

## INNOVATION AS A DETERMINANT OF CURRENT ECOLOGY

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**Purpose:** authors based on trends, goals, theses and examples of good practices presented in the article focus – both in theoretical and practical dimensions – on striving to identify need to develop eco-innovation as an element strengthening environmental policy in global, regional and national dimension.

**Design/methodology/approach:** theses presented in the article have been verified using the following methods: literature review, critical literature analysis, document and comparative analysis, and examples of good practice.

**Findings:** innovations in the field of ecology focus in particular on human activities in two areas. The first is use of existing living and inanimate natural resources resulting from need to maintain life expectancy. In the second area, focus on its protection and care for its duration. Therefore, it should be emphasized that associating innovations with them is extremely important in modern ecology. Striving to create new eco-friendly solutions of an eco-innovative nature both in the sphere of its social acceptance and in utilitarian dimension.

**Originality/value:** the article enriches, and at the same time develops, knowledge and discussion in the field of defining eco-innovations – and their impact on the lives of communities and individuals. Thanks to knowledge presented in the article, the need to look for solutions that can strengthen the impact of eco-innovation on the natural environment is clearly justified.

**Keywords:** innovation, eco-innovation, current ecology.

**Category of the paper:** Conceptual paper, Case study.

### 1. Introduction

The modern world determined in its development by globalization and, developing its social and economic structure, Industrial Revolution 4.0 notes existential threats in area of natural environment with increasing intensity. It relates in particular to right to life – which,

as Krajewski writes – is realized in environment and through environment. The indicated dependence is conditioned essentially by human – as far as a human being from necessity of his life explores and uses them (Krajewski, 2015, pp. 9-24). This state implies need to increase knowledge about state of environment and possibilities of using its resources. These goals include eco-innovations, which are implemented within framework of global ecological policy, as a particle of innovation corresponding to area of natural environment surrounding man. The importance and relevance of eco-innovation are emphasized by numerous strategies and documents with a global, regional and national dimension – indicating the need for radical protection of the natural environment. The indicated goal is particularly emphasized by the United Nations in the report "A healthy planet, healthy people" (Global forecasts..., 2019). In the report, its authors believe that environmental degradation caused by human activity is progressing so quickly that it may soon threaten foundations of our existence. They emphasize role of decision makers at all levels who must urgently take global action to avoid a catastrophe, or at least, to mitigate its effects. First of all – as authors of the report note – one should strive to reduce CO<sub>2</sub> emissions as well as reduce air and water pollution. The report identifies global threats – a counteraction that is necessary. They include:

- air pollution, which can cause between 6 and 7 million premature deaths by 2050,
- species extinction. It is currently threatened with extinction 42% of terrestrial, 34% of freshwater and 25% of marine invertebrates,
- climate change,
- soil degradation,
- pressure on terrestrial and marine ecosystems,
- urbanization,
- waste of food and natural resources,
- presence of contaminants in freshwater systems,
- increasing population growth.

In one of its many conclusions, UN experts state that ensuring a dignified life and well-being for nearly 10 billion people by 2050 without compromising our planet's ecological limits, it will be one of the most serious challenges and responsibilities humanity has ever faced.

In the European Union, on the other hand, document that best reflects need for environmental protection is "The Seventh General EU Environmental Action Program until 2020 – good quality of life, taking into account the limitations of our planet". The authors of the document set nine key priorities and actions for the EU in the 2020 perspective, which are (<https://ec.europa...>, 2019):

- protection, preservation and improvement of the Union's natural capital,
- transforming Union into a resource-efficient, green and competitive low-carbon economy,

- protecting Union citizens against environmental problems and threats to their health and well-being,
- maximizing benefits of Union environmental legislation by better implementing it,
- improving knowledge and evidence base of EU environmental policy,
- securing investments for environmental and climate policy and taking into account ecological costs of all social activities,
- greater consideration of environmental issues and greater policy coherence,
- supporting sustainable nature of urban development in Union,
- increasing Union's effectiveness in addressing international challenges in environment and climate.

