PROCESS AND PRODUCT INNOVATIONS FOR THE IMPROVEMENT OF THE STATE OF THE ENVIRONMENT

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Abstract: The article aims to identify the research streams on environmental innovations in Europe and worldwide in response to current challenges such as climate change, wasteful energy policies, overuse of resources, water supply shortages, deforestation and many others. environmental innovations are products and processes that reduce environmental impacts which might help to make the future a little brighter. Within this review there are also identified the strengths and limitations of financing the innovativeness in Poland.

Key words: eco-innovation, environmental innovation, environmental technology, eco-design, environmental design, sustainable design, or sustainable innovation.

1. Introduction and theoretical background

Many environmental problems need to be addressed by humans to achieve sustainable living on the Earth. One of the research areas which can support this process is environmental innovations, which are also called eco-innovations or sustainable innovations. Sustainable innovations is relatively a young area of research, however it is an area of increasing concern for policy makers, academics and practitioners. From the analysis of the literature, it can be observed that the relevance of environmental innovations issue is increasing within academia. Sustainability issues affect more and more product and service design and development not only in the richest countries but also worldwide. In a broad sense, environmental innovations can be defined as innovations that consist of new or modified processes, practices, systems and products which benefit the environment and contribute to environmental sustainability [12]. A. Reid, and M. Miedzinski are defining eco-innovation as creation of novel and competitively priced goods, processes, systems, services, and procedures designed to satisfy human needs and provide a better quality of life for everyone with a life-cycle minimal use of natural resources and a minimal release of toxic substances [11]. For the European Union term 'eco-innovation' means technological development that generates products, equipment or production processes that reduce environmental risk or minimise pollution and resource use. Moreover the multifaceted concept of eco-innovation encompasses three stages of the technological development process: invention, innovation and diffusion [3].

Eco-Innovation Observatory (EIO), characterized environmental innovation as: any innovation that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle [10]. EIO's definition broader than traditional concept of innovating to reduce negative environmental effects. It also includes the ways and methods of minimizing the use of natural resources in the design, production, use, re-use and recycling of products and materials.

Sustainable innovations includes all environmentally friendly technological advances contributing to more efficient and responsible use of natural resources. Nevertheless such an advances have to be socially acceptable. Sometimes eco-innovations are defined as

innovations which contribute to the economic, environmental and social pillars of sustainability and it seems to be clear, but when an innovation is called eco-innovation - the emphasis should be placed on environmental value which should be created by the innovative product or process. Of course an innovative product or processes may somehow add market value but when it is non-profit venture and it is financed from public money it should create first of all ecological value. It has to be stated that there exist also technically feasible eco-innovations, which are not implemented because of social and institutional barriers.

According to United Nations Environment Programme (UNEP), eco-innovation provides a win-win solution to improving economic competitiveness and sustainability. UNEP also points to the diffusion of eco-innovations saying that such an innovation starts at the company strategy level but it extends influence to the supply chain. For creation of an enabling environment for eco-innovation. In turn, OECD's Oslo Manual the propose that the general definition of innovation which is: "*the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations*" (OECD Oslo Manual), can be applied to eco-innovation, but there are two other significant, distinguishing characteristics of eco-innovation:

- Eco-innovation reflects the concept's explicit emphasis on a reduction of environmental impact. It is also pointed that the effect may be intended or not.
- Eco-innovations are not limited to innovation in products, processes, marketing methods and organizational methods, but also includes innovation in social and institutional structures [12].

OECD's report points that eco-innovations can be understood and analysed in terms of an innovation's targets (the main focus); the mechanisms methods for introducing changes in the targets) and impacts (the effects on environmental conditions). This three dimensions of eco-innovations are shown on the Figure 1.

