impact of production, consumption and investment processes**

Source: Author's own elaboration




**Picture 2. Elements of eco-efficiency**

Source: Author's own elaboration

**Table 1. Factors of production in comparison with efficiency and eco-efficiency**

| Factors of production | Efficiency | Eco-efficiency |
|---|---|---|
| labour | work productivity | work environmentally friendly productivity |
| capital | Profitability | profitability |
| ground and natural resources | increase of crop productivity per hectare | reasonable use reduce wastage |
| technology | increase of production processes | energy and resource efficiency |

Source: Author's own

during the performance of work. However, costs may also arise before and after work. In the first case may relate to labor, employment and other effects to the environment as a result of the so--called externalities. In this matter it is essential to reduce of them to make processes more efficient and environmentally friendly.

Gjalt Huppes and Masanobu Ishikawa suggests the choice between: environmental intensity and environmental productivity in the realm of value creation, and environmental improvement cost and environmental cost-effectiveness in the realm of environmental improvement measures (Huppes, Ishikawa 2005: 43). The issue of eco--efficiency can be interpreted taking into account factors of production (*Table 1*)

According to United Nations Conference on Trade and Development: "eco-efficient strategies reduce the damage caused to the environment while increasing or at least not decreasing (shareholder) value" (UNCTAD 2004: 1). In this sense there are two key elements – environment and business. For the first one there is a need to secure the quality, and for the second ensuring the ability to generate profits without simultaneously reduce production capacity or sales. In this range of issue it is pointed to (UNCTAD 2004: 8-9):

- provide information on the environmental performance of an enterprise with respect to its financial performance,
- improving the decision-making process,
- forecast the impact of current and upcoming environmental issues on future financial performance.

"Information about environmental performance vis-à-vis financial performance is useful in determining the ability of an enterprise to adapt to changes in the environment in which it operates".

The information necessary in the process of deciding concern the determination of indicators in the areas (UNCTAD 2004):

- water use,
- energy use,
- global warming contribution,
- ozone depleting substances,
- waste.

The majority of them can be analyze by some statistical dates shared inter alia EUROSTAT, European Environment Agency, Central Statistical Office of Poland (*Table 2*).

**Table 2. Examples of indicators according to areas of eco-efficiency study**

| Areas | Indicator | Poland (2012) |
|---|---|---|
| water use | Production purposes | 7697,1 hm3 |
| energy use | Energy use in industry and construction industry | 45806 GWh |
| global warming contribution | Emission of carbon dioxide (CO2) from the plants especially noxious | 214887106 tonne per year |
| ozone depleting substances | *Halogen-derived hydrocarbons:* CFC-11, CFC-12, CFC-13, CFC-111, CFC-112, CFC-113, CFC-114, CFC-115, CFC-211, CFC-212, CFC-213, CFC-214, CFC-215, CFC-216, CFC-217 from the plants especially noxious | 14 tonnes |
| waste | Waste generated during the year according to the polish classification of activities in 2012 | 123123,5 thous. tonnes |

Source: Central Statistical Office of Poland (2013a: 151, 242); Central Statistical Office of Poland (2013: 14); Strateg, http://strateg.stat.gov.pl/Home/Strateg

## The ecological safety and the role of eco-efficiency

A human being impacts on environment as a result of production and consumption processes. Especially "industrial production has generated a huge amount of poisonous substances in various forms. These substances severely affect the global climate and destroy people's living conditions and natural ecological environment" (Chen, Song, Xu 2015: 577). Anthropogenic contribution to reducing environment is indisputable, hence the need to intensify efforts towards environmental protection. In the 70's and 80's of the last century, the issue was further supported by the development of concepts involving the need for sustainability based on the three capitals: natural, man-made and human (Żylicz 2014: 281).

The last, the issue of the environment is taken into account in the consideration of national security, through the concept of ecological safety. According to J. W. Przybytniowski the most frequently used definition reads: "ecological safety should be understood as a relative public safety free from environmental hazards, caused by human factor as a result of physical processes or due to negligence, accident, mismanagement or design, which comes from home or abroad" (Przybytniowski 2014: 1026). In the opinion of Author the concept of ecological safety particularly stresses the aspect of human impact on the environment and the consequences associated with it. At the same time, however, it takes into account the impact of environmental degradation on mankind. This justifies the functioning of the two terms that are mistakenly considered to be identical: ecological safety, environmental security (safety). Another obstacle in terms of terminology is associated with the English terms used interchangeably: security and safety. The first refers to the creation of the security system and the other to the state. Essential for the analysis of ecological safety is a matter of diagnosing threats, their sources and response.

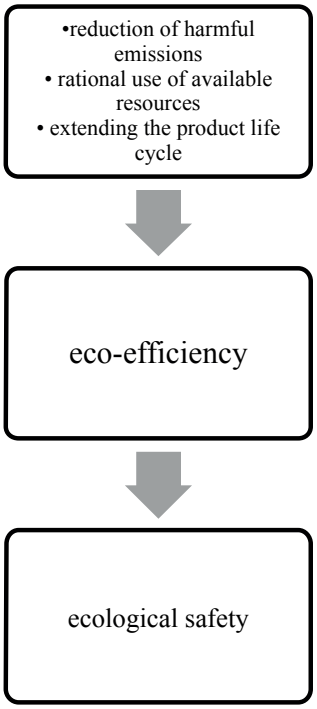
However, first it should be determine the issue of the ecological safety against another - environment. According to Anna Surówka environmental protection acts as subordinate to ecological safety: "ecological safety is first and foremost pursuit to create an environment of human existence free from threats, that could adversely affect their health or endanger his life. Environmental protection is thus one of the forms to ensure the safety ecological, which focuses on prevention of the degradation environment and the changes, which would adversely affect human health" (Surówka 2012: 154-155).