Assuming that the above priorities will be achieved, EU vision in 2050 is as follows. Citizens enjoy a good quality of life, taking into account ecological limitations of the planet. Prosperity and healthy environment result from an innovative, circular economy where nothing is wasted, natural resources are managed in a sustainable way, and biodiversity is protected, valued and restored in a way that increases society's resilience. Low-carbon economic growth affects consumption of resources, setting the direction for the development of a secure and sustainable global society.

In Poland, environmental policy is fully applicable in Resolution No. 67 of the Council of Ministers of July 16, 2019 on the adoption of the "State Environmental Policy 2030 – Development Strategy in the Area of Environment and Water Management" (Government Monitor..., 2019). The resolution stated, among others, that building an innovative economy while maintaining the principles of sustainable development is a requirement of modern state policy. Sustainable development means stable economic growth associated with rational management of environmental resources and respect for human rights. It is man who is supreme value in State Energy Policy until 2030 by focusing on thematic quality of life, health and well-being of Poles, while ensuring environmental protection, maintaining biodiversity and other forms of animate and inanimate matter. The role of ecological policy is therefore to ensure ecological security of state. Eco-innovations play a particularly important role in stimulating the transition to a circular economy, preventing climate change, protecting air quality, loss of biodiversity or sustainable use of water resources and ensuring their good quality. At the same time, its contribute to increasing competitiveness and economic development as well as strengthening economy's resistance to environmental pressures, improving efficiency of natural resources use and reducing negative impact of human activities on environment. Changing production and consumption modes for more energy-efficient adaptation to climate change and transforming waste into high value-added products will require new technologies, processes and services.

Based on the above provisions, trends, goals and theses in this article, authors, both in theoretical and practical dimension, strive to identify need to develop eco-innovation as an element strengthening global environmental policy, regional and national. In this context, it is worth recalling that ecology, in basic meaning, is study of relationship of organisms with environment in which they live, and relationship between the organisms themselves<sup>1</sup>.

## 2. Innovations – theoretical aspect

The term innovation comes from the Latin word *innovatis*, which means creating something new. It appeared around 400 A.D. in Latin church as *innovatio*, meaning renewal – change (Dictionary of Foreign Words, 1980, p. 307). In the 13th century this concept was used in Italian by Machiavelli (*innovatore*). The starting point for considering the importance of innovation in modern economy is definition proposed by J.A. Schumpeter. He defined innovation through prism of specific situations, among which he distinguished (Schumpeter, 1960): introduction of a new product that consumers have not yet dealt with, or adding new features to product; introduction of a new production method not yet tried out in a given industry; opening a new market, i.e. one in which a given type of domestic industry did not previously operate, regardless of whether market existed before or not; acquiring a new source of raw materials or semi-finished products, regardless of whether this source already existed or had to be created; introducing a new organization structure for some industry, e.g. creating a monopoly or breaking it. Innovations are also defined in theory of economics. In this approach, four types of innovation are distinguished (Stawasz, 1999):

- product innovations – they consist in improving product already manufactured in enterprise,
- process (technological) innovations – changing production methods (or providing services). It can be based on changes in equipment or organizational production sphere,
- organizational innovations – understood as introduction of a new organization method in the field of business practices or external relations of company,
- marketing innovations usually associated with a change in marketing strategy include changes in pricing policy, appearance, packaging, promotion or positioning of product and is based on the perception of the product (service) as new, even if from technological point of view it has not changed significantly.

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<sup>1</sup> The word "ecology" is a combination of two Greek words: *oikos* (farm, home, residence) and *logos* (word, science). It was first used in 1873 by Ernest Haeckel to denote part of biology that deals with relationships between organisms and environment. See Dictionary of Contemporary Terms, edited by A. Bullock et al., Katowice 1999, p. 130.

Innovations are also defined in terms of its impact area, and are divided into: global innovations, regional innovations, local innovations, innovations at industry level, and innovations at enterprise level. In turn, due to the importance of new products, we can distinguish the following two types of innovations: jumping (inventing the light bulb) and linear (subsequent generations of televisions). From the point of view of changes caused by the following innovations are known (Bryx, 2014, pp. 35-36):

- radical (new: products, technologies or business management method),
- recombination (using existing technological, production and organizational solutions to create new products, technologies or management systems),
- modification (they consist of minor changes in existing products, technologies and management systems to improve them).

