EKONOMIA i ŚRODOWISKO

ECONOMICS AND ENVIRONMENT

Journal of the Polish Association
of Environmental and Resource Economists

No. **4 (71)** • 2019

Ekonomia i Środowisko

ISSN 0867-8898
ISSN 2300-6420 (online)

Published by: Fundacja Ekonomistów Środowiska i Zasobów Naturalnych
15-092 Białystok, ul. Sienkiewicza 22
www.fe.org.pl; e-mail: czasopismo@fe.org.pl

Publishing: Agencja Wydawnicza EkoPress
Process Manager Andrzej Poskrobko / tel. 601 311 838

Printed by: Zakład Poligraficzny ARES s.c.
Roman Józefowicz / tel. 506 177 893

www: www.ekonomiaisrodowisko.pl

ECONOMICS AND ENVIRONMENT

Journal of the Polish Association
of Environmental and Resource Economists

EKONOMIA I ŚRODOWISKO

Czasopismo Polskiego Stowarzyszenia
Ekonomistów Środowiska i Zasobów Naturalnych

THEORETICAL AND METHODOLOGICAL PROBLEMS

ENVIRONMENTAL POLICY AND MANAGEMENT

STUDIES AND MATERIALS

GENERAL ENVIRONMENTAL AND SOCIAL PROBLEMS

DISCUSSION AND REVIEWS

THEORETICAL AND METHODOLOGICAL PROBLEMS

PROBLEMY TEORETYCZNE I METODYCZNE

Aleksandra **NOWAKOWSKA** • Małgorzata **GRODZICKA-KOWALCZYK**

CIRCULAR ECONOMY APPROACH IN REVITALIZATION: AN OPPORTUNITY FOR EFFECTIVE URBAN REGENERATION

Aleksandra **Nowakowska,** Associate Prof. (ORCID: 0000-0002-2912-4934) – *University of Lodz*
Małgorzata **Grodzicka-Kowalczyk,** MSc Eng. (ORCID: 0000-0003-0717-8584) – *University of Lodz*

Correspondence address:
Faculty of Economics and Sociology
Polskiej Organizacji Wojskowej Street 3/5, 90-255, Łódź, Poland
e-mail: aleksandra.nowakowska@uni.lodz.pl

ABSTRACT: The paper seeks to identify challenges and present opportunities the cities can take from applying circular economy (CE) based solutions in revitalization processes. In particular, the analysis focuses on revitalization areas and activities, which open up natural opportunities for implementing such CE based solutions. Successful examples of revitalization efforts undertaken in European cities illustrate and confirm the appropriateness and purposefulness of restoring degraded urban areas by transforming them into circular districts. For the purpose of the paper we conducted desk research and analysed the following sources: (1) subject matter literature, which we subjected to critical analysis; (2) reports and expert opinions drawn up by European and global institutions and organisations; (3) strategic documents of cities, which apply the CE idea in their revitalization efforts. The paper is the first attempt undertaken on grounds of Polish subject matter literature to combine CE related activities with urban regeneration.

KEY WORDS: circular economy, urban circular economy, sustainable development, revitalization process

Introduction

Cities as the fastest developing areas, which experience the most dynamic changes play key role in the transformation of global economy. This fact can be successfully exploited in the transition from the linear model to resource-saving economy based on circular business models. Already today almost 50% of the global population live in urban areas and by 2030 the percentage will increase to 60%. According to data presented in 2018 in *The circularity gap report. An analysis of the circular state of the global economy* about 75% of the global GDP originates directly from cities, which, at the same time, generate ca. 75% global carbon dioxide emissions and consume ca. 75% of global resources (Circle Economy, 2018). Obviously, advancing urbanisation increases the demand for housing, available infrastructure, transport, food and water, which, in turn, generates increasingly more waste, deteriorates the quality of natural environment, and restricts opportunities to pursue lasting and sustainable growth. For the above stated reasons, turning cities into leaders of environmentally-friendly changes seems to be a correct approach.

Urban social and economic systems that we currently know are, to a large extent, based on the exploitation of the easiest accessible environmental resources. Ecological footprint assessment published by the WWF in the report *EU Overshoot Day – Living Beyond Nature's Limits* announces 10th May 2019 as the *EU Overshoot Day* (WWF, 2019). It means that if the *ecological footprint* of every human being living on Earth were equivalent to the average *ecological footprint* of an EU resident (with regard to, inter alia, CO_2 emissions, food consumption, the use of timber and space), 10th May would mark the date by which resources of our planet would have been exhausted beyond what the planet's ecosystems can renew over the whole year. It is estimated that the EU societies, which account for only 7% of global population, use up almost 20% of the Earth's biological resources. The problem of consumption that exceeds natural capabilities to renew resources is a global one: Earth Overshoot Day falls earlier every year, in 2018 it fell on 1 August, while in 1997 on the end of September.

In this context, the implementation of circular economy concept in cities has become one of the major challenges of the urban policy over recent years. It is a new social, technological, environmental, and political challenge but also a great opportunity to add on dynamics to economic growth and create responsible and sustainable urban growth that actively engages a number of urban communities dealing with growth and development processes. Urban revitalization intensely pursued over the last three decades in European cities is a specific field, in which circular economy ideas are being implemented.

Revitalization comes as a response to the degradation of spatial, social, and economic structures inflicted by cyclical and "circular" qualities exhibited by cities (Van den Berg et al., 1982, pp. 24-45; Forrester, 1970; Cunningham, 2002). It aims at regenerating degraded areas and restoring their proper value. Revitalization and circular economy have got two ideas in common. First, both processes highlight the circularity of goods, as well as economic and spatial processes and view them as an inherent quality, which triggers degradation and the loss of utilitarian quality and value of goods or urban structures. Secondly, both approaches focus on the restoring of value and the reuse of resources that have been potentially "used up" in development processes. Degradation and consumption (of goods, products or urban structures) is not a final stage in the life cycle but becomes a challenge and the starting point for activities aimed at the regeneration, revival or giving new value to assets. In revitalization, as well as in circular economy, we can observe a specific sequence of processes and transformations. As a result, revitalization becomes an excellent platform for the implementation of circular economy idea into cyclical and circular urban setting.

The paper discusses challenges and opportunities stemming from the application of circular economy solutions in revitalization. In particular, the analysis focuses on revitalization areas and activities, which offer natural possibilities to implement circular solutions. The paper makes references to successful revitalization projects carried out in European cities, which deployed the CE idea.

Literature review

For over three decades the subject matter literature has been describing numerous theoretical concepts focused on the solution of contemporary environmental issues (e.g., concepts such as sustainable development, green economy or industrial ecology). Their common denominator is aiming at minimising the environmental impact of business activities. One of such solutions is the concept of circular economy also referred to as closed-loop economy, circle economy and described using different terms in different languages (Geissdoerfer et al., 2017, pp. 757-768; Ghisellini, Cialani, Ulgiati, 2016, pp. 11-32; Kirchherr, Reike, Hekkert, 2017, pp. 221-232). The idea of circular economy was developed and rose to fame thanks to the works of McDonough, Braungart, and Stahel (Braungart, McDonough, Bollinger, 2007, pp. 1337-1348; Stahel, 1982, pp. 72-96).

The CE concept originates from industrial ecology which postulates using biological analogies to create sustainable economic systems (Loiseau et al.,

2016, pp. 361-371; Romero, Molina, 2012, pp. 427-436). It highlights optimisation of material and energy flows in economic systems and stresses the need to design production processes taking account of local environmental ramifications and considering their global impact. That is indicative of the need to ensure collaboration of many groups of local actors in developing new business models thus creating a specific industrial symbiosis. Concepts related or identical with circular economy include *Cradle to Cradle* idea (Braungart, McDonough, 2002), the approach known as regenerative design (Lyle, 1996), *biomimicry* idea (Benyus, 1997) or *blue economy* concept. Circular economy is directly referred to as a new economic model that allows meeting social needs and offers fair use of resources without restricting regeneration capacity of our planet (Metabolic, 2018).

The inclusion of CE related activities in urban management gains in importance and opens up space for the implementation of numerous local innovations aimed at improving urban metabolism (Lindner, Mooij, Rogers, 2017). With regard to that, special attention is paid to waste management and its impact upon the condition of cities and areas neighbouring them; circular economy has for years been seen as a chance to reorganise the process. One interesting approach proposes resolving the problem of urban farrows, which often emerge as a consequence of linear economy, with eco-innovation solutions which, on the one hand, change their role in urban metabolism and, on the other hand, trigger circular processes which in the future will impact entire cities (Amenta, van Timmeren, 2018; Rigillo et al., 2018). New approach to streams of organic waste flowing through the urban environment, capturing and transforming them into energy or nutrients are an interesting area for studies and practical operations (Ellen MacArthur Foundation. Urban Biocycles, 2017). Conducted works show how much we can change urban governance by reducing high costs (economic and environmental) of organic waste disposal and turning waste into resource for further re-use by giving it new value. Another aspect touched upon in the context of CE in cities concerns the impact of urban processes on the condition of water or air and the engagement of urban communities as a new model of collaboration using the living labs method (Voytenko et al., 2016). Huge CE potential in the construction industry, the major sector using almost half of global natural resources mined every year, is also stressed. The report *Scaling the circular built environment – pathways for business and government* presented after COP24 (Katowice, Poland) argues that the construction industry is ready to embrace circular models but points to the need of putting in place bold changes in the forms of collaboration between the private and public sectors to work out new models for infrastructural investment projects also in degraded urban areas (Circle Economy, 2018).