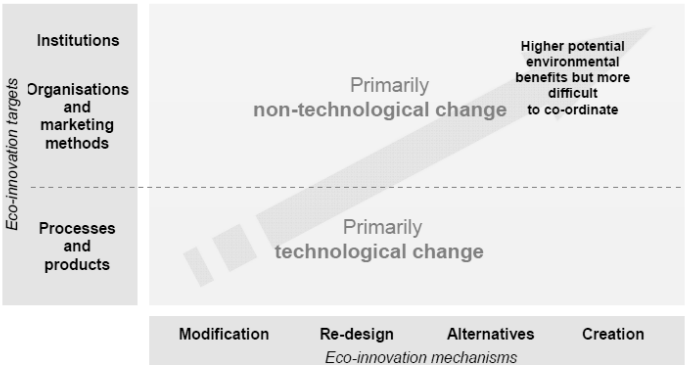

Fig. 1. The typology of eco-innovation.
Source: [14]

According to recent research conducted by the OECD, large companies no longer saw a distinction between environmental innovation and innovation in general. The reason is that, when the environment is always taken into consideration during the innovation process the distinctions between environmental and other industrial innovations is useless. This, in the

future, may lead to a mainstreaming of environmental thought within the innovation process. The consequence of this development for companies would be that all along the supply chain would begin looking at the ecological footprint of their suppliers [13].

Many governments encourage entrepreneurs to implement innovations which meet both economic and environmental challenges. In many countries there are specialised agencies which support the environmental innovations. One of the most dynamically operating Environmental Protection Agencies are United States Environmental Protection Agency and European Union Environmental Protection Agency.

US EPA carry out a lot of programs which help communities and businesses modify their practices in ways that provide cleaner environment. The well known EPA's programs are:

- ENERGY STAR program operating since 1992. Which promote energy efficiency in products, homes and buildings around the world
- The E3: Economy, Energy and Environment Program which is a technical assistance framework helping manufacturers and manufacturing supply chains and communities, across the country to reduce pollution and energy use while increasing profits and creating new job opportunities.
- Lean Practices - practices which refers to a collection of principles and methods that focus on the identification and elimination of non-value added activity (waste) in any process. The Agency is implementing three practices: lean start-up, lean process improvement, and agile development.
- Environmentally Preferable Purchasing program – it includes recommendations for the federal purchasers to help them identify and procure environmentally sustainable products and services. The aim of recommendations is also to stimulate market demand for green products and services using the buying power of federal purchasers. The recommendations can be useful also for other businesses interested in green supply chain
- Sustainable materials management - program supporting using and reusing materials in the most productive and sustainable ways over their entire life cycles. It helps to reduce environmental impacts, conserve resources, and reduce costs.
- Renewable Energy on Contaminated Land – within the program EPA identifies the renewable energy potential of current and formerly contaminated lands, landfills and mine sites when it is aligned with the community's vision for the site.
- Green infrastructure– it is a program promoting the infrastructure which reduces and treats stormwater at its source instead of conventional drainage systems designed to move urban stormwater away from the built environment.
- Green chemistry program – it supports the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances.

Sustainability issues are present in all documents for strategic planning on European Union. In the *Europe 2020. A strategy for smart, sustainable and inclusive growth* European Commission has identified three interrelated priorities:

- Smart growth: developing an economy based on knowledge and innovation;
- Sustainable growth: promoting a more resource efficient, greener and more competitive economy;
- Inclusive growth: fostering a high-employment economy delivering social and territorial cohesion [4].

The European Environment Agency (EEA) aims to support sustainable development by providing independent information on the environment, to policymaking agents and the public. The key topics of the EAA activities are:

- Air pollution and climate change – the Agency supports the EU in developing long-term strategies to reduce emissions of air pollutants and greenhouse gases by providing assessment and information to policy-makers
- European water resources – EAA supports the policy process, by a series of reports to assess the state of Europe's waters and future challenges.
- Environment and health – the Agency works on development of methodologies to assess the impacts of the environment on health; Improvement of access to information; assessment of the link between climate change and health
- Resource efficiency and waste – this topic includes the subtopics such as green economy, municipal waste, resource efficiency, waste prevention. The EEA provides divers report including flagship report, The European Environment: State and Outlook 2010.

Apart of above topics the Agency in active in many other topics such as biodiversity, land use, marine, soil and others.

2. Key drivers of environmental innovations

Manufacturing industries are responsible for significant part of the world's consumption of resources and generation of waste and also for about a third of global energy consumption [7. Literature on determinants of eco-innovation put emphasis on the important role of regulation which is important tool to push the industry to reduce air pollutions as well as water or noise emissions, avoid hazardous substances, and increase recyclability of products. Companies somehow wish to become less environmentally polluting but without incurring high costs. Environmental innovations may be the solution for this problem. More and more companies undertake environmental innovations and adaptations in order to reduce their emissions without increasing their costs, moreover in many cases they can save costs thanks to environmental innovations.