Anticipating Schumpeter's thoughts, it should be noted that innovation means introducing a new solution to practice. The subject of his considerations are primarily technical innovations and its impact on the economy. Any dissemination of innovation is a separate type of change, known as imitation (Bryx, 2014).

According to K. Koziół-Nadolna, according to the latest theories, innovations are the result of numerous complex interactions between individuals, organizations and environment, in which these units and organizations operate. The development of theory of innovation and innovation processes indicates a further evolution of these phenomena together with progressing processes in modern economy, which will result in the creation of more complex and reality-matching models of innovation process. One of them is open approach (open innovation, open invention), which is based on various concepts and theories (Koziół-Nadolna, 2012, pp. 295-303), which was described and developed by H.W. Chesbrough (Chesbrough, 2003). His approach says that in a world of widely disseminated knowledge, companies cannot rely solely on their own research, but should purchase patents or licenses for inventions and other innovative solutions from other companies. In addition, companies should share their inventions, which they do not use, to other entities on basis of selling licenses, creating consortia or more and more popular spin-off companies in Poland. The message of open model is based on the following view – since it is impossible to stop changes on market, you need to learn to profit from it (Sieniawska, 2010).

In turn, in the context of a closed approach to innovation, it is worth noting that it has been characterized according to several of the following principles (Sieniawska, 2010):

- company employs the best employees, the most intelligent people in sector, employees themselves come up with and develop ideas for new products or services,
- enterprise inventing innovations by itself will achieve effect of priority on market, company that first introduces product to market, usually wins,

- company will allocate the most investment funds for research and development (further referred to as R&D – Research and Development) in sector, which will result in the largest number of best ideas, which in turn will lead to position of market leader,
- organization must have control over intellectual property so that competitors do not profit from their ideas.

In the field of economics, another proposal for definition of innovation was proposed by Philip Kotler, who stated that innovation is all seen as new (Kotler, 1994, p. 322). The concept of his authorship was extended by Peter F. Drucker, noting that innovation is a conscious and beneficial change resulting from the needs or systematic observation of environment (Drucker, 1992, pp. 40-45). In this light, innovation can be determined by human activity, which must lead to something new. On the basis of this principle, it can be assumed that one of the most common is the definition according to which "innovation is the process of transforming existing possibilities into new ideas and introducing them into practical application" (Okoń-Horodyńska, 2013, p. 9). In Poland, the word innovation means "the introduction of something new, a newly introduced thing, novelty, reform" (Dictionary of foreign words, 1980, p. 307). Thus, innovative activity consists of all scientific, technical, organizational, financial and commercial activities that actually lead or are to lead to implementation of new words (Dictionary of foreign words, 1980, p. 307; Report on..., 2000).

### **3. Eco-innovations – an attempt to define**

Eco-innovation is a manifestation of economy based on determined knowledge in its development Industrial Revolution 4.0. It notices, among others Dolińska, writing that changes taking place on a global economy scale point to its evolution towards a knowledge-based economy in which knowledge is constantly developed and its practical use in innovations (knowledge products) implemented in the organization's activities and in markets (Dolińska, 2009, pp. 53-54). In this light, when looking for an explanation of term eco-innovations, it is worth emphasizing that one of its first definitions was given by M. Carley and P. Spapens, who defined the eco-innovations as "intended conduct characterized by entrepreneurship, covering product design stage and integrated management during its life cycle, which contributes to pro-ecological modernization of industrial age societies by taking into account ecological problems in development of products and related processes" (Carley et al., 2000, p. 159). In their perception, eco-innovations determine integrated solutions that reduce resources and energy expenditure, while increasing the quality of products or services.

In other terms, ecological innovation is creation of new and affordable competitive goods, processes, systems, services and procedures that meet human needs and increase quality of life – while minimizing exploitation of natural resources over their life cycle (materials, including

energy and surface area) per product unit and minimum emission of toxic substances (Stępnia-Kucharska, 2012, pp. 293-319). In turn, reaching for definition developed by the Central Statistical Office, eco-innovations are considered to be a new or significantly improved product (product or service), process, marketing or organizational method that brings benefits to environment compared to alternative solutions (Oslo Manual, 2005). The Organization for Economic Cooperation and Development, on the other hand, emphasizes that the term innovation fully fits into the concept of eco-innovation, but only if it is extended by two areas of influence. The first is an innovation that reflects concept of a clear focus on reducing environmental impact when such an effect may or may not occur. In the second approach, it includes innovations in social and institutional structures (Michalski, pp. 1-22).