The sources of threats are anthropological or natural. First one cover inter alia: emission of harmful substances (f.ex. emission of carbon dioxide), technical disasters (Chernobyl), extensive production processes (f.ex. extraction of oil not obeying the rules of environmental protection), damage to the environment as a result of the war (f.ex. burning oil wells in the Gulf Persian in 1991). The second include natural disasters (f.ex. droughts, tsunamis). The complexity of these sources and their actual effects require a multifaceted approach. Each of them causes serious environmental damage, as well as social and economic costs. All cause losses. Some of them may be settled in accounting terms, especially those associated with economic activities such as the destruction of the production hall by floods. However, they require the expenditure related to the liquidation of damages. The same applies to environmental damage, provides the possibility of renewing the environmental values. This is possible only with respect to those that a man can reconstruct, f.ex. planting trees, it has already been cut. Social harm, if they relate to human health and life, are often not possible to reverse. To limit the negative effects of the hazards, it is necessary to constrain their consequences and create the possibilities of preventing their occurrence. As far as there are serious difficulties in terms of predictability of natural disasters, is greater possibility to predict the hazards and their effects, which occur with respect to the anthropological risks. Especially in the latter case it should be pointed to the relevant activities for the reduction of human pressure on the environment. They can be traced to:

- a reduction of harmful emissions originated as a result of production, consumption, and investment processes,
- rational use of available resources,
- extending the product life cycle.

Introduce measures in these areas, through training in the field of eco-efficiency is one of the possible ways to reduce the risks caused by human activity, primarily in the economic sphere (*scheme 2*.)

Discussed earlier economical, environmental and social costs related to the implementation of the principles of sustainable development constitute barriers to creating of ecological safety. In turn benefits facilitate forming conditions of it. First, we can estimate, based on the data on f.ex. carbon dioxide emissions in key




**Scheme 2. Connection of the eco-efficiency with the creation of environmental safety**

Source: Author's own elaboration.

industrial sectors, productivity use of raw materials. On this basis, it is possible to make rational decisions on increasing the profitability of the business. Provided, however, incorporating of them to the national accounts. At the same time, this issue may be one of these arguments to novel reason for which the issue of ecological safety does not play a major role in terms of sectoral approaches to the national security. It is also important to take into account the environmental costs in calculating the efficiency of economic activity. Thus summarizing, the development of ecological safety is dependent on the classification of costs in the accounts at the level of enterprises and countries. At the same time it is necessary to verify expenditures on counteracting the effects of the hazards. For example, it is necessary to make the calculation of profitability pre-empt potential risks (f.ex. by shaping eco- efficiency) and expenses incurred in connection with the occurrence of them (Szyja 2014: 433-438). However, because of the likelihood of risk and its scope should take actions in reducing their effects, especially those whose source is human activity.

And in this matter, it is essential to reduce the achievement of this goal at the enterprise's level through the use of eco-efficient solutions in production processes, product, services and trade.

## Concluding remarks

The efficiency is aimed to reduce all forms of waste and ensuring a degree of customer satisfaction. In this area it focuses on the rational management of the company. At the same time, however, the issue is related to the economy in terms of increasing the productivity and reduce the cost of business. In some area efficiency brings positive results, especially in terms of mobilizing of the technological progress, which help to achieve the target: produce faster and more while reducing costs. However, in some sectors of the economy, this can be fatal.

The issue of efficiency as well refers to the key category of capital: natural, man-made and human in connection to the sustainable development. It should be emphasized the operation of two terms: environmental efficiency and eco--efficiency. The first one is narrower and forms the basis for determining the second. The role of eco-efficiency can be analyzed through the prism of the costs, benefits and added value for economy, environment and society. Each of these categories has an impact on the three elements of the sustainable development concept. At the same time the term of eco-efficiency should be identify through three related components: saving, environmental friendly added

value, less nuisance for the environment. Their inclusion is crucial to reduce the environmental risks caused by anthropological factors, especially: a reduction of harmful emissions originated as a result of production, consumption, and investment processes, rational use of available resources, extending the product life cycle. Taking action in selected areas there is essential for ecological safety. It is important to point to, that reducing natural factors of the risk for ecological safety is lower than in the case civilization ones due to the likelihood of these former. It is therefore important to implement mainly solutions to reduce human impact on the environment. Examples in this matter are practices related with the eco-efficient projects.

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**Rola ekowydajności w zakresie kształtowania bezpieczeństwa ekologicznego**

**Abstrakt**

Kwestia ekowydajności jest związana z działaniami ukierunkowanymi na zwiększenie produktywności surowców, zasobów naturalnych i oszczędności energii w produkcji i jednocześnie oferowania produktów i usług przyjaznych dla środowiska naturalnego. Tego rodzaju działania przynoszą korzyści przedsiębiorstwom i środowisku, a także społeczeństwu. Poprzez zmniejszenie presji procesów produkcyjnych, konsumpcyjnych i inwestycyjnych na środowisko naturalne możliwe staje się zmniejszenie prawdopodobieństwa wystąpienia zagrożeń antropologicznych i oddziaływania tym samym na zapewnienie bezpieczeństwa ekologicznego.

Artykuł podejmuje kwestie wyjaśnienia możliwych powiązań ekowydajności i zapewnienia bezpieczeństwa ekologicznego. Rozważania obejmują zagadnienia terminologiczne, a także elementów kluczowych obu pojęć.

Teza opracowania brzmi: tworzenie rozwiązań w zakresie ekowydajności służy kształtowaniu bezpieczeństwa ekologicznego.

**Słowa kluczowe:** środowisko, wydajność, ekowydajność, bezpieczeństwo ekologiczne, ludzkość
**JEL:** O14, O44, Q52, Q54, Q56, Q57