There are various technologies which enable companies to reduce their emissions by employing resource saving, using new resources and pollution controls. In order to move towards sustainable future it is needed to promote sustainable manufacturing initiatives and both industry and government should support the environmental innovations which play key role in this process. The relation between sustainable manufacturing and eco-innovations is presented on the Figure 2.

According T. Hillestad and others the main barriers to environmental innovation are [6]:

- inefficiencies in the internal communication process;
- lack of environmental training for companies' employees;
- managerial limitations to understanding the relevance of green issues;
- difficulties to build networks between partners and green teams;
- unskilled green team for research and development (R&D);
- poor economic perspective with low perception of green innovation gains;
- investment with long-term return;
- difficulties in obtaining financial resources; and
- sluggish environmental regulatory system based on governmental inefficiencies.

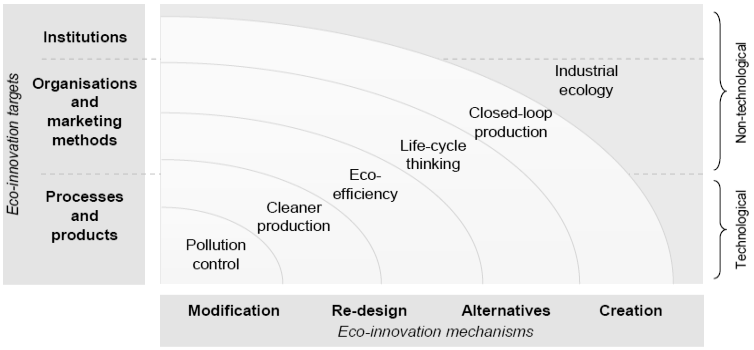

Fig. 2. Conceptual relationship between sustainable manufacturing and eco-innovations
Source: [14]

According to R. Malaman market demand for environmental innovations is generally slack and difficult to predict. He pointed four reasons for such a situation:

- The objective of cleaner production is lower on the agenda of firms than that of profit.
- In the introductory stage cleaner technologies may feature higher costs and inferior quality.
- Information problems seem to be greater than in other cases, due to the complexity of environmental aspects and lack of knowledge.
- Environmental innovations call for more organisational and institutional changes. Another distinguishing factor reported is that awareness of environmental issues may play a role as an additional incentive to those involved in the environmental innovation process [8].

There are three main categories of environmental policy instruments:

- Regulatory instruments – laws, regulations, standards or technologies introduced by public authorities to be achieved or used by companies; aimed at direct influencing the environmental performance of companies.
- Economic instruments - instruments that use markets, price, and other economic variables to provide incentives for polluters to reduce or eliminate negative environmental externalities such as taxes or subsidies.
- Communicative instruments - often used in conjunction with regulatory or economic ones aiming at internalising environmental awareness and responsibility into individual decision-making by applying pressure, persuasion or stimulation either directly or indirectly. This category includes approaches such as education, information extension, training, social pressure, negotiation [8].

An example research on effects on innovation of environmental policy instruments are presented in the table 1.

The results of the research carried out by European Environment Agency and presented in the Technical Report on Environmental tax reform in Europe: opportunities for eco-innovation says that:

- environmental tax reform, shifting taxes from labour to energy and resources will create additional jobs and trigger eco-innovation; and

Tab. 1. Effects on innovation of environmental policy instruments

Category of Instrument	Type of Instrument	Effects on innovation
Regulatory instruments	Regulations	diffusion, incremental innovations
		innovation outside regulated sector
		affect small firms less than big
		search process also before implementation
	Technology forcing standards	radical innovations
	Product regulation	product rather than process innovations
	Component, pollutant regulation	process rather than product innovations
	Permit based regulation	larger effects than incident based regulation
Economic instruments	Taxes	some effects on process and product innovation
		search process also before implementation
	Subsidies	more effects than taxes (regards energy and diffusion)
		limited effects
Communicative instruments	Voluntary agreements	small effects
	Network creation	some effects

Source: [8]

- impacts of eco-innovation in the form of additional EU exports or shifts in industry structures will have a slight positive influence on GDP and create a smaller number of additional jobs [3].
- These findings correspond to the results from the OECD study of taxation, innovation and the environment, which main conclusion is that environmental taxation can spur innovation [14]. According to OECD analysis, environmental policy instruments are not obstacles to economic activity. Moreover, environmental taxes can serve as catalysts for the creativity that underpins thriving economies. EEA Technical report states that eco-innovation in the short term can boost efficiency and competitiveness and in the long term is a key factor to sustained prosperity by enabling economic growth to continue within environmental limits [3].