Eco-innovations also have their own and unique typology. In the literature, term eco-innovations is classified according to the following types (Eco-innovation, 2019):

- resource stream innovations,
- eco-innovation products and processes,
- organizational eco-innovations,
- marketing eco-innovations,
- eco-innovations with a social dimension.

Each type of eco-innovation is different and has distinctive features. Ecological innovation of resource stream mainly focuses on material and energy flows that take place in the product life cycle, and their goal is to reduce material, water and energy consumption of processes related to product design, services, development, implementation and development of products related to him. At the same time, reduction of absorbency towards resources should simultaneously stimulate improvement of life quality. The indirect goal of this type of innovation is to determine changes at mental and behavioral level, consisting in transition of society from model of excessive consumption, which generates too much burden on environment by, among others, excessive waste towards closed circulation of matter, elimination of waste and reduction of overall material consumption (Prystrom, 2013, pp. 81-90). In turn, eco-innovation products are associated with launch of products or services on market that were determined at design stage by the direction of impact, which is maximum reduction of the negative impact of product/service on environment (e.g. passive residential buildings). However, the characteristic features of eco-innovation processes are the lowest risk and the largest savings in financial terms. This type of eco-innovation is characterized by a process of reducing material, water and energy consumption in production process and at distribution stage. It is worth noting that eco-innovation processes in different sources are defined differently, e.g. cleaner technology, zero emissions, material efficiency, zero waste. The indicated terminology is shaped by strategic goals of an innovation-oriented enterprise, elimination of ecological threats, increasing productivity of used resources, acquiring new sources of raw materials and its effective use, creating modern technologies with high efficiency and developing new materials with high quality features such as strength, flexibility, reliability

(Karlikowska, 2013, pp. 87-90). Organizational eco-innovations are another type. They consist in introducing new management methods, systemic solutions such as certified management systems according to ISO 14000 or EMAS standards, or systemic tools such as LCA – life cycle analysis, as well as introducing solutions on a wider, sectoral scale, e.g. business networks, clusters, cooperation platforms. This type of eco-innovation is characterized by a socio-economic dimension due to its links with organizational learning processes. In this light, it is worth noting that implementation of system environmental management has essential importance for creating a value chain in enterprise, because it integrates aspects of environmental protection in every decision-making process, starting from product design, through marketing action plan, delivery concept and logistics to sales system (Chrzanowski, 2015, pp. 68-92). The briefest definition has marketing eco-innovations that focus on areas related to product packaging, product placement, promotion, price policy. The last of the described types of eco-innovations focuses on social issues. Is defined as new solutions to social problems, more effective, efficient and more durable than previously used, whose values benefit entire community, not just an individual. In this context, two main features of social innovation are noted in the literature. The first feature is their goal, which is to create social change and added value for society, not commercial innovation and profit. In turn, the twitching feature is participants of eco-innovation process, which are not only enterprises but also public institutions and non-governmental organizations (Nowakowska, 2011).

In view of the above theses, definitions and goals related to eco-innovation, it is worth emphasizing that they are a special area of interest of European Union recognized as the "key" to its competitiveness and innovation. In this context, eco-innovation is any innovation that leads to achievement of sustainable development by reducing negative impact of production activities on environment, increasing the nature's resistance to load or ensuring greater efficiency and responsibility in natural resources use. In other terms, eco-innovation is defined by its application. This definition is dominated by eco-innovation conducive to development of new processes, technologies and services, thanks to which enterprises become more environmentally friendly, facilitating the optimization of the potential for economic growth, while at the same time enabling to take on challenges such as climate change, scarcity of natural resources and biodiversity loss. When the development opportunities factor is taken into account, eco-innovations are the main development determinant of enterprises. Their use implies reducing costs of doing business, allows to take advantage of new development opportunities and positively shapes company's image. The above theses and directions of perception of eco-innovation in EU determine need to accelerate process of practical implementation of good ideas in the field of eco-innovation as well as industrial development, eliminating economic and legal barriers, as well as promoting investment and stimulating demand and disseminating knowledge in this field (Eco-innovations..., 2019).



Contrary to the theoretical utilitarian approach, term eco-innovations refers to all forms of innovation – technical and non-technical – which create opportunities for enterprises and bring benefits by preventing or reducing negative impacts on environment, or by optimizing use of resources. Eco-innovations are closely linked to way we use natural resources and how we produce and consume, as well as concepts of eco-efficiency and eco-industry. They favor transition of production enterprises from "end of pipe" technology to "closed circulation" solutions that minimize flow of materials and energy by changing products and production methods, bringing a competitive advantage to many enterprises and sectors (Eco-innovations..., 2019).

Due to reference of eco-innovative characteristics to other types of innovations, it is worth noting that they are equally complex and multidimensional. Considering this type of approach to eco-innovation shows that they are more than just an instrument for implementing sustainable development.

#### **4. Information as the basic factor shaping eco-innovation functionality**

In modern managed enterprises, information is considered as fourth factor of production next to land, labour and capital. In a different approach, information is treated as third, next to energy and matter, fundamental quantity with a decisive impact on society, on forms of its cohabitation and cooperation (Ansoff, 1985, p. 28). Referring indicated regularities to eco-innovation issues, it seems that a properly shaped system of obtaining and transmitting information about eco-innovation and its surroundings will create a kind of mechanism of coexistence and relations between these areas. It seems that looking at the processes caused by eco-innovations in surroundings only from position of obtaining and transmitting information is far from sufficient. This position mainly determines environment in which changes are taking place today which are important for organizations functioning, especially economic ones. Their impact is not due to fact that they occur quickly and are hardly predictable or unpredictable. These include (Ansoff, 1985, p. 28):

- globalization processes and, consequently, need for enterprises to operate on international market,
- intensification of competition (also in an international context), leading to a focus on customer needs and relationship: results – outlays,
- disappearance of many existing markets and creation of new ones,
- emergence of new organizational forms, which are a consequence of, among others functioning of enterprises as a network, numerous mergers and alliances, which results in organizing work in form of multi-task teams, bringing together people with

interdisciplinary knowledge and skills, independent and creative people, and also leads to decentralization and flattening of organizational structures,

- fast pace of development and implementation of new technologies and operating techniques, which results in increasingly shorter product implementation cycles and short life cycles,
- activity of individual stakeholders groups of striving to meet their needs.

The changes take place in all aspects of eco-related activities, occurring in civilizational, cultural and socio-economic area. The increase in its novelty and speed, as well as the increase in intensity and complexity of environment means that it is referred to as turbulent (Ansoff, 1985, p. 28). It is also becoming more extensive, diverse, unstable and comprehensive (Bolesta-Kukułka, 1993, p. 174). Assuming that decision-making processes are shaped by dynamic – even "turbulent" – environment, coexistence mechanism should fit into dimensions indicated and make relations between eco-innovation and its environment dependent on these dimensions.

In this context, question arises as to what information should be essential content shaping the indicated mechanism? It seems that factors determining the ability of eco-innovation to shape the indicated mechanisms - characteristic of creative thinking about indicated relationship – will be:

- an appropriate level of information aggregation in line with existing relationships between eco-innovation and its environment,
- an appropriate level of information aggregation in line with expectations of environment,
- ensuring by information increased knowledge in eco-innovation,
- ensuring through information that eco-innovation can effectively respond to challenges it faces.

In the light of theoretical considerations on meaning of information, ensuring its expected quality is only part of a broader process shaping mechanism under discussion. The information obtained should have a deeper meaning in the decision-making process, especially in the context of accuracy of the described (diagnosed) phenomena and processes related to eco-innovation. It is equally important to give acquired information importance of effective use in achieving utilitarian goals. Acquired, collected, ordered and aggregated information should guarantee its practical application. Allow identification and analysis of trends, forces, events and phenomena that may be fundamental importance for building and functioning of coexistence mechanism and occurring between eco-innovation and its environment (Majerska, 2015, pp. 26-38). This function seems to be considered a key challenge.

In the light of the above theses, it is worth noting that, as shown by numerous scientific studies – as well as practical experience – it is now recognized that key capital of an organization is knowledge and its skills, primarily ability to respond to changes in surroundings. Bartlett and Ghoshal even state that in today's highly a competitive, driven by

new technologies, world unique potential, which is a key barrier to development and achievement of strategic goals of companies and organizations is the lack of specialized knowledge and experience that responds to changing surroundings and potential in area of organization and management, which creates basis for their use in implementation company goals and mission (Barlett et al., 1989). In turn, Naisbitt claims that while in traditional understanding of strategic resource capital was material in terms of material, i.e. traditional production factors, current formula of this resource exposes three elements, which are information, knowledge and creativity (Naisbitt et al., 1985). On the other hand, the Strategy for Responsible Development, which documents the directions of Poland's development until 2020 with a perspective by 2030, notes that responsible and sustainable development shapes national economy strength and guarantees innovation growth. The sustainable development of national economy supported by innovations forms foundation for capital that young people will be able to multiply. Huge significance in these processes is attributed to human innovation, which will determine national economy strength, which will result from situation on the labour market shaping purchasing power of Polish zloty, thereby shaping Poland's position in competitive global markets (Strategy..., 2017). Still differently perceives these phenomena Nonaka, who believes that key source of competitive advantage in both labour market and enterprise is knowledge. In his opinion, changing economic situation shaping situation on the markets, dynamically changing and emerging innovative technologies, and developing competition result in disappearance of products within one day. In such conditions, successes are achieved by enterprises and organizations operating on the basis of updating and developing their knowledge, including it in all processes occurring in enterprises and organizations and based on them strive to create new technologies and products. Such activities are defined as markets, including knowledge-based enterprises whose sole purpose is systematic innovation (Nonaka, 1991).

By creatively anticipating concept of coexistence and relationships between eco-innovation and its environment, it seems that key need is to consider its maximally wide spectrum of impact – taking into account previously indicated goals focusing on areas of society, economy, environment and infrastructure. Given the above relationships, it seems that developing a model for gathering information on relationship between eco-innovation and its environment will require an alternative to existing interdisciplinary approaches.

## **5. Eco-innovations - good practices**

The general characteristics of information indicated in the article – in relation to eco-innovation - should create premises guaranteeing desire to stimulate and maintain harmony and balance between goals of eco-innovation and its environment – in social, economic,

environmental and infrastructural dimensions. In this context, it is worth pointing out good examples of seeking – aforementioned – harmony and balance between eco-innovation and environment (Eco-Innovation..., 2018).

One such example is a project implemented in Czech Republic relies on regeneration of acetone as a new input material. The project is implemented by LINDE Witkowitz<sup>2</sup>. In accordance with requirements of quality and safety in area of environmental protection set out in its own policy, LINDE Vitkovic has developed an innovative recycling method thanks to which acetone is effectively and ecologically reused as a raw material and material. Every year, LINDE Vitkovic restores 106 tones of contaminated acetone to its reuse – eliminating huge amounts of hazardous waste from market. Thus, due to waste management and environmental protection, recycled waste is not transported, mixed with other waste or stored. In the light of example described, it is worth noting – on the basis of European policies – that many companies from Small and Medium Enterprise sector still do not realize that eco-innovativeness is associated with numerous economic benefits. Due to the perception of eco-innovation in terms of economic benefits, definition of activities for protection of natural environment in terms of costs is significantly reduced – in extreme scenario, ignoring need to take such actions.

Another example are German practices related to deposit system for the multiple use of coffee cups. The system operates in 23 cities and 850 cafeteria objects and is based on deposits of coffee drinkers in amount of 1 Euro. As a result of deposit payment, customers receive a discount buying coffee, they can return coffee cup to wash and resell at any time a partner cafe. The effect of using system is replacing with one deposit cup nearly 500 single-use cups. It is estimated that 2.8 billion ready-made disposable cups are consumed annually in Germany, resulting in paper consumption of 43,000 trees, 110,000 tones CO<sub>2</sub> emissions, 40,000 tones of waste and 1.5 billion liters of water. In contrast, reusable deposit cups do not contain harmful substances and can be reused up to 500 times.

An interesting example of good practice is Italian start-up focusing on production of textiles from citrus waste. Based on developed solutions, the process of extracting cellulose from "pastazzo" (citrus fruit residue) and method of yarn production have been patented in Italy. The final product of this process is a biodegradable material, imitating silk – created in 100% in form of soft, light and delicate to touch citrus fabric. This is an extremely important measure that significantly reduces costs of Italian entrepreneurs related to utilization and illegal removal of citrus waste. The scale of the problem is production in Italy of 700,000 tones of citrus waste in a one-year cycle.

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<sup>2</sup> LINDE Witkowitz is a plant in Usti nad Labem. Mainly supplies complete acetylene cylinders and cylinder bundles. It performs periodic tests and refurbishment of technical gas cylinders as well as full ecological utilization of rejected acetylene cylinders.

British eco-innovation in the form of re-recovery of residues from used paints is a very original solution. It is estimated that on average one can of households in United Kingdom uses 17 cans of paint, which in country corresponds to 50 million liters of paint used per year. Recovered paint residues are distributed at affordable prices to diverse social recipients (such as sports clubs, amateur theater groups, art groups, etc.), construction companies, social housing associations, tenants and low-income people. Resource Futures, an environmental consultancy, owned by employees, operating on a non-profit basis and sponsored by global paint manufacturer Dulux, recovers unused paint. As a result of actions taken – based on its own system developed – company intends to recover and redistribute more than 1.5 million liters of paint in 2020.

The examples of good practices described above indicate that important development determinants in field of eco-innovation are, among others:

- international cooperation,
- local authorities and communities cooperation with eco-innovators,
- public-private partnership,
- cooperation of enterprises with research units (R&D),
- cooperation between world of business and science,
- modernizing existing solutions,
- readiness to take economic risk,
- combining new technologies with sustainable development,
- creating products that strengthen impact of enterprises on society and environment in dimension of clean technologies,
- investments in experimental laboratory work,
- creativity and persistence of eco-innovators in pursuit of adopted goal,
- proper recognition of the demand for eco-innovations due to socio-cultural conditions of their recipients,
- proper promotion of eco-innovation, e.g. through instrumental campaigns.

In the context of good practices described above, it is worth noting the report Implementation of Sustainable Development Goals in Poland adopted by the Government of Republic of Poland in 2018. In the report, it is emphasized that in environmental dimension Poland is seeking to improve the state of environment and sustainable resource management. The goal of the state is to increase available water resources and achieve high water quality, rational management of natural and geological resources, as well as effective waste management. Improving air quality in Polish cities remains a priority. We focus on cooperation, partnership and shared responsibility of public entities, business and citizens for development processes. The expression of this is leaving from administration system in favor of co-management and sharing responsibility for success of transformational changes. The key is to build social dialogue around the most important projects as well as broad social support and trust between public entities and their partners to achieve development goals (Implementation of Balanced Objectives..., 2018, pp. 10-11).

## 6. Eco-innovations – good practices examples from Silesia Voivodeship

In accordance with Śląskie 2020+ Silesia Voivodeship Development Strategy, development and innovation activities in voivodeship should be aimed at "maintaining voivodeship on a path of lasting and balanced development and increasing region's competitiveness" (Strategia ŚLĄSKIE 2020+, 2013). Among innovative activities, activities aimed at ensuring ecological security for voivodeship inhabitants through development of services, transfer and application of environmental protection technologies are extremely important (Lorek, 2011).

Examples of organizational eco-innovations in institutional nature in Silesia Voivodeship are cooperation platforms, informal groups and networks established to deal with pro-environmental activities, such as, for example, ecological clusters. The strong region economy, as well as quite high business activity in R&D sphere, create very favorable conditions for development of clusters in region (EOCIC, 2019). At the same time, intensive development of cluster initiatives in recent years, often based on cluster development support programs, does not always translate into further activity of these cooperation networks in later years, after project implementation has been completed.

In voivodeship, technological clusters dominate (e.g. Euro-Centrum Cluster of Energy Saving Technologies, supporting energy-saving and passive construction, or Polish Wood Cluster, focused on wood industry and biomass production and use), although there are also clusters of knowledge (e.g. Cluster "3x20", aimed at implementing EU energy and climate package "3x20") or typically business, such as Silesian Water Cluster, aimed at sustainable water and sewage management (Dubiel, 2016). Clusters existing in voivodeship are characterized by various legal forms (some operate as corporate agreements, others in form of associations). Most ecological clusters are young structures in initial phase of innovative development (e.g. Silesian Water Cluster, Polish Wood Cluster) or in growth phase (e.g. "3x20" Cluster).

According to specialist reports for technological area of "Technology for Environmental Protection" implemented as part of the "Regional Specialist Observatories Network", Silesia Voivodeship, due to number of innovative enterprises and research and development activity, has significant potential in developing eco-innovation, in particular technological, and moreover, number of scientific and research units focused on implementation activities as part of cooperation between science and industry is increasing. (Raport Specjalistyczny, 2018).

An example of an eco-innovative solution is BioCargo, which is a device for analyzing activated sludge physiological state and sewage toxicity, as well as transporting environmental biological samples. This device was developed by scientists from Central Mining Institute with a view to maintaining high quality wastewater treated by biological wastewater treatment plants and determining its proper functioning by analyzing activated sludge physiological state and assessing sewage toxicity, as well as initial diagnostics during commissioning, service and

repairs in these facilities, which is a response to difficulties of many wastewater treatment plants related to maintaining a constant quality of treated wastewater and assessment of proper treatment plant functioning (<https://biocargo.eu/>, 2018).

Another interesting example of technological eco-innovation is comprehensive technology of renovating wells and sewage chambers, combining use of thin-walled GRP panels from Aquaren Panel System (APS) and renovation of connections and ducts using sleeve hardened by BlueLight LED system. This technology was developed jointly by Aquaren Sp. z o.o. and Kraso-Tech GmbH (Wilińska, 2017). As in existing technologies, sleeves for renovation of network were hardened chemically or by introducing water at 800°C, use of this technology reduces consumption of both water and energy to heat it, which translates into reduced impact on environment.

An interesting example of developed eco-innovation process is separating components forming laminate layers, i.e. polyamide (PA) and polyethylene (PE) from post-production waste of food packaging foil, developed by scientists from Silesian University of Technology. By using a selective solvent for separation that only dissolves polyethylene layer, polyamide is separated by hot centrifugation, and polyethylene is recovered by precipitation from solvent by cooling followed by centrifugation. This technology allows recovery of raw materials from waste of PE-PA and PE-PET laminates used in packaging industry (cuttings, etc.), which allows reducing waste stream. The developed technology is at technological readiness level TRL 4 (Piotrowski et al., 2018).

The above examples indicate that market of environmental technologies in Silesia Voivodeship is developing rapidly, and developed solutions are largely implemented, which proves the high demand for this type of technology in voivodeship. Due to region specificity, many of eco-innovations developed and implemented in voivodeship are mainly focused on a more sustainable use of environmental resources.

## 7. Conclusions

The overall content presented above focuses in particular on human activities in two areas. The first is use of existing living and inanimate natural resources resulting from need to maintain life expectancy. In the second area, focus on its protection and care for its duration. In these two activities – it seems – that two determinants shaping its development are of particular importance. The first is to follow key principles for environmental policy in these activities, which include:

- sustainable development principle,
- integrating environmental policy with sectoral policies principle,
- equal access to natural environment principle,

- regionalization principle,
- socializing environmental policy principle,
- "polluter pays" principle,
- prevention principle,
- precautionary principle,
- using the best available, economically justified techniques and technologies principle,
- subsidiary principle.

Eco-innovation is another determinant. It is particularly evident in undertaken actions of a forward-looking nature that respond to changes in environment surrounding changes in good practices. In the light of this thesis, eco-innovations are the basis for transformation of circular economy. They include innovation in way products are designed, manufactured, used and reused recycled. From a design perspective, they focus on aspects such as modularity, multifunctionality, ability to reproduce, and longevity. On the other hand, in business terms they refer to models integrating service offers, including: product handling systems, dematerialized services, joint consumption and resource management (Eco-Innovation..., 2018).

However, it should be noted that there is no universal solution for all products and services and circular economy. Therefore, in the final conclusion it is worth emphasizing that optimal matching of environmental policy with innovations is extremely important in achieving set goals. Striving to create ecologically new eco-innovative solutions both in sphere of its social acceptance and in utilitarian dimension.

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