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Bożydar ZIÓŁKOWSKI[1]

THE WORLD TRENDS IN ECO-INNOVATION ASSESSMENT

In this paper the results of eco-innovation assessment were analyzed. Eco-innovations are considered as a solutions to minimize the negative impact on the environment to a greater degree than their previous counterparts. For this reason, the eco-innovations include in particular: pollution prevention, pollution control, cleaning technology, cleaner technology, environmentally improved products, loop closing, environmental management systems, waste management, environmental optimisation of production chain, system innovation. The big number of different indicators makes the decision-making in strategic management is difficult but needed. The own researches aimed at identification of leading trends in eco-innovation assessment and interest revealed by world companies. The own literature study on the results generated after application of eco-innovation indicators delivers significant knowledge on the international research trends. The subject of this work are 18 scientific papers published after the successful realization of eco-innovation projects. They have been analyzed in the context of 34 key findings. Among the identified and included into the analysis of criterion on assessment of interest in eco-innovations are: technological eco-innovations, management/system eco-innovation, process eco-innovation, external stakeholders role in supporting eco-innovation, competitive advantage as a benefit from eco-innovations. The results of researches realized in this paper show that eco-innovative technologies have the biggest importance for the world companies. Thus the present trends show increasing role of technological solutions when comparing with management/system and process solutions.

Keywords: eco-innovations, eco-innovation assessment, eco-innovations in companies, strategic management

1. INTRODUCTION

Eco-innovations are among the leading strategic priorities of the European Union. The similar situation is noticeable in many countries where development strategies accentuate the need of investments for environment protection by means of increasing efficiency or new technologies. However, constructing strategic plans requires right diagnosis of situation on the market by means of eco-innovation assessment indicators.

Eco-innovation assessment tools are worth of attention for two reasons. On the first hand the great number of indicators can perplex many theoreticians and practitioners and diminish understanding of the main idea for measuring eco-innovations. On the other hand it is worth scrutinizing what are the results of these indicators application in eco-innovation assessment and which devel-

[1] Dr inż. Bożydar Ziółkowski, Katedra Przedsiębiorczości, Zarządzania i Ekoinnowacyjności, Wydział Zarządzania, Politechnika Rzeszowska, al. Powstańców Warszawy 8, 35-959 Rzeszów, tel. 178651376, e-mail: bozydarz@prz.edu.pl.

opmental trends emerge. To answer these questions a couple of international research papers have been analyzed in this work. The aim of this paper was identification of scientific trends in eco-innovation assessment and the resulting findings.

The next chapters introduce the idea of eco-innovations related to sustainable development concept as well as indicators for eco-innovation assessment.

2. THE ASSUMPTIONS OF ECO-INNOVATION IDEA

It is difficult to create an universal definition of eco-innovations. The commonly used interpretations put the main attention to the single different issues, without reference to all required items. In spite of the "eco" prefix which is correlated in parallel with the ecology, environment or economy, eco-innovations are not always defined in these three-dimensional context. For example, E. Jones, N. A. Stanton, D. Harrison when accepting the sustainable development dependency stated that eco-innovation aims at developing *new* products and processes, which meet the *needs* of customers in the most eco-efficient way[2]. In majority of research works the environmental element is most frequent, like e.g. in the *Report for Sectoral Innovation Watch* where eco-innovation was defined as novel and competitively priced goods, processes, systems, services, and procedures that can satisfy human needs and bring quality of life at life-cycle minimal use of natural resources per unit output (resource and energy efficient), and a minimal release of toxic substances[3].

The numerous definitions of eco-innovations are not the only factor which makes difficult the comparison of different solutions named as eco-innovations. Confusing is also the complexity of existing expressions used interchangeably with eco-innovations like: ecological innovation, environmental innovation, technological environmental innovation, sustainable development innovation[4]. All terms mentioned above are defined very often quite differently in many studies. A good exemplification for that can be the classification of targets of eco-innovations presented in table 1.

[2] E. Jones, N.A. Stanton, D. Harrison, *Applying structured methods to Eco-innovation. An evaluation of the Product Ideas Tree diagram*, „Design Studies" 22/6 (2001), p. 519–542.