Furthermore EEA states that innovations stimulated by environmental policy are essential in the process of creating 'green economies' that can deliver growing incomes while preserving natural systems and social equity.

One of very important drivers of eco-innovations is diffusion of innovation. This research area focus on exploration how environmental innovations proliferate. Despite of the fact, that the positive attitude towards eco-innovations is growing and many eco-innovations are present on the market for many years it is desirable for many innovative products and processes to spread. an important challenge to overcome regarding the proliferation of eco-innovations is the *Not In My Back Yard* (NIMBY) syndrome which describes the gap between high level of public declarative support for eco-innovations and frequent non-engagement or local opposition towards specific investments.

3. The 6th wave on innovation and circular economy

The 6th wave of innovation is the idea which explain the 6 groups of innovations which are implemented during last 250 years, starting from the industrial revolution and ending

with sixth wave of innovations which determine sustainability, radical increase of resource productivity, whole system design, biomimicry, green chemistry industrial ecology, renewable energy and green nanotechnology ant other environmental innovations. Successive waves of innovations are illustrated on the Figure 3.

Above concept corresponds to the concept of circular economy, which is of considerable interest of European Union and also other developed countries. It is a concept which promotes high productivity of resources and aiming to reduce waste and avoid pollution. It is the basis for the European Union Circular Economy Strategy. European Commission adopted a Circular Economy Package, which includes legislative proposals on waste to stimulate Europe's transition towards a circular economy which should boost global competitiveness, foster sustainable economic growth and generate new jobs. The illustration of circular economy is presented on the figure 4. European Commission is expecting that the actions proposed within Circular Economy Package will contribute to "closing the loop" of product lifecycles through greater recycling and re-use, and bring benefits for both the environment and the economy [1].

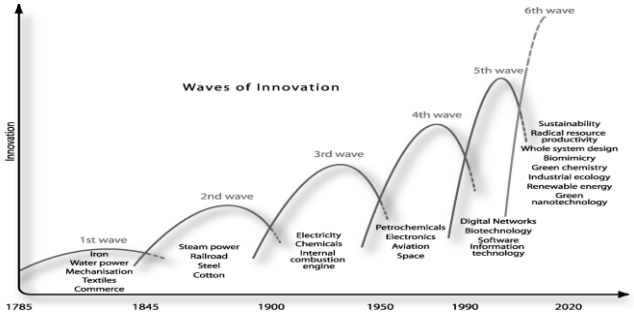

Fig. 3. Waves of innovation.
Source: [17]

At present in The European Union the pressure to reduction of environmental impacts and progress towards circularity is growing. The current system of production and consumption which is predominately linear system in which resources are extracted, processed, used and disposed as waste have to be changed into circular economy model [3].

Eco-innovation is a vital element of all circular economy efforts. It has a potential to enable the transition to a resource-efficient circular economy model and support the change of dominant business models (from novel product and service design to reconfigured value chains); the transformation of the way citizens interact with products and services (ownership, leasing, sharing, etc.) and develop improved systems for delivering value (sustainable cities, green mobility, smart energy systems, etc.); [2].

4. Eco innovations in Poland – the status and funding

Poland is consistently moving up Bloomberg Innovation Index which ranks economies using factors including research and development spending and the concentration of hi-tech public companies. Poland has moved up from No. 30 in 2013 to 22 in 2017. Also in o European Innovation Scoreboard Poland is moving up**.** It was placed among moderate innovators and ranked 23rd in 2016 in comparison to 24th in 2015.

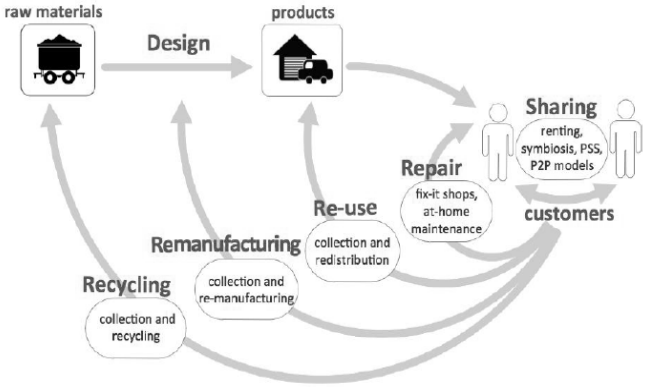

Fig. 4. illustration of circular economy
Source: [10]

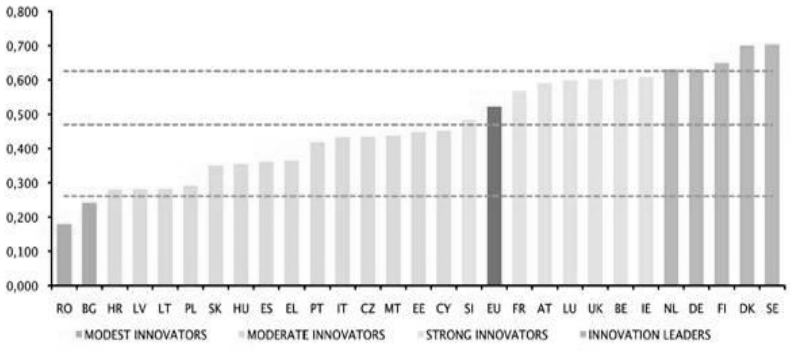

Fig. 5. EU Member States' Innovation Performance
Source: [18]

Despite the many limitations of the national economy in the area of innovation Poland is moving slowly up. Poland due to its size and potential have a chance to become a leader of innovation in the region, but it is a very long process and hard work to build the ecosystem of innovation, especially in industries in which there is true potential of human resources for the effective commercialization of innovation and the industries which are bind to the markets, which will continue to grow in the coming years. Especially, the eco-innovations is the challenge. Poland is in the very end of European countries in terms of eco-innovations. The Eco-Innovation Scoreboard of European countries in presented on Figure 6.

In the Eco-Innovation Scoreboard Poland was classifies as country catching up in eco-innovation, with around 80% or less performance compared to the EU average. The Poland's scores of all five components is very low. The lowest performance of Poland in in the category of eco-innovation inputs and eco-innovation outputs. A little better scores for resource efficiency outcomes and much better for eco-innovation activities and socio-economic outcomes. The detailed scores in five components of the Eco-Innovation Scoreboard is presented in the Figure 7.

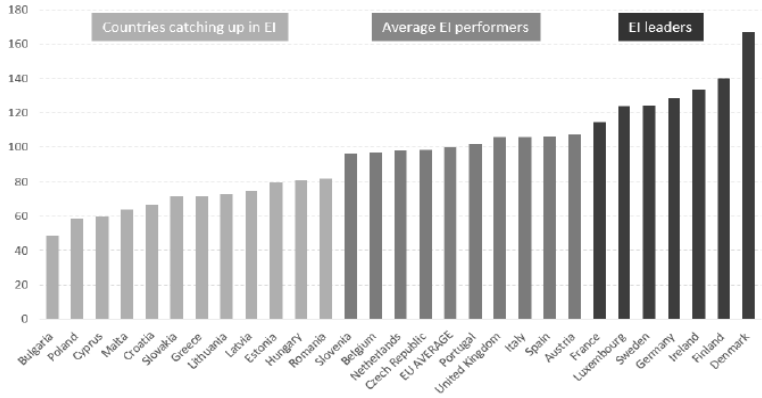

Fig. 6. Eco-Innovation Scoreboard 2015
Source: [19]

There many other ideas which corresponds to the concept of circular economy and eco-innovations. Just to mention two them. First is the concept of Factor 10 – the idea of radical reduce of resource turnover by 90% on a global scale within the next decades. It was evolved from Factor 4 concept originally proposed by L. H. Lovins, A. Lovins and E.von Weizsäcker, which claim to reduce resource and energy use by 75 % by doubling output and halving input of production. The second is the concept of Blue Economy: 10 years - 100 innovations - 100 million jobs, developed by G. Pauli. The concept propose a model of business which suits to concepts of sustainability and green economy.