So far, direct linkages between the CE idea and urban revitalization have not been broadly discussed in foreign subject matter literature. Limited pool of first works available in this area focus on the identification of areas in which CE principles are implemented in revitalized cities, as well as on ways, in which the efficiency of such solutions is measured. Studies and activities geared towards the implementation of CE principles in revitalization carried out in eight European harbour cities (Amsterdam, Rotterdam, London, Antwerp, Hamburg, Marseille, Lisbon, and Porto) surely merit our attention. In the case of these cities stress was put on the analysis of effects of CE related solutions and the re-inclusion of urban ecosystems in districts which have got derelict combined with the generation of tools helpful in monitoring cities after they have experienced circular revitalization (Gravagnuolo, Angrisano, Girard, 2019).

Conducted projects and studies highlight the complexity of both revitalization processes as well as the multidimensional implementation of circular economy idea. The Netherlands is a leading example of such approach to revitalization in Europe and the country's experience and the experiences of some other cities (e.g., Charlotte (USA) circular strategy *Circular Charlotte. Towards a zero waste and inclusive city*) assume using a vast proportion of municipal waste generated annually and the creation of new jobs (Metabolic, 2018). In Glasgow (UK) when the Athletes' Village was being built for the Commonwealth Games held in the city in 2014 parts of Glasgow got revitalized and developed into a CO_2-neutral district (Glasgow Chamber of Commerce) demonstrating the efficiency and effectiveness of CE related activities in ensuring the sustainability of urban development and the auto-regeneration abilities of cities.

Research methods

We carried out desk research of sources such as:

- critical analysis of subject matter literature,
- reports and expert opinions drawn up by European and global institutions and organisations, in particular: United Nations, WWF, European Commission, The Ministry of Infrastructure and the Environment (The Netherlands), Ellen MacArthur Foundation, Circle Economy,
- strategic documents of the following cities: Amsterdam, Prague, Glasgow, and Maribor.

This is a theoretical paper which seeks to demonstrate how the CE idea can become part of revitalization processes. It is the first attempt to combine

activities within the area of circular economy with urban regeneration described in the Polish subject matter literature.

Research results

According to the first *Circularity Gap Report* launched in Davos in January 2018 by Circle Economy the world is only 9.1% circular (based on the global *circularity metric*). Amounts of resources necessary to meet global needs increase at a significant rate: it is estimated that total extraction of fossil raw materials (metal ores, minerals, and biomass) will more than double between 2015 and 2050 growing from 84.4 Gt to at least 170 Gt at the estimated increase of global population by ca. 32% (United Nations, Population Division, 2019). Against this background, the still dominant linear model of economic growth stands no chance of proving itself in the modern world or successfully contributing to stop its degradation. The transition to circular management of urban systems is a precondition for solving environmental problems.

The shift from today's linear economic model to circular economy consists predominantly in gradual change of the mindset, mainly in revealing new benefits that may be drawn from already existing processes. Circular economy viewed as an economic system expected to replace the "end-of-life" approach with the reuse, recycling, and recovery of materials at production, distribution and consumption stages concerns micro, mezzo, and macro levels (city, region, country). Its goal is to achieve sustainable development, high quality environment, prosperity, and social equality for the benefit of present and future generations (Kirchherr, Reike, Hekkert, 2017). Hence, we are not expected to come up with a revolutionary, totally new and alternative idea of the economy but to gradually transform the current linear economy into circular one and work out appropriate models that reduce the consumption of external resources.

Waste, generated by transforming natural raw materials in production processes, is tangible final outcome of linear economy. Production process has got a twofold negative environmental impact. The first one is connected with the acquisition of often non-renewable resources. The second one links with the distribution of waste, by-products of production, which cannot be used any more. Circular economy idea promotes the development of systems that would be independent of natural resources and using materials and production processes that could ensure the longest durability of products and reduce negative environmental impact to zero.

Cities are key elements in the building of circular economy. Urban areas and growing needs of their residents generate the main destructive factors for the environment. At the same time, cities are sources of social capital necessary to put in place changes. Cities, as centres capable to absorb suburban units or come together to create, e.g., metropolitan zones are also exceptionally dependent on their environment when it comes to, e.g., supplies of resources indispensible to operate or dispose waste.

Circular economy is viewed as an opportunity to trigger sustainable growth, especially to develop auto-regeneration capabilities in cities. Principles of circular economy applied in urban governance are expected to reduce the amount of waste and – as a result of the application of innovative technologies – support its reuse. In order for such solutions to be operational we need collaboration between the city and the private sector (Palafox et al., 2017). The role and status of cities may change from "contributors to the drainage of natural resources" to "contributors to the closing of circularity gap". Cities may become independent of external resources and, taking advantage of their huge social and economic importance, become leaders and platforms for the implementation of circular economy solutions.

Circular economy is seen as a solution that enables to improve the quality of life at reduced consumption of resources but, importantly, without the need to give up meeting already identified social needs (e.g., in consumption or access to housing) provided they are met in innovative way. The evolution of cities towards circular business models may help in resolving many problems, however, this solution is not free from challenges. Special attention should be paid to the solution, which, if implemented, may impact the independence of urban structures. Solutions pertaining to circular economy may help in solving the problem of water and energy shortages (e.g., by generating energy from bio-waste or energy recovery from industry). Buildings and other infrastructural elements are abundant resources which can be reused. Reused construction materials can save resources, reduce waste disposed in landfills and reduce the consumption of energy needed to produce "from scratch". It is vital to reuse unoccupied urban areas and "recycle" degraded sites. Green areas in cities may be used as regulators of urban climate, air, and water and, at the same time, provide space for growing food and leisure. Urban structures contain important infrastructure that enables recycling of resources, their reuse and recovery, e.g., greywater recycling systems or waste processing plants (Williams, 2019).

In situation when planet's resources are being depleted, available urban space is "shrinking", and in the face of growing population in urban areas, preventing degradation of urban structures leading to their "hibernation" is a big challenge. Revitalization of degraded urban areas, which ensures not

only elimination of problems and their root-causes but also guarantees sustainability of their effects is a relatively new approach in urban policy. By introducing solutions pertaining to circular economy into revitalization we may, on the one hand, boost the effects of the process and, on the other hand, foster synergy mechanisms and their diffusion in individual areas of revitalization (table 1).

Table 1. Areas and challenges in the implementation of CE in revitalization

Revitalization areas	Implementation of CIRCULAR ECONOMY
SOCIAL	• increased awareness of environmental impact, • openness to collaboration aimed at co-creating the city, • increased awareness of the role of natural environment for the quality of life, • switching to responsible behaviours in taking care of the environment, • changing the approach to the consumption of goods, • openness to cultural diversity.
ECONOMIC	• drafting innovative business models with restricted financial risk, • identification of value chains promoting collaboration of urban actors, • support to the collaboration between the city and the private sector.
ENVIRONMENTAL	• rainwater reuse, • efficient management of municipal resources, • using renewable energy sources, • creating self-regenerating urban ecosystems, • ensuring biodiversity.
FUNCTIONAL – SPATIAL	• launching spatial planning mechanisms consistent with circular economy rules, • introduction of spatial planning tools that consider research management of resources, such as water, heat, etc., • engaging private investors in planning.
TECHNICAL	• strengthening the role of tools used to estimate maintenance costs of planned infrastructural investment, • implementing solutions geared towards the recovery of construction materials in revitalization, • collaboration with construction industry, in particular with construction chemistry in urban revitalization while using recovered materials, • implementing adaptation-based solutions in infrastructure.

Source: authors' own work based on Williams, 2019.

In the opinion of the European Commission, the change of the operating model should help European cities to create secure jobs, promote innovation that ensures competitive advantage, and provide opportunities for developing new environmental protection tools. As a result, consumers should get access to more durable and innovative products, be able to save money and enjoy higher quality of life (EC, 2015). Actions proposed by the EU are

expected to contribute to "closing the loop" of product life cycle through increased recycling and reuse, bringing benefits to the environment, as well as the economy. New targets for recycling were also adopted (selected): 65% for municipal waste recycling by 2035, 70% for packaging waste by 2030, paper and cardboard: 85%, ferrous metals: 80%, aluminium: 60%, glass: 75%, plastic: 55%, and wood: 30%. In addition, a binding landfill target was laid down to reduce landfill to maximum 10% of municipal waste by 2035 (http://ec.europa.eu/environment/circular-economy/index_en.htm). It is also assumed that the accomplishment of the above listed targets will necessitate significant engagement of society and local authorities and will also have important impact upon the rate of transformation of European cities towards the circular model.

The Netherlands, European leader in the implementation of circular solutions at the local level, aims at significant reductions in the consumption of raw materials (e.g., fossil raw materials) – in accordance with regulations adopted for the country and presented in 2016 in the strategy *A Circular Economy in the Netherlands by 2050 Government-wide Programme for a Circular Economy* – by 2030 consumption is supposed to be reduced by 50% compared to the current level. Moreover, the country's ambition is to arrive at a situation when in 2050 resources will be used exclusively in processes that do not generate environmental losses. Already today, many sectors of the Dutch economy actively apply the reuse principle. Last but not least, the Dutch strongly stress the need to engage many local actors, develop collaboration between local authorities, NGOs, entrepreneurs, and residents and highlight the important role each of these stakeholders have to play.

Amsterdam is one of the first cities which got engaged into activities geared towards the transition to circular economy. The city sees huge potential of such a solution and the current strategy deployed to put circular solutions in place focuses mainly on two sectors: construction (it is estimated that by reusing construction materials for building residential buildings the city would be able to build 70 thousand new homes by 2040 generating savings in the order of EUR 85 mio annually) and organic waste (the use of highly valuable organic waste may give the city around EUR 150 mio annually over the period of five to seven years). The report worked out for Amsterdam includes guidelines for the remodelling of value chains in the city to stimulate innovation, business opportunities and creating new jobs in the already existing as well as in newly created sectors (Circle Economy, 2016).

On the list of Amsterdam activities there are pilot projects implemented in the form of CityLab, in which circular innovations are tested. Buiksloterham – a former industrial neighbourhood and – because of its past industrial function – the most polluted site in Amsterdam is a good example of such a

project. In 2015, in accordance with the strategy worked out by an organisation called Metabolic, authorities of the city of Amsterdam in cooperation with more than 20 different organisations and firms launched a process of transforming Buiksloterham into a sustainable circular district. The area operates like an urban laboratory receiving constant support from the city. Each investment project must meet sustainable development norms with respect to the construction of buildings, waste management, electricity, and heating or cooling of buildings. As a result of these actions the site becomes an attractive place to live and work. Circular Buiksloterham strategy is geared towards providing energy self-sufficiency of the neighbourhood, construction of buildings of recovered materials, maximum savings in water consumption, ensuring biodiversity, flexible infrastructure, as well as ensuring safe and attractive environment for residents. The district is a living urban lab and a testing ground for solutions in the field of stakeholder collaboration, implementation of new technologies or meeting social expectations. Below (table 2) we can find the main assumptions of the *Transitioning Amsterdam to a Circular city. Circular Buiksloterham* strategy that delineates actions by 2034 (Metabolic, 2014). In the case of Buiksloterham, as well as other neighbourhoods in Amsterdam (e.g., Haven-Stad, De Ceuvel), activities implemented since 2015 and intended to bring degraded city areas back to life using eco-innovative solutions have already produced positive effects.

Table 2. Assumptions of Circular Buiksloterham Development Strategy by 2034

Area of city functioning	Overarching Goals
Energy	Buiksloterham is energy self-sufficient with a fully renewable energy supply
Materials & products	Buiksloterham is a zero waste neighbourhood that with a near 100% circular material flow
Water	Buiksloterham is rainproof and has near 100% resource recovery from waste water
Ecosystems and biodiversity	Buiksloterham's ecosystems are regenerated and its base of natural capital is self-renewing
Infrastructure & mobility	Infrastructure is maximally-used and local mobility has zero emissions
Socio-cultural	Buiksloterham has a diverse and inclusive culture, and a high quality, livable environment
Economy	Buiksloterham has a strong local economy that stimulates entrepreneurship and encourages the creation and exchange of multiple kinds of value (social, environmental, cultural)
Health & wellbeing	Buiksloterham is a healthy, safe and attractive environment with recreational activity space for all residents

Source: Metabolic, 2014.

Increasingly more cities in Western Europe decide to implement circular strategies. Prague is one of the recent cases. The capital city of the Czech Republic views circular economy as a way to become a resilient city that offers its residents opportunities to practice more sustainable lifestyle, and helps firms in practicing innovation and respecting environmental resources. In *Circular Prague* report drafted in 2019 the following three areas are highlighted as priorities, in which changes are planned: construction industry (so far only 10% of materials used in this industry have originated from secondary sources), households (expected to be able to reuse up to 70% of currently produced bulky waste), and biomass management (mainly to generate biofuel to meet the needs of the city) (Circle Economy, 2019). Another good example is Maribor, a city whose 12% of area is assessed as degraded and, as such, a target for revitalization deploying circular solutions. *Strategy for the transition to circular economy in the Municipality of Maribor* points, inter alia, to the regeneration of degraded soil and its reuse in order to create biologically active sites (Wcycle Institute Maribor, 2018).

Conclusions

The CE concept is gaining in popularity and has become not just an intellectually attractive theoretical concept but a strategic challenge and a goal of activities undertaken within the framework of urban policy. Respecting the idea of circular economy is in its infancy and is little disseminated in the context of urban regeneration. However, the concept offers huge opportunities for achieving sustainable and effective revitalization processes. Circular economy gives cities a package of solutions, which, if used properly with the engagement of parties who can impact urban development, seek to reduce or even eliminate factors that contribute to urban degradation. By using circular solutions we can make cities self-sufficient and able to regenerate.

The transition of cities to circular economy model calls for the change in approach to the management of urban space and requires to openly embrace eco-innovations in revitalized neighbourhoods, which are often the most valuable areas for the economy and for local communities. Whenever new functions are being introduced using innovative and environmentally-friendly methods, often viewed as "revolutionary", the process should deeply engage all local actors to foster sustainability, effectiveness, and efficiency of revitalization efforts.

The implementation of circular economy principles strengthens the complementary dimension and synergy of activities undertaken as part of regeneration. Hence, revitalized areas can not only be "cured" by circular projects

but also become "drivers" of circular changes initiated in the structure of the city.

The contribution of the authors

Aleksandra Nowakowska – 50% (concept, research method, literature review, analysis and conclusions).

Małgorzata Grodzicka – Kowalczyk – 50% (concept, literature review, analysis and conclusions).

Literature

Amenta L., Van Timmeren A. (2018), *Beyond Wastescapes: Towards Circular Landscapes. Addressing the Spatial Dimension of Circularity through the Regeneration of Wastescapes*, "Sustainability" No. 10(12), 4740, DOI: 10.3390/su10124740

Benyus J. (1997), *Biomimicry – Innovation Inspired by Nature*, William Morrow, NYC

Van den Berg L. et al. (1982), *Urban Europe. A study of Growth and Decline,* Pergamin Press, pp. 24-45

Braungart, M., McDonough W. (2002), *Cradle to Cradle, Remaking the Way We Make Things*, North Point Press, New York

Braungart M., McDonough W., Bollinger A. (2007), *Cradle-to-cradle design: creating healthy emissions – a strategy for eco-effective product and system design*, "Journal of Cleaner Production" Vol. 15, Issues 13-14, pp. 1337-1348

Circle Economy (2016), *CIRCULAR AMSTERDAM, A vision and action agenda for the city and metropolitan area*, Amsterdam, The Netherlands

Circle Economy (2018), *The CIRCULARITY GAP report. An analysis of the circular state of the global economy*, Amsterdam, The Netherlands

Circle Economy (2019), *CIRCULAR PRAGUE,* Amsterdam, The Netherlands

Cunningham S. (2002), *Restoration economy*, Berrett – Koehler Publishers, San Francisco

Ellen MacArthur Foundation (2017), *Urban Biocycles*, Ellen MacArthur Foundation, Isle of Wight, UK

European Commission (2015), *Communication from the European Commission to the European Parliament, the council, the economic and social committee, and the committee of the regions, Closing the loop – An EU action plan for the Circular Economy,* Brussels, COM(2015) 614

European Commission (2019), *Circular Economy Strategy*, www.ec.europa.eu/environment/circular-economy/index_en.htm [15-06-2019]

Forrester J.W. (1970), *Urban dynamics*, The MIT Press, Cambridge Mass

Geissdoerfer M. et al. (2017), *The Circular Economy – A new sustainability paradigm?*, "Journal of Cleaner Production" Vol. 143, pp. 757-768, DOI: 10.1016/j.jclepro.2016.12.048

Ghisellini P., Cialani C., Ulgiati S. (2016), *A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems*, "Journal of Cleaner Production" Vol. 114, pp. 11-32, DOI: 10.1016/j.jclepro.2015.09.007

Glasgow Chamber of Commerce (2019), *Circular Glasgow & The Business of Cities, The Circular Economy & Cities Implications & Imperatives*

Gravagnuolo A., Angrisano M., Girard L.F. (2019), *Circular Economy Strategies in Eight Historic Port Cities: Criteria and Indicators Towards a Circular City Assessment Framework*, "Sustainability" No. 11, 3512, pp. 2-24, DOI: 10.3390/su11133512

Kirchherr J., Reike D., Hekkert M. (2017), *Conceptualising the Circular Economy: An analysis of 114 definitions*, "Resources, Conservation and Recycling" Vol. 127, p. 221-232, DOI:10.1016/j.resconrec.2017.09.005

Lindner P., Mooij C., Rogers H. (2017), *Circular Economy in Cities around the World*, Blekinge Institute of Technology Karlskrona, Sweden

Loiseau E. et al. (2016), *Green Economy and Related Concepts: An Overview*, "Journal of Cleaner Production" No. 139, pp. 361-371, DOI:10.1016/j.jclepro.2016.08.024

Lyle J.T. (1996), *Regenerative Design for Sustainable Development*, John Wiley &Sons, INC

Metabolic (2014), *Transitioning Amsterdam to a Circular city. Circular Buiksloterham*, Amsterdam

Metabolic (2018), *A roadmap for building circular value chains. Guidelines for regional research and identifying synergies*, Amsterdam

Metabolic (2018), *Circular Charlotte. Towards a zero waste and inclusive city,* Amsterdam

The Ministry of Infrastructure and the Environment and the Ministry of Economic Affairs, also on behalf of the Ministry of Foreign Affairs and the Ministry of the Interior and Kingdom Relations (2016), *A Circular Economy in the Netherlands by 2050 Government-wide Programme for a Circular Economy,* The Netherlands

Palafox G. et al. (2017), *The Little Book of CIRCULAR ECONOMY in cities*, Lancaster University

Rigillo M. et al. (2018), *Eco-Innovative Solutions for Wasted Landscapes*, *RI-VISTA Ricerche per la progettazione del paesaggio*, p. 146-159

Romero D., Molina A. (2012), *Green Virtual Enterprise Breeding Environments: A Sustainable Industrial Development Model for a Circular Economy*, Collaborative Networks in the Internet of Services. IFIP Advances in Information and Communication Technology, 380, pp. 427-436

Stahel W. (1982), *The product-life factor. In An inquiry into the nature of sustainable societies: The role of the private sector*, The Woodlands USA, pp. 72-96

United Nations, Population Division, Department of Economic and Social Affairs (2019), *World Population Prospects 2019, File POP/1-1: Total population (both sexes combined) by region, subregion and country, annually for 1950-2100, Medium fertility variant, 2020-2100,* online edition

Voytenko Y. et al. (2016), *Urban living labs for sustainability and low carbon cities in Europe: Towards a research agenda*, "Journal of Cleaner Production" No. 123, pp. 45-54, DOI: 10.1016/l/jclepro.2015.08.053

Wcycle Institute Maribor (2018), *Strategy for the transition to circular economy in the Municipality of Maribor*, Maribor, Slovenia

Williams J. (2019), *Circular Cities: Challenges to Implementing Looping Actions*, "Sustainability" No. 11(2), 423, DOI: 10.3390/su11020423

WWF (2019), *EU Overshoot Day – Living Beyond Nature's Limits, Report 2019*, Global Footprint Network, Brussels, Belgium, www.euractiv.pl/section/energia-i-srodowisko/news/od-dzis-unia-europejska-zyje-na-ekologiczny-kredyt/ [15-06-2019]

Anna MATEL • Tomasz POSKROBKO

COULD SURVEY TECHNIQUE OR OTHER RESEARCH CONDITIONS "CHANGE" OUR ECOLOGICAL BEHAVIOUR? – TESTING RESPONSE BIAS IN CONSUMER RESEARCH

Anna **Matel,** PhD Eng. (ORCID: 0000-0002-4239-914X) – *University of Bialystok*
Tomasz **Poskrobko,** PhD Eng. (ORCID: 0000-0002-6981-8180) – *University of Bialystok*

Correspondence address:
Faculty of Economics and Finance, University of Bialystok
Warszawska Street 63, 15-062, Białystok, Poland
e-mail: a.matel@uwb.edu.pl

ABSTRACT: Based on concerns raised in other disciplines, the presented study aimed to investigate whether response bias affects the results of declarative research on ecological behaviour. The study was conducted in order to determine how the design and execution of declarative tests influenced the obtained results. A series of experiments was conducted in which the research techniques, persons delivering the surveys, or order of questions were changed or modified, or where little incentives were used. The tests showed that the results of declarative research on ecological behaviour is subject to response bias. The respondents declared rarer non-ecological behaviour in face-to-face interviews than in surveys, when the study was conducted by a lecturer, and when they were first asked to express their opinion on this type of behaviour. This effect weakened as the respondents answered further questions in the survey.

KEY WORDS: response bias, ecological behaviour, sustainable consumption, survey technique, consumer research

Introduction

Studies on consumer behaviour are carried out in two basic ways: using stated and revealed preference method (Louviere, 2000). In this study we investigate the first approach. Declarative tests are favored when the studied phenomenon is not directly observable, such as individuals' beliefs and attitudes (Lenzner et al., 2011). A range of studies, especially in the field of psychology, indicate that results obtained in this manner are flawed (Brutus et al., 2010; Ioannidis, 2007; Krosnick, 1999; Krosnick et al., 2002), especially in self-reported questions (Bruce and Desmond, 1997; Caputo, 2017). Some respondents tend to avoid effort they have to put in understanding and interpreting the question, retrieving the relevant information from memory, integrating this information and reporting (Tourangeau and Rasinski, 1988). Respondents tend to avoid the way of thinking named by D. Kahneman (2011) as slow one and tend to think fast. They simply give intuitive responses to find this argument plausible. Such response strategy is defined as *satisficing* (a combination of the words *satisfy* and *suffice*). It means that a respondent gives more or less superficial responses that appear reasonable or acceptable, without going through all the steps involved in the question-answering process (Holbrook et al., 2003; Krosnick, 1991). Consequently, there is inconsistency between the behaviour declared and exhibited in real life. Literature refers to this phenomenon as response bias (Paulhus, 1991). This subject has not been fully explored in studies on consumers' ecological behaviour or, broadly, sustainable consumption. In effect, response bias is ignored at the design and execution stage of research, and when researchers formulate their conclusions based on the results of declarative tests (Ioannidis, 2007). That is why we have undertaken to find out whether response bias can significantly modify the declared ecological behaviours of consumers.

An overview of the literature

D. L. Paulhus (1991) defined response bias as "a systematic tendency to respond to a range of questionnaire items on some basis other than the specific item content (i.e. what the item was designed to measure)". According to R.E. McGrath et al. (2010) response bias is "a consistent tendency to respond inaccurately to a substantive indicator, resulting in systematic error in prediction". It may be caused or reinforced by a wide range of factors related to the design or execution of a study, including:

(1) change of survey technique,

(2) change of person conducting the survey,

(3) using little incentives,
(4) changing the order of questions in the survey.

Declarative tests can produce different results depending on the used surveying technique, what is known in literature as mode effect (Cannell et al., 1981; Doušak, 2017). The applied technique affects the respondents' engagement (Holbrook et al., 2003), defines their level of anonymity (Vanderhoven et al., 2012), develops willingness to answer sensitive questions (Burkill et al., 2016) and tendency to provide socially accepted answers (Triki et al., 2017; Yang et al., 2017).

Respondents show tendencies to reduce their engagement especially when the test is carried out using a technique which gives them control over its execution time. For example, such control is greater in telephone than in face-to-face interviews. Control over the duration of the experiment is even greater in respondents who fill out paper questionnaires or do electronic survey (Holbrook et al., 2003; Marta-Pedroso et al., 2007).

Mode effect is also related with the degree of anonymity (Vanderhoven et al., 2012). Respondents are not willing to admit to embarrassing, socially unacceptable behaviour or beliefs if the surveying technique does not provide them with a sufficient feeling of anonymity (Paulhus, 1984). F. Kreuter et al. (2008) observed that in web survey the level of reporting of sensitive information increased in comparison with computer-assisted telephone interviewing (CATI) research. K. S. Chan et al. (2004) observed similar relations. Such relationship is also connected with an aspiration to provide socially desirable responses, which is called social desirability bias. It means the tendency to underreport socially undesirable behaviors as well as over report more desirable attributes (Latkin et al., 2017) and is often motivated by the desire to avoid embarrassment and repercussions from disclosing sensitive information (Tourangeau, Yan, 2007).

The analysed variable, which may result in response bias, is also the person conducting the survey. Experimenter demand effect refers to situations where the subjects try to read the experimenter's intentions through a set of provided guidelines (Fleming and Zizzo, 2013). The effect comes from social conformity as well as the power of the experimenter's social authority. This means that it is likely to obtain different results depending on who is conducting the survey, how the respondents read the experimenter's intentions, and how they perceive his or her authority.

Another phenomenon related to declarative research is the effect of order (McFarland, 1981). It refers to how the order of survey questions affects the obtained results. For example M. C. Rousu et al. (2017) found that self-reported health outcomes were worse when smokers were first asked to report their weight. D. L. Lasorsa (2003) asked participants to rate their interest in

politics, as well as assessed their political knowledge. He found that respondent who first were asked to answer difficult political knowledge questions declared lower interest in this area.

The last tested form of response bias is an influence of using little incentives on the data quality (Castiglioni et al., 2008; Mutti et al., 2014). The influence of monetary incentives are broadly analyzed in literature (Booker et al., 2011), especially in terms of response rate (Singer and Ye, 2013). According to E. Simmons and A. Wilmot (2004), such incentives have a stronger effect than gifts like for example lottery tickets.

Research methods

The conducted study aimed to assess how declared ecological behaviour is affected by: the research technique (face-to-face interviews, paper and pencil research), person conducted the study (student, lecturer), receiving small incentives for participation taking the survey (organic sweets), and the order of questions (behaviour and opinions). Response bias testing was based on methodological indication discussed by A. L. Holbrook et al. (2003). According to them (1) different groups of people should be interviewed in different way, (2) respondents should not participate in similar research to avoid practice effects (3) there should not be reassignment (respondents who refuse to be interviewed in one mode should not then be interviewed in another mode), (4) respondents should not be able to choose the way they are interviewed (Holbrook et al., 2003).

The main part of the questionnaire comprised two matrix questions (figure 1). The first question regarded behaviours considered unecological, while the second regarded the level of respondents' approval for such behaviours. The surveyed behaviours included:

(1) taking a shortcut across a lawn (hereafter referred to as behaviour no. 1 and opinion no. 1),
(2) using disposable plastic bags (behaviour no. 2, opinion no. 2),
(3) leaving the tap on while brushing (behaviour no. 3, opinion no. 3),
(4) leaving the lights on while leaving a room (behaviour no. 4, opinion no. 4).

The questions about behaviours employed a five-degree scale (1 – very often; 2 – fairly often; 3 – sometimes; 4 – sporadically, 5 – never). According to J. R. Rossiter (2011) such scale is the most exposed for response bias. The arithmetic means of answers were analyzed (the higher it was the more ecologic behaviour respondents declared) – $\bar{x}_n$, where: $\bar{x}$ – *arithmetic mean of respondents' answers, n – the number of the experimental group according to table 1.*

The questions about opinions also employed a five-degree scale, where: 1 – I definitely don't approve of such behaviours; 2 – I generally don't approve of such behaviours; 3 – no opinion; 4 – I generally approve of such behaviours; 5 – I definitely approve of such behaviours. Also, we analyzed the arithmetic mean of the answers, but this time the higher it was the less ecologic opinions respondents declared.

1. How often do you behave in those ways:

	very often	fairly often	sometimes	sporadically	never
taking a shortcut across a lawn					
using disposable plastic bags					
leaving the tap on while brushing					
leaving the lights on while leaving a room					

first matrix

2. What is your attitude towards those behaviours:

	I definitely don't approve of such behaviours	I generally don't approve of such behaviours	no opinion	I generally approve of such behaviours	I definitely approve of such behaviours
taking a shortcut across a lawn					
using disposable plastic bags					
leaving the tap on while brushing					
leaving the lights on while leaving a room					

second matrix

Figure 1. The design of basic version of the questionnaire

Source: author's own work.

The differences in the mean results were analysed statistically using the difference of mean test ("t-test") and the two sample Kolmogorov–Smirnov test ("K-S test") to assess the accordance of variable distribution. The calculations were done in SPSS. In total, the study was conducted on a sample of 866 students of the University of Bialystok Faculty of Economics and Management, who were divided into 9 study groups. There was additional group of students who were asked to assess the difficulty of each question (N=60). According to table 1, three groups (no 1, no 2, no 3) were conducted by a lecturer teaching a course of environmental economics and other by a student.

Three groups (no 1, no 4, no 8) were surveyed using the direct interview method. Two groups (no 3, no 6) were surveyed with using small incentives to participate in the study. In one group (no 7) the order of matrices was changed – first the respondents were asked about their opinion, and then about their behaviour. In two groups (no 8, no 9), the order of questions within the matrices was changed.

Such selection of groups was intended to create the possibility of pair-wise comparison. In the given set, there was at least one pair of groups that differs only by one factor (controlled experimental variable) while the other experimental conditions remind unchanged. This allowed to deduce that the observed discrepancies were due to the change of the controlled variables. Thus, groups no 1 and no 2 as well as groups no 4 and no 5 differed only in the research technique. Groups no 1 and no 4 as well as groups no 2 and no 5 differed only by the person who conducted research. Groups no 2 and no 3 as well as groups no 5 and no 6 differed only in the use of incentives. Groups no 5 and no 7 differed only in the order of matrices. Finally, groups no 4 and no 8 as well as groups no 5 and no 9 differed only in the order of questions within the matrices.

Table 1. The size and conditions of study groups

a person conducted research		interview (only basic version)	questionnaire		
			basic version	using incentives	whole matrix reversed
lecturer (only basic version)		group 1 N=97	group 2 N=100	group 3 N=95	-
student	basic version	group 4 N=102	group 5 N=101	group 6 N=101	group 7 N=80
	question within the matrix reversed	group 8 N=88	group 9 N=102	-	-

Source: author's own work.

Women constituted a majority (68.6%) of all respondents. 69.3% respondents were aged between 20 and 23. More than half of them (59.1%) reported that they originated from a town or a city.

Results of the research

Research technique and declared ecological behaviours

In the first experiment, the research technique was the controlled variable. The experiment was carried out in two rounds – the first one conducted by a lecturer, the other by a student (groups no 1 and no 2 as well as no 4 and 5 were compared). The aim was to assess whether respondents avoid declaring non-ecological behaviours when surveyed face-to-face.

Table 2. The comparison of respondents' declarations depending on the research technique employed

Question	in surveys conducted by lecturer			in survey conducted by student		
	interview – questionnaire $\bar{x}_1 - \bar{x}_2$	t-test	K-S test	interview – questionnaire $\bar{x}_4 - \bar{x}_5$	t-test	K-S test
behaviour 1	3.25-2.79	0.002**	0.030**	3.03-2.73	0.085*	0.196
behaviour 2	2.51-2.27	0.164	0.884	2.44-2.29-	0.060*	0.615
behaviour 3	4.16-4.26	0.570	0.980	4.15-4.18	0.594	1.000
behaviour 4	3.34-3.34	0.999	1.000	3.5-3.26	0.563	0.769
opinion 1	3.18-3.19	0.913	1.000	2.75-3.09	0.019**	0.046**
opinion 2	2.84-2.81	0.816	0.907	2.66-2.7	0.749	1.000
opinion 3	4.20-4.05	0.352	0.995	4.06-4.27	0.103	0.499
opinion 4	3.56-3.72	0.252	0.902	3.77-3.63	0.361	0.930

** statistically significant difference at significance level of 0.05
* statistically significant difference at significance level of 0.10

Source: author's own work.

The respondents declared more pro-ecological behaviours when the survey used face-to-face methods. Statistically significant differences in the experiment which was carried out by the lecturer were only observed in the first question concerning behaviour. In the experiment carried out by the student both the first and second question about behaviour and the first question on opinions showed statistically significant differences. This may mean that some response bias occurred, although the effect weakened over the course of the experiment.

The results of the experiment indicate that there is a relation between the research technique used and the response to the first question. This confirms that the research technique affects the strength of the declared ecological

attitude. Yet it is still uncertain whether this deviation is due to the specificity of the question or the fact that it was asked as the first one in the survey.

Therefore, the experiment was carried out once again, but this time the order of questions was reversed. This means that the question about *behaviour 1* last in the matrix, *behaviour 2* was penultimate, and so on. The survey was carried out by a student.

Table 3. The comparison of respondents' declarations depending on the research technique employed with question within the matrix reversed

Question	interview-questionnaire $\bar{x}_8 - \bar{x}_9$	t-test	K-S test
behaviour 1	3.04-2.48	0.004**	0.393
behaviour 2	2.84-2.68	0.455	0.979
behaviour 3	4.11-4.07	0.862	0.873
behaviour 4	3.61-3.29	0.091*	0.486
opinion 1	3.18-2.84	0.057*	0.094*
opinion 2	2.95-3.03	0.706	0.908
opinion 3	4.27-4.03	0.141	1.000
opinion 4	3.77-3.66	0.547	0.802

Source: author's own work.

With the order of questions reversed within each matrix, the declared responses on damage to green areas (behaviour 1) were nevertheless significantly different, even though this time the question was posed last. The change in order did not reduce the mode effect. This indicates that the question itself may be somewhat specific and would cause response bias no matter where it is placed in the survey. However, there were also statistically significant differences (at 0.10) in declarations on leaving the lights on, which was the subject of the first question after reversing the matrix. This confirms that the first question in the survey is the most likely to suffer from response bias.

The experiment did not identify, however, the reasons for the consistent deviation in the question about damaging green areas. According to previous research (Podsakoff et al., 2011), difficult questions are more likely to suffer from mode effect, especially the complex, abstract or ambiguous items. This indication led us to ask another group of respondents (N=60) to assess the level of difficulty of answering the each of the posed questions. We employed a six-degree scale, where: 1 was very easy to answer and 6 was very difficult to answer. When it comes to questions concerning behaviours, the respond-

ents found question no. 1, about taking a shortcut across a lawn, to be the most difficult (4.0 difficulty rank). Similarly ranked was question no. 4 (3.88 difficulty rank). The question no. 2 was found easier by the respondents (3.63 difficulty rank). However, when it comes to assessing the difficulty of expressing opinions, the respondents considered the most difficult questions 1 (4.00 difficulty rank) and 2 (4.08 difficulty rank). Such observation confirms that questions considered by the respondents difficult and requiring cognitive effort are particularly exposed to the occurrence of mode effect.

Interviewer's influence on declared ecological behaviours

Next, the study looked into whether the ecological behaviours declared by respondents are affected by the person carrying out the survey. An influence of the interviewer/poller was checked in interview and questionnaire by comparison the results obtained in research conducted by lecturer teaching a course in environmental economics and student. It was hypothesized that respondents will declare more ecological behaviour when research is conducted by the lecturer, especially in interviews.

Table 4. The comparison of respondents' declarations depending on the interviewer

Question	in interviews			in questionnaires		
	lecturer-student $\bar{x}_1 - \bar{x}_4$	t-test	K-S test	lecturer-student $\bar{x}_2 - \bar{x}_5$	t-test	K-S test
behaviour 1	3.25-3.03	0.122	0.075*	2.79-2.73	0.698	1.000
behaviour 2	2.51-2.44	0.711	1.00	2.27-2.28	0.914	0.998
behaviour 3	4.16-4.15	0.917	1.000	4.26-4.18	0.608	0.983
behaviour 4	3.34-3.50	0.293	0.999	3.34-3.26	0.594	0.998
opinion 1	3.18-2.75	0.03**	0.010**	3.19-3.09	0.455	1.000
opinion 2	2.85-2.66	0.222	0.638	2.81-2.70	0.451	0.862
opinion 3	4.20-4.06	0.332	0.911	4.05-4.26	0.132	0.901
opinion 4	3.56-3.77	0.149	0.113	3.72-3.63	0.555	0.742

Source: author's own work.

Changing the interviewer resulted in a significant difference in the respondents' declared behaviour only in the case of face-to-face surveys. Moreover, the change was only noted in the first question, both in matrix one and two. It is anticipated that the power of authority only works in face-to-

face conditions and has no effect in surveys filled out in paper. Also, it can be expected that the influence of the interviewer would diminish across further questions in the survey.

Little incentives and declared ecological behaviours

Next, the study looked into whether the ecological attitude declared by respondents is affected by receiving little incentives. The influence was evaluated in the survey conducted by both the lecturer and the student.

Table 5. The comparison of respondents' declarations depending on rewards for the respondents

Question	surveys conducted by lecturer			survey conducted by student		
	without rewording – with rewording $\bar{x}_2 - \bar{x}_3$	t-test	K-S test	without rewording – with rewording $\bar{x}_5 - \bar{x}_6$	t-test	K-S test
behaviour 1	2.79-2.79	0.997	1.000	2.73-2.60	0.395	1.000
behaviour 2	2.27-2.14	0.417	0.986	2.29-2.31	0.892	0.994
behaviour 3	4.26-4.05	0.229	0.792	4.18-4.16	0.906	0.817
behaviour 4	3.34-3.21	0.434	0.939	3.26-3.18	0.627	0.817
opinion 1	3.19-3.25	0.649	0.999	3.09-3.00	0.519	0.969
opinion 2	2.81-2.81	0.997	0.851	2.70-2.70	1.000	1.000
opinion 3	4.05-4.04	0.961	0.973	4.27-4.23	0.752	1.000
opinion 4	3.72-3.64	0.594	0.836	3.63-3.59	0.798	1.000

Source: author's own work.

No significant changes due to the reward were observed. What is more, it did not matter whether the rewards were given by the student or the lecturer. The use of incentives did not affect the respondents' average declarations on ecological behaviour nor the distribution of their answers.

Order of questions and declared ecological behaviours

The final analysed variable in the study was the influence of the order of questions. The original version of the survey had respondents first declaring statements about ecological behaviours, followed by their opinion on the

subject. The experiment tested whether changing the sequence of questions would have a significant influence on the obtained results. The order of questions within the matrix was not altered, but rather the order of whole matrices. It is hypothesised that respondents avoid declaring non-ecological behaviour when they are first asked to express their opinion on the subject in question.

Table 6. The comparison of respondents' declarations depending on order of questions in the questionnaire

Question	behaviour asked first – opinion asked first $\bar{x}_5 - \bar{x}_7$	test-t	K-S test
behaviour 1	2.73-3.10	0.012*	0.901
behaviour 2	2.29-2.76	0.004*	0.737
behaviour 3	4.18-3.91	0.154	0.201
behaviour 4	3.26-3.23	0.853	0.996
opinion 1	3.09-3.23	0.387	0.092
opinion 2	2.70-2.95	0.130	0.142
opinion 3	4.27-4.04	0.149	0.642
opinion 4	3.63-3.74	0.533	0.992

Source: author's own work.

After reversing the order of questions, the respondents declared that they are less likely to conduct the two first of the analysed non-ecological behaviours. This means that they declared more pro-ecological behaviour if they were first asked to express their opinion. It is expected that the subjects endeavoured to keep their answers consistent and did not want to admit to behaviour that did not go in line with the opinion they expressed earlier. This resulted in a tendency to diminish the frequency of declared non-ecological behaviour.

Discussion

In general, results of the research correspond with relevant studies so far. It reveals that the results of research based on self-reported declarations are exposed to response bias, as was indicated in many studies (e.g. Bruce and Desmond, 1997; Caputo, 2017). Thus, this type of research requires special attention at the stage of design as well as at implementation stage in order not to affect respondents' answers. In our study, the technique influenced the

answers given by the respondents (similarly: Doušak, 2017; Holbrook et al., 2003; Vanderhoven et al., 2012; Burkill et al., 2016). Our results are similar to those obtained by C. Marta-Pedrosoa et al. (2007) who observed that respondents declared higher willingness to pay for preserving the Cereal Steppe of Castro Verde in direct interview than in web survey. We observed, as in study by A. Triki et al. (2017), that during direct interviews respondents are prompted to provide socially acceptable answers. Respondents were less prone to admit non-ecological behaviours. It corresponds with research conducted by F. Kreuter et al. (2008), where the number of responses to sensitive information increased with the level of respondents' anonymity (similarly: K.S. Chan et al., 2004).

In our research the relations between question difficulty and mode effect was observed. It confirms the relation indicated by P.M. Podsakoff et al. (2012) who revealed that complex, abstract or ambiguous questions are subject to response bias.

In presented research respondents' declarations concerning ecological behaviours were influenced by the person who conducted the survey. Such effect, described by P. Fleming and D.J. Zizzo (2013), is often observed in experiments. In our study the effect was only observed in direct research. The difference between respondents' answers was insignificant in case of paper-and-pencil interviews. We presume that social conformity – responsible for this effect – occurred only in face-to-face contact with the person considered as authority. What is more the research results could depend on the power of the experimenter's social authority, which remains unknown in our research.

The research conducted confirmed that the order of questions in the questionnaire influences respondents' answers. We assume that in our study it was due to respondents' willingness to maintain consistency throughout the questionnaire. This observation is similar to that described by M. C. Rousu et al. (2017), where smokers declared their health outcomes as weaker after reporting their weight. We think that respondents in our research underreported their non-ecological behaviours when firstly they expressed their opinion about themselves.

In our research we have not observed any impact of incentives on research results. In the literature the impact of monetary incentives is usually undertaken (Booker et al., 2011). We used smaller incentives (ecological sweets). According to our research with little incentives to encourage respondents to attend research does not generate response bias.

Conclusions

Summing up, the research results indicated that response bias should be consider as a potential problem in ecological behaviour research. It was shown that the research technique, person carrying out the survey, and the order of questions in the questionnaire may affect the ecological behaviours declared by respondents. There was no observed influence of using small incentives. The strength of response bias weakened over the course of responding to further survey questions. This means that the initial questions in the survey are the most susceptible to error. It was also observed that the strength of mode effect is greater in questions which are perceived by the respondents as difficult. In general respondents declared less non-ecological behaviour when the survey was carried out in the form of face-to-face interviews, no matter who conducted it (lecturer or student). Respondents declared less non-ecological behaviour when they were first asked to express their opinion on the subject in question.

Research revealed that researchers can unconsciously influence the results of a declarative research, in this case exploring respondents' ecological behaviour. We suppose that non-ecological behaviours are generally negatively evaluated within society. Hence, people can avoid admitting them in declarative research, especially if they are asked directly. This in turn indicates, that this type of behaviour should be explored using methods that ensure anonymity. In particular, direct research – like face-to-face interviews – should not be conducted by a person who is known and recognized as an authority by respondents. We recommend not to ask respondents in the first place for expressing their self-opinion about non-ecological behaviours and then – their own behaviours. This is because non-ecological behaviours are usually socially undesirable. Some respondents, after expressing disapproval for them, might try to adjust responses on their behaviours to their previous answers. This is because respondent tend to maintain consistency throughout their answers.

The contribution of the authors

Anna Matel – 50% (conception, literature review, acquisition of data, analysis and interpretation of data).

Tomasz Poskrobko – 50% (conception, literature review, acquisition of data, analysis and interpretation of data).

Literature

Booker C.L., Harding S., Benzeval M. (2011), *A systematic review of the effect of retention methods in population-based cohort studies*, "BMC Public Health" No. 11, p. 249, DOI:10.1186/1471-2458-11-249

Bruce A.S., Desmond S.A. (1997), *Limitations of Self-Report Delinquency Surveys: A "Hands-on" Approach*, "Teaching Sociology" No. 25, p. 315-321, DOI:10.2307/1319300

Brutus S., Gill H., Duniewicz K. (2010), *State of Science in Industrial and Organizational Psychology: A Review of Self-Reported Limitations*, "Personnel Psychology" No. 63, p. 907-936, DOI:10.1111/j.1744-6570.2010.01192

Burkill S. et al. (2016), *Using the Web to Collect Data on Sensitive Behaviours: A Study Looking at Mode Effects on the British National Survey of Sexual Attitudes and Lifestyles*, "PLOS ONE" No. 11, p. 1-12, DOI:10.1371/journal.pone.0147983

Cannell C.F., Miller P.V., Oksenberg L. (1981), R*esearch on Interviewing Techniques*, "Sociological Methodology" No. 12, p. 389-437, DOI:10.2307/270748

Caputo A. (2017), *Social desirability bias in self-reported well-being measures: Evidence from an online survey*, "Universitas Psychologica" No. 16(2), DOI: https://doi.org/10.11144/Javeriana.upsy16-2.sdsw

Castiglioni L., Pforr K., Krieger U. (2008), *The Effect of Incentives on Response Rates and Panel Attrition: Results of a Controlled Experiment*, "Survey Research Method" No. 2(3), p. 151-158, DOI:10.18148/srm/2008.v2i3.599

Chan K.S. et al. (2004), *The interview mode effect on the Center for Epidemiological Studies Depression (CES-D) scale: an item response theory analysis,* "Medical Care" No. 42, p. 281-289

Doušak M. (2017), *Survey Mode as a Moderator of Context Effects*, "Advances in Methodology & Statistics" No. 14, p. 1-17

Fleming P., Zizzo D.J. (2013), *Experimenter Demand Effects and Altruism Towards the Experimenter by Piers Fleming*, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2248639 [15-07-2019]

Holbrook A.L., Green M.C., Krosnick J.A. (2003), *Telephone versus Face-to-Face Interviewing of National Probability Samples with Long Questionnaires: Comparisons of Respondent Satisficing and Social Desirability Response Bias*, "Public Opinion Quarterly" No. 67, p. 79-125, DOI:10.1086/346010

Ioannidis J.P.A. (2007), *Limitations are not properly acknowledged in the scientific literature*, "Journal of Clinical Epidemiology" No. 60, p. 324-329, DOI:10.1016/j.jclinepi.2006.09.011

Kahneman D. (2011), *Thinking, fast and slow*, New York, Farrar, Straus and Giroux

Kreuter F., Presser S., Tourangeau R. (2008), *Social Desirability Bias in CATI, IVR, and Web SurveysThe Effects of Mode and Question Sensitivity*, "Public Opinion Quarterly" No. 72, p. 847-865, DOI:10.1093/poq/nfn063

Krosnick J.A. (1999), *Survey Research,* "Annual Review of Psychology" No. 50, p. 537-567, https://doi.org/10.1146/annurev.psych.50.1.537

Krosnick J.A. (1991), *Response strategies for coping with the cognitive demands of attitude measures in surveys*, "Applied Cognitive Psychology" No. 5, p. 213-236, DOI:10.1002/acp.2350050305

Krosnick J.A., Alwin D.F. (1987), *An evaluation of a cognitive theory of response – order effects in survey measurement*, "Public Opinion Quarterly" No. 51, p. 201-219, DOI:10.1086/269029

Krosnick J.A. et al. (2002), *The Impact of No Opinion Response Options on Data Quality: Non-Attitude Reduction or an Invitation to Satisfice*?, "Public Opinion Quarterly" No. 66, p. 371-403, DOI:10.1086/341394

Lasorsa D.L. (2003), *Question-Order Effects in Surveys: The Case of Political Interest, News Attention, and Knowledge,* "Journalism&Mass Communication Quarterly" No. 80(3), p. 499-512

Latkin C.A. et al. (2017), *The relationship between social desirability bias and self-reports of health, substance use, and social network factors among urban substance users in Baltimore, Maryland*, "Addictive Behaviours" No. 73, p. 133-13, DOI:10.1016/j.addbeh.2017.05.005

Lenzner T., Kaczmirek L., Galesic M. (2011), *Seeing Through the Eyes of the Respondent: An Eye-tracking Study on Survey Question Comprehension*, "International Journal of Public Opinion Research" No. 23, p. 361-373, DOI: 10.1093/ijpor/edq053

Louviere J.J. (2000), *Stated Choice Methods: Analysis and Applications*, University Press, Cambridge

Marta-Pedroso C., Freitas H., Domingos T. (2007), *Testing for the survey mode effect on contingent valuation data quality: A case study of web based versus in-person interviews*, "Ecological Economics" No. 62, p. 388-398, DOI: 10.1016/j.ecolecon.2007.02.005

McFarland S.G. (1981), *Effects of Question Order on Survey Responses*, "Public Opinion Quarterly" No. 45, p. 208-215, DOI:10.1086/268651

McGrath R.E. et al. (2010), *Evidence for response bias as a source of error variance in applied assessment*, "Psychological Bulletin" No. 136, p. 450-470, DOI:10.1037/a0019216

Mutti S. et al. (2014), *Prepaid monetary incentives-Predictors of taking the money and completing the survey: Results from the International Tobacco Control (ITC) Four Country Survey*, "Sociological Methods & Research" No. 43, p. 338-355, https://doi.org/10.1177/0049124113506406

Paulhus D.L. (1991), *Measurement and control of response bias, in: Measures of Personality and Social Psychological Attitudes*, in: J.P. Robinson, P.R. Shaver, L.S. Wrightsman (eds.), *Measures of personality and social psychological attitudes*, Academic Press, San Diego, p. 17-59

Paulhus D.L. (1984), *Two-component models of socially desirable responding*, "Journal of Personality and Social Psychology" No. 46, p. 598-609, https://doi.org/10.1037/0022-3514.46.3.598

Podsakoff P.M., MacKenzie S.B., Podsakoff N.P. (2011), *Sources of Method Bias in Social Science Research and Recommendations on How to Control It*, "Annual Review of Psychology" No. 63, p. 539-569, https://doi.org/10.1146/annurev-psych-120710-100452

Rossiter J.R. (2011), *Measurement for the Social Sciences: The C-OAR-SE Method and Why It Must Replace Psychometrics*, Springer-Verlag, New York

Rousu M.C., O'Connor R., Bansal-Travers M. (2017), *Smokers' BMI and perceived health: Does the order of questions matter?,* "Preventive Medicine Raport" No. 5, p. 140-143

Simmons E., Wilmot A. (2004), *Contents Incentive Payments on Social Surveys: a Literature Review, "*Social Survey Methodology Bulletin" No. 53, p. 1-11

Singer E., Ye C. (2013), *The Use and Effects of Incentives in Surveys*, "Annals of the American Academy of Political and Social Science" No. 645, p. 112-141

Tourangeau R., Rasinski K. (1988), *Cognitive processes underlying context effects in attitude measurement*, "Psychological Bulletin" No. 103, p. 299-314

Tourangeau R., Rips L.J., Rasinski K. (2000), *The Psychology of Survey Response by Roger Tourangeau,* Cambridge University Press, Cambridge, DOI:10.1017/CBO9780511819322

Triki A., Cook G.L., Bay D. (2017), *Machiavellianism, Moral Orientation, Social Desirability Response Bias, and Anti-intellectualism: A Profile of Canadian Accountants*, "Journal of Business Ethics" No. 144, p. 623-635

Vanderhoven E. et al. (2012), *Face-to-Face Peer Assessment in Secondary Education: Does Anonymity Matter, "*Procedia – Social and Behavioral Sciences, International Conference on Education & Educational Psychology" (ICEEPSY 2012) No. 69, p. 1340-1347, DOI:10.1016/j.sbspro.2012.12.071

Yang J. et al. (2017), *Are Sex Effects on Ethical Decision-Making Fake or Real? A Meta -Analysis on the Contaminating Role of Social Desirability Response Bias*, "Psychological Reports" No. 120, p. 25-48, DOI:10.1177/0033294116682945

ENVIRONMENTAL POLICY AND MANAGEMENT

POLITYKA EKOLOGICZNA I ZARZĄDZANIE ŚRODOWISKIEM

Anna **DUBEL** • Mariusz **TRELA**

FINANCIAL EFFICIENCY ANALYSIS OF PV PLANTS IN POLAND UNDER THE EVOLVING SUPPORT SCHEME

Anna **Dubel,** PhD (ORCID: 0000-0001-5474-2147) – *AGH University of Science and Technology*
Mariusz **Trela,** PhD (ORCID: 0000-0001-8376-7554) – *AGH University of Science and Technology*

Correspondence address:
Gramatyka Street 10, 30-067, Kraków Poland
e-mail: adubel@zarz.agh.edu.pl

ABSTRACT: Financial efficiency analysis of PV plants with a capacity of 1 MWp is presented in the paper, taking into account two RES-E support schemes, which have been implemented in Poland. The aim of the paper is to analyze how the RES-E support mechanisms for Poland impact the actual investor's financial results. The compared RES-E support mechanisms are the following: the auction system (an option of a feed-in-tariff scheme) implemented recently in Poland and the 'green certificates' system, which has been in operation for over a decade now. Financial efficiency analysis method with the sensitivity analysis is implemented to determine the conditions for the most financially effective PV investments. The results show the crucial factors of financial efficiency of the PV farms, which are also discussed in view of the conducted sensitivity analysis, which takes into account changes in the analyzed parameters. The study explores the current policies influencing the conditions of investments in PV plants in Poland providing information for policy makers, investors and researchers interested in the solar energy domain.

KEY WORDS: efficiency analysis, PV farm, auction system, green certificates

Introduction

Our experience of dealing with the potential PV farms investors in Poland shows, that their reluctance to adopt the PV systems is mostly related to the perceived high risk of an investment. This high risk is mostly attributed to the legal ecosystem and financial efficiency of the technology, both adding to the expected profit uncertainty. Therefore, in the paper we examine the profitability factors related to the PV investments under different RES-E support schemes in Poland. This should help the investors to make the better-informed decisions about investments in solar PV systems.

Very important factors for the financial efficiency analysis of PV farms are related to the specific features of the investments size and location, such as solar conditions or grid connection requirements (Dubel, Trela, 2014). Application of multi-criteria decision analyses (Sánchez-Lozano et al., 2016) can help to determine the most favourable locations for the PV investments.

There is a high potential worldwide for the implementation of the RES and especially PV technologies. The Bloomberg New Energy Finance (New Energy Outlook, 2015) is forecasting that declines in the cost of photovoltaic technology (of about 60% by the year 2040 compared to the costs from 2015) will drive a 3,7 trillion USD investments in solar, both large-scale and small-scale, of which 2,2 trillion USD will be attributed to installations on rooftops and other local PV systems, handing consumers and businesses the ability to generate their own electricity. The solar energy will become the cheapest way of producing energy in many countries during the 2020s and 2030s. Its price is expected to decline significantly in this period.

Although Poland is classified among the European developed countries with regard to the PV energy implementation, it still needs to catch up with the countries more advanced in this development. The energy sector in Poland is still dominated by hard coal and lignite industries. (Frost, Sullivan, 2016). The target of energy share from renewable sources in gross final consumption of energy for Poland is at the level of 15%, to be reached by the year 2020 (GUS, 2013).

In order to reach desirable RES targets and incentivise the RES-E production, including PV electricity generation, various schemes have been implemented in the EU Member States to promote this source and to overcome investors' reluctance towards such investments. The main existing policies, diverse among the EU Member States, comprise (Ragwitz et al., 2005a): feed-in tariffs, quota obligations based on tradable green certificates, investment grants, tender procedures and tax measures. The identified (Ragwitz et al., 2005a) key barriers to the mainstreaming of RES-E in the EU countries include: administrative, financial and social issues as well as insufficient elec-

tricity grid capacity. Moreover, the economic efficiency of RES-E support is perceived lower than it would be possible in an advanced policy environment and the level of "risk associated with RES-E investments is still evaluated as comparatively high by the relevant financial institutions in some markets" (Ragwitz et al., 2005a). Building-up on these concerns financial efficiency of PV systems under the evolving support scheme in Poland is analyzed in the paper.

The comprehensive review of support instruments for renewable electricity conducted by Ragwitz et al. in 2005 shows that the best progress towards the RES-E targets was achieved in countries with stable support systems and low overall barriers for the development of RES-E, i.e. Denmark, Finland, Germany and Spain. Rodrigues et al 2016 studied several countries, including Australia, Brazil, China, Germany, India, Iran, Italy, Japan, Portugal, South Africa, Spain, United Kingdom, and the United States of America, to identify the most profitable conditions and places for PV investments and indicated Australia, Germany, and Italy as the best countries.

Case studies dealing with determination of the PV plant economic efficiency as well as the results and profitability of various PV support schemes have been identified (Moreira et al., 2003; Trela, Dubel, 2014; Azofra et al., 2015; Cervone et al., 2015; Liu et al., 2015; Rodrigues et al., 2016; Bakhshi, Sadeh, 2016) to build the developed analysis upon these findings.

Evolution of PV support scheme in Poland

Driven by the EU directives (e.g. Directive 2009/28/EC) and strategies (e.g. Energy, 2020) the polish energy sector has been undergoing constant changes (RES Law 2015, Energy Law 1997 with later changes). The brief history of the polish support scheme in relation to EU and other EU Member States policies is presented.

With the adopted RES Law in June 2016 and Regulation of the Ministry of Economy on the reference price in 2016 Poland moved from quota obligations based on tradable green certificates to the auction-based system as an option of a feed-in tariff system. In 2005 (Ragwitz et al., 2005b) Poland was developing a certificate system to support its already existing obligation scheme. In the European Union also Sweden and Romania as well as Belgium, UK and Italy (in combination with other approaches) had a quota obligation systems (Ragwitz, 2013). It can be observed that the countries with the mixed systems have the most effective schemes, for which they were pro-actively searching. The studies delivered within the RE-SHAPING project, aiming at providing help to the EU Member States in the RES Directive imple-

mentation, showed the disproportion between the minimum to average solar PV generation costs ranging between 270 to 420 EUR/MWh and average to maximum remuneration is at the level of about 120 EUR/MWh in Poland. At the same time in Poland potential profit rate is assumed to be negative and the policy effectiveness indicator is 0%, according the RE-SHAPING studies. Taking the above into consideration together with the mentioned extremely low PV RES-E production in Poland, initiative towards the modification of the PV support scheme in the country is justified and substantiated.

Analysis of the situation on the electricity market in Poland within the framework of the operating support systems

Acting in Poland since 2005, the system of so called "green certificates" does not currently fulfil its function, primarily because the market price of certificates of energy origin is so low (43.91 PLN/MWh; based on the OZEX_A, access on the 12.10.2017) that in combination with the average price of electricity sold on the competitive market (162.50 PLN/MWh; based on Information of the President of the Energy Regulatory Office No. 65/2017 – average price for the second quarter of 2017) cannot guarantee the return of investment costs incurred in the case of many RES installations. Moreover, the prices of the green certificates have been decreasing dramatically over the past few years (see figure 1), and therefore in many cases the investment decisions concerning the construction of renewable electricity installations have been made under the assumptions of investment income that has not been matching the market realities.

In figure 1 the prices of the certificates of origin of electricity produced in renewable energy sources in the period from the 1st of March 2009 till the end of 2016 (PMOZE_A) are presented. Property rights to the certificates of origin of electricity produced in renewable energy sources prior the 1st of March 2009 are considered as different financial instrument and therefore they are not shown in figure 1.

These assumptions had sometimes led to calculations of the energy prices used for the RES investments' analyses at the level of twice the current market price of energy sales. As a consequence, the actual revenues for a given period of many RES investments are less than the sum of operating costs and financial costs (the vast majority of investments use bank loans as an additional source of financing), leading to bankruptcy in the long run. Despite numerous market signals of a negative return on investment, so far no big wave of bankruptcies has yet occurred. This is due to the fact that almost every RES investment has been co-financed from the EU funds and in

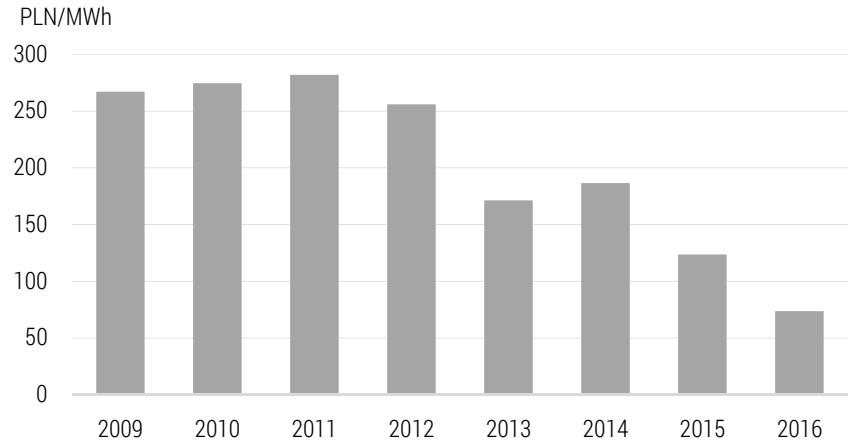


Figure 1. Average annual prices of property rights arising from certificates of origin for electricity from renewable sources ("green certificates") in Poland in 2009-2016 [PLN]

Source: author's own work based on TGE.

such case an investor would be required to return the subsidy received if the project long-term performance is not shown (usually in 5 years time). Therefore, it is often more financially justified to produce electricity at a loss demonstrating the long-term performance of the project than to terminate the activity.

The reason for such sharp falls in prices of certificates is their oversupply, which main reasons are as follows:

1. Granting of equal rights to biomass and coal co-firing technologies as well as other technologies for obtaining certificates of origin of electricity production – one certificate for one MWh of electricity (until 2016). The low investment required to implement this technology in relation to revenues from energy sales led to the rapid development of this technology and, consequently, the "production" of a large number of so-called green certificates.
2. Allowing substitute fees, regardless of the possibility of acquiring the certificates and the price of the property rights resulting from certificates of electricity production origin, has led to the situation where an entity obliged to present a certain amount of green certificates sometimes decided to pay a much higher replacement fee instead of buying certificates of origin. This decision was taken by small entities in view of the transaction costs associated with the complexity of the acquisition pro-

cess and the subsequent remission of certificates of electricity production origin.

3. The lasting validity of certificates of origin in the subsequent years after the year in which the energy was produced on one hand is the obvious consequence of giving the property rights to the producer for a unit of produced energy, on the other hand, causes the green certificates to accumulate on the market. This, coupled with the recent surpluses of their supply, has led to the ever-lower levels of the green certificates market prices.

The failure of this support system, limiting the possibilities of development of renewable energy sources in Poland, has forced action to reform it. As the result an auction system under the Renewable Energy Act of the 20th of February 2015 was introduced. This has had far-reaching consequences in the approach to investing in renewable energy sources in Poland. The investors, whose power plants have produced electricity since the 1st of July 2016, could already benefit from this support system based on the auction system. On the other hand, the investors who started electricity production before the 1st of July 2016 can theoretically choose whether they will continue to reckon up in the 'green certificates' system or whether they will benefit from the auction system. The difference, however, is that in the case of "new" producers the contract for the sale of energy is signed for 15 years, whereas in the case of existing installations, the length of the contract is 15 years counted from the start of energy production by the installation. This means de facto that for the existing installations the auction price is guaranteed