[3] A. Reid, M. Miedzinski, *Eco-Innovation Final Report for Sectoral Innovation Watch, Systematic Eco-Innovation 70 Report*, Technopolis group 2008, (www.technopolis-group.com/resources/downloads/661_report_final.pdf), p. 52.

[4] See more: B. Ziółkowski, *Kierunki ewolucji w obszarze ekoinnowacji*, [in:] *Zarządzanie strategiczne w praktyce i teorii*, ed. A. Kaleta, K. Moszkowicz, „Prace Naukowe UE w Wrocławiu", 2012/260, p. 607–617.

Table 1. Targets of eco-innovations

	Eco-innovations	**Targeted decisions**
1	Pollution prevention	Plant operations and maintenance, small changes in the existing production lines, input substitution
2	Pollution control	Treatment of pollution before release into environmental media through special devices (usually end-of-pipe)
3	Cleaning technology	Treatment of pollution within the environment (receiving water, soil, or air). An example is remediation of polluted soils
4	Cleaner technology	New technology investment
5	Environmentally improved products	Product features of material use, energy use, durability and reusability thanks to design for the environment and re-use
6	Loop closing	Sourcing, product design, sitting of new facilities
7	Environmental management systems	Decision-making for reducing environmental impacts of products and processes
8	Waste management	Collection, transport, processing, recycling, reuse and disposal of waste materials
9	Environmental optimisation of production chain	Production chains: resource extraction, processing, manufacturing, final product and end-of-life use or care through design for recycling etc.
10	System innovation	New product-service systems (for example, customized mobility or decentralized systems of energy)

Source: Modified on the basis of: R. Kemp, *Environmental innovations and economic success of firms – a rejoinder*, [in:] *Green Roads to Growth, Proceedings of Expert and Policy Maker Forums*, ed. H. Saxe, C. Rasmussen, Copenhagen 1–2 March, 2006, Environmental Assessment Institute, København, p. 243–273.

The presented in table 1 solutions refer to three very popular types of innovations, i.e. technological eco-innovations, process/system eco-innovations and management eco-innovations. The other commonly used typology of eco-innovations relates to three dimensions of sustainable development and embraces: social, environmental and economic eco-innovations. For this reason eco-innovations are called very often as sustainable development or sustainable innovations.

The factors determining implementation of all types of eco-innovations have been presented in table 2.

Table 2. Determinants of sustainable innovation

Supply side	– offsets (cost savings) caused by environmental innovations – market characteristics: company size and market structure (monopolistic structures can prevent environmental innovations because there is no incentive to innovate at all) – possibilities for the protection of innovations (problem of internalising the positive externalities (spillovers) of an innovation): attitude to risk and the uncertainty of environmental innovations. Asymmetric information and moral hazard are notable characteristics of the initial situation of potential users of an innovation – path dependencies: the available technological possibilities (accumulation of human capital, available knowledge) induce further innovations (technology push hypothesis) – fitting time window for the realisation of the innovation
Demand side	– market demand (demand pull hypothesis): state, consumers and firms – social awareness of the need for clean production; environmental consciousness and preference for environmental friendly products
Institutional and political influences	– environmental policy (incentive based instruments or regulatory approaches) – institutional structure: e.g. political opportunities of environmentally oriented groups, organisation of information (low, existence of innovation networks) – pressures from "the world community": e.g. international agreements on CO_2

Source: J. Horbach, *Methodological aspects of an indicator system for sustainable innovation*, [in:] *Indicator Systems for Sustainable Innovation*, ed. J. Horbach, Physica-Verlag, Heidelberg, New York 2005, p. 1–20, p. 5.

To achieve a progress in strategic planning for market or regional development aimed at eco-innovations some solid diagnostic assessment tools are required. This issue was presented in the next chapter in context of indicators being in use as well as available data sources.

3. ECO-INNOVATION ASSESMENT TOOLS

Despite of a long history in eco-innovations development the problem of complex and non-universal measuring tools is still a critical factor for the scientific activity in this area.

"Currently, the field of eco-innovation lacks statistics and indicators. The challenge consists very much of trying to combine the two important frames in eco-innovation development: the innovation chain or system; and environment technology seen in a wider perspective. However, the methods and perspectives applied in innovation indicators are quite different from environmental indicators. Eco-innovation indicators are response-indicators measuring societal progress, supple-

menting other indicators along the DPSIR chain (Driving forces, Pressures, State, Impact and Response). Also, eco-innovation indicator development is at an early stage, which means the development must be underpinned by research, conceptual development, surveys and assessments"[5].

The similar conclusions have been also formulated after the project "Measuring eco-innovation" finalized in the year 2008 in the European Union. The researchers and practitioners identified persistent lack of sufficient environmental data and methodological frameworks for measuring eco-innovations[6].

The further researches revealed that eco-innovation indicators should achieve the following purposes[7]:

- place new focus on the eco-innovation development rather than the environmental state,
- allow for international benchmarking at the national and regional level,
- integrate with innovation statistics,
- provide maximum incentives for environmental action among key actors in the innovation system,
- provide new analytical insights into the greening of industry and the economy.

The multidimensional character of eco-innovations results from their multisectoral nature exemplified by indicators in the table 3.

Table 3. Indicators for the economic and ecological impacts of eco-innovation for different eco-innovation systems

Eco-innovation	**Examples for indicators**
Steel production	
Economic	GDP, employment, investments
Ecological	CO_2 emissions, energy consumption
Energy saving diesel cars	
Economic	Share of diesel motors with direct injection
Ecological	Reduction of fuel consumption
Re-organisation of material flows in a firm	
Economic	Cost-savings
Ecological	Waste reduction

Source: J. Horbach, *Indicator Systems for Sustainable Innovation*, Physica, Heidelberg, New York 2005, according to: J. Horbach, K. Rennings, *Deliverables 4 – 5, (Panel-) Survey Analysis of Eco-Innovation: Possibilities and Propositions*, July 2007 (on-line http://www.merit.unu.edu/MEI/index.php?pi=proposal, accessed 19.10.2012), p. 6.

[5] European Environment Agency, *Eco-innovation indicators*, Copenhagen 2006, (on-line: http://technologies.ewindows.eu.org/resources/case_studies/conferences/innovation_indicator_29_09_05/ei_study.pdf, accessed on February 2007), p. 4.

[6] S. Pontoglio, R. Kemp, *Workshop conclusions about ways for combining different measures of eco-innovation for meeting policy needs and research challenges*, Coming from final WORKSHOP ECO-INNOVATION of the MEI & ECODRIVE PROJECTS, Brussels 7 & 8 February 2008.

[7] European Environment Agency, *op. cit.*, p. 7.

There are two following sources of information used for eco-innovation assessment: generic data which are not specifically collected to measure eco-innovation and surveys designed specifically to measure eco-innovations. The items specified among the generic data are:

"1. Input measures: e.g. R&D expenditures, R&D personnel, other innovation expenditures (such as investment in intangibles, including design expenditures, software and marketing costs).

2. Intermediate output measures: e.g. number of patents; numbers and types of scientific publications.

3. Direct output measures: e.g. number of innovations, descriptions of individual innovations, sales of new products from innovations.

4. Indirect impact measures: e.g. changes in eco-efficiency and resource productivity"[8].

The right hierarchy among eco-innovation indicators and linked to them types of data sources presents table 4.

Table 4. Data sources for measuring environmental innovation activities

Types of environmental innovation	Main indicators	Main data sources
Eco-products (goods and services)	Output indicators: environmental characteristics of the new products with respect to comparable products (by using eco- balances), patents Input indicators: R&D expenditure and personnel	Surveys and information from industrial associations, eco-labels, case studies, patent statistics, bibliometrics
Process integrated measures, logistics, organizational measures	Improvement of energy intensity, reduction of material use etc.	Surveys, case studies, official statistics
End-of-pipe processes	Innovation activities of suppliers of environmental goods (patents, R&D expenditure and personnel) Demand side: analysis of environmental investment	Surveys, official product statistics, official statistics of environmental investment, patent statistics, case studies, bibliometrics
Recycling	Recycling share with respect to total waste amount	Official statistics (recycling belongs to the ISIC or NACE classification), surveys, patent data, bibliometrics, case studies

Source: J. Horbach, *Methodological aspects of an indicator system for sustainable innovation*, [in:] *Indicator Systems for Sustainable Innovation*, ed. J. Horbach, Physica, Heidelberg, New York 2005, p. 1–20, p. 10, after own modification according to: K. Rennings, T. Zwick, *The employment Impact of Cleaner Production on the Firm Level: Empirical Evidence from a Survey in Five European Countries*. ZEW-discussion paper No. 01–08, Mannheim 2001.

[8] OECD, *Sustainable Manufacturing and eco-innovation, Framework, Practices and Measurement*, Synthesis Report, OECD 2009, s. 23–24.

As mentioned at the beginning, the methodologies and indicators for eco-innovation assessment used in present international researches are still limited by some constrains. However the tools already constructed deliver interesting results which are very useful mainly in forecasting and strategic planning too.

In the next chapter the question of the present identified trends on eco-innovation development was presented on the basis of many international researches.

4. DIAGNOSIS OF TRENDS AFTER ECO-INNOVATIONS ASSESSMENT

The literature study on the results generated after application of eco-innovation indicators delivers significant knowledge on the international research trends in this area. The subject of this work are 18 scientific papers published after the successful realization of eco-innovation projects. They have been analyzed in the context of 34 key findings[9].

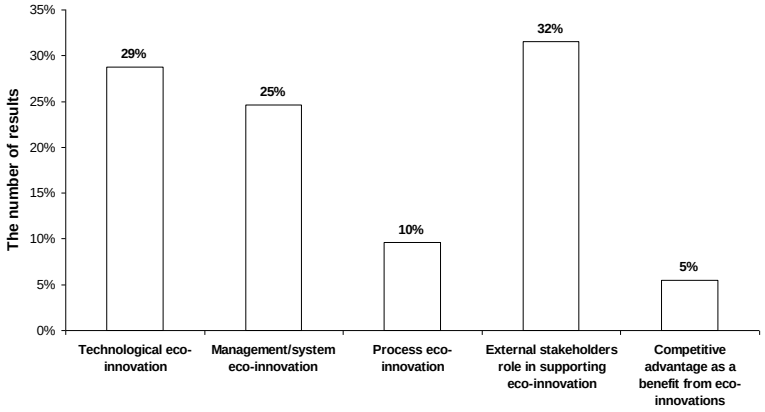
The analysis of eco-innovation projects was performed from multidimentional perspective embracing the following three categories/types of eco-innovations: technological (including introduction of new technologies), management/system (including behavioral changes among managers and employees, creation of practices, programs, strategies, marketing activities), process (including changes in operations, performance improvement). The role of external stakeholders (like governments, competitors, consumers) and competitive advantage was also included into the group of categories. It should be mentioned that among the analyzed in this paper items/key findings there were also elements not suitable to be classified into any of the created above categories.

The own researches showed the scale and trends of interest in eco-innovations development mainly among the companies. Technological solutions are the leading theme in the sphere of eco-innovations development in companies. Among all analyzed categories the importance of eco-innovative technologies was mentioned in 29% of all results. Thus the present and future trends in eco-innovation development seem to bias more technologically when comparing to other two types of analyzed eco-innovations i.e.: management/system and process solutions. The role of management/system eco-innovations was also frequently mentioned by companies. They assessed eco-innovations (25% of results) as a group of opportunities allowing implement some solutions from the field of better practices and marketing activities. The importance of eco-innovations in the context of process improvements by companies is rather rare.

In the general group of scrutinized companies the highest frequency was attributed to the role of external stakeholders (i.e.: governments, competitors, consumers). From all assessed results about 32% related to the leading role of external bodies in supporting eco-innovation development. The structure of results collected during researches presents the figure 1.

[9] The data were retrieved from: C.C. Cheng, E.C. Shiu, *Validation of a proposed instrument for measuring eco-innovation: An implementation perspective*, „Technovation" 2012/32, p. 329–344.

Figure 1. The role of categories after eco-innovations assessment in companies



Source: The results of own researches.

It is worth mentioning that in the results related to external stakeholders the major attention was paid to the role of governments. According to the assessed projects on eco-innovations the regulating activity of governments is crucial success factor in the future development of this sphere. The stricter environmental regulations are assessed as a determinants, drivers, pressure and supporting elements for market creation. The need of firms to be compliant with governmental regulations is a decisive stimulator and probably a future trend setter.

As revealed the realized assessment, eco-innovations are rarely viewed as a competitive advantage for companies. This means that the beneficial role of eco-innovations was not grounded yet in the awareness of industry sector. This seems to be also a significant challenge for the national and regional governments in creation of future development policy for eco-innovations.

The highlighted in this chapter the most important outcomes of own researches on eco-innovation assessment inform on the most popular companies' activities in developing eco-innovations. It would be very useful to realize the similar researches in regional and national context in the future.

5. CONLUSIONS

The results of own researches cast a light on the present trends in eco-innovation measurement practices as well as possible development directions. The eco-innovation activities in the world companies are oriented to technology (29% of results). The second and in parallel the most visible trend in eco-innovation assessment made by companies is oriented to the role of external stakeholders (32% of results), especially governments. The government initiatives are assess as the most important factors triggering companies to adopt environmental practices as well as create the mar-

ket push and pull effects. As revealed the researches the trend in assessing eco-innovations as a significant benefit and competitive advantage is rare in companies.

When assessing the presented results it is worth of suggesting to realize similar researches in regional and national context in the future. The presented outcomes can be also compared with other researches on eco-innovation development trends. The methodology used in this paper should be also utilized as a reference basis in various scientific projects.

LITERATURE

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ŚWIATOWE TRENDY W OCENIE EKOINNOWACJI

W artykule poddano analizie wyniki oceny ekoinnowacji. Ekoinnowacje traktowane są jako rozwiązania minimalizujące negatywny wpływ na środowisko w stopniu większym niż ich dotychczasowe odpowiedniki. Z tego względu do ekoinnowacji zalicza się przede wszystkim: technologie zapobiegania zanieczyszczeniom, technologie kontroli zanieczyszczeń, technologie oczyszczające, czystsze technologie, środowiskowo ulepszone produkty, zamknięty obieg, systemy zarządzania środowiskowego, zarządzanie odpadami, środowiskową optymalizację łańcucha produktowego, innowację systemową. Duża liczba zróżnicowanych wskaźników sprawia, że podejmowanie decyzji w zarządzaniu strategicznym jest utrudnione, choć konieczne. Badania własne miały na celu identyfikację wiodących trendów w ocenie ekoinnowacji oraz skali zainteresowania nimi wśród światowych przedsiębiorstw. Analiza literatury w zakresie wyników uzyskanych po zastosowaniu wskaźników ekoinnowacji dostarcza istotnej wiedzy na temat międzynarodowych trendów badawczych. Przedmiotem niniejszej pracy jest 18 artykułów naukowych opublikowanych po udanej realizacji ekoinnowacyjnych projektów. Przeanalizowano je w kontekście 34 kluczowych wyników badań. Wśród zidentyfikowanych i uwzględnionych w analizie kryteriów oceny zainteresowania ekoinnowacjami znalazły się: ekoinnowacje technologiczne, ekoinnowacje systemowe/ze sfery zarządzania, ekoinnowacje procesowe, rola zewnętrznych interesariuszy we wsparciu ekoinnowacji, przewaga konkurencyjna jako korzyść posiadania ekoinnowacji. Wyniki przeprowadzonych w niniejszym artykule badań wskazują, że największym zainteresowaniem światowych przedsiębiorstw cieszą się technologie ekoinnowacyjne. W związku z tym obecne trendy wskazują na rosnącą rolę rozwiązań technologicznych w zestawieniu z ekoinnowacjami systemowymi (także w obszarze zarządzania) lub procesowymi.

Słowa kluczowe: ekoinnowacje, ocena ekoinnowacji, ekoinnowacje w przedsiębiorstwach, zarządzanie strategiczne

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