		Eco-innovation inputs	Eco-innovation activities	Eco-innovation outputs	Resource efficiency outcomes	Socio-economic outcomes	Eco-IS
EI leaders	Denmark	368	71	157	108	86	167
	Finland	182	152	190	77	120	140
	Ireland	310	135	65	104	63	134
	Germany	154	162	140	107	87	129
	Sweden	121	154	160	102	93	124
	Luxembourg	106	115	205	131	60	124
	France	111	110	108	108	138	115
Average EI performers	Austria	98	126	136	107	73	108
	Spain	94	134	102	112	105	106
	Italy	75	118	117	116	101	106
	United Kingdom	126	116	74	126	87	106
	Portugal	79	167	83	86	99	102
	Czech Republic	63	181	47	66	147	99
	Netherlands	66	77	106	124	108	98
	Belgium	89	116	111	98	71	97
	Slovenia	74	92	98	78	142	96
Countries catching up in EI	Romania	39	138	53	64	120	82
	Hungary	72	98	27	81	126	81
	Estonia	78	129	53	48	100	80
	Latvia	43	60	95	70	109	75
	Lithuania	43	94	59	81	87	73
	Greece	57	37	101	78	61	72
	Slovakia	38	101	52	78	87	72
	Croatia	21	100	89	80	49	67
	Malta	25	72	55	104	46	64
	Cyprus	14	54	132	77	17	60
	Poland	40	54	58	62	77	59
	Bulgaria	19	71	27	46	81	49
Minimum		*14*	*37*	*27*	*46*	*17*	*49*
Maximum		*368*	*181*	*205*	*131*	*147*	*167*
Range		*354*	*144*	*178*	*86*	*131*	*118*

Fig. 7. Scores in the five components of the Eco-Innovation Scoreboard 2015
Source: [19]

Poland is the largest beneficiary of European Union funds. The EU has allocated EUR 82.5 billion to Poland in the 2014–2020 period. Most of the funds will be invested in increasing the competitiveness of the Polish economy and the highest growth is expected in the area of innovativeness and support for entrepreneurs. Investments in environmental protection and energy production which may employ eco-innovations will be financed as well. In the perion of 2014–2020 EU funds will be implemented in Poland by means of 6 national operational programmes managed by the Ministry of Economic Development and 16 regional programmes managed by Marshal's Offices. For financing of the innovations the most important is Operational Programme Smart Growth This programme is also the largest operational programme financing research, development and innovation in the European Union, with the allocation of 8.6 billion euros of European funds. For the low carbon economy and environmental protection the biggest founding is available within the Operational Programme Infrastructure and Environment. It is the largest program with the allocation of 27.4 billion of European funds.

Additionally Polish companies can apply for research grant available in the HORIZON 2020 program. One of the possibility is the Factories of the Future 2020 call for proposals of public-private partnership. Factories of the Future 2020 it is a strategic multi-annual research roadmap developed by The European Factories of the Future Research Association (EFFRA). PPP are expected to deliver the technologies needed for the new sustainable and competitive factories of the future, which should be clean, highly performing, environmental friendly and socially sustainable. According to the roadmap the key manufacturing challenges and opportunities are [5]:

- Manufacturing the products of the future: Addressing the ever changing needs of society and offering the potential of opening new markets
- Economic sustainability of manufacturing: Combining high-performance and quality with cost-effective productivity, realising reconfigurable, adaptive and evolving factories capable of small scale production in an economically viable way
- Social sustainability of manufacturing: Integrating human skills with technology
- Environmental sustainability of manufacturing: Reducing resource consumption and waste generation

5. Conclusions

Environment innovations are still a new phenomenon but it is expanding quickly across many countries including Poland. The heart of environmental innovations is in the quality and manner of how resources are conserved and efficiently used. Eco-innovations can be the way to elicit direct or indirect ecological improvements. Environment innovations issues are interested not only for researchers in environmental management and policy and the staff of regional and national authorities but also for companies staff involved in corporate social and environmental responsibilities programs. Manufacturing industries can help to overcome global environmental challenges and it is necessary to identify areas in which eco-innovative solutions can substantially reduce environmental impact. Environment innovation is also an opportunity for small and medium size companies to save costs, expand to new markets, create new jobs, and reduce pressure on the environment. European Funds allocated for Poland in period 2014-2020 is a big opportunity for Polish companies to improve the results in terms of innovation and eco-innovation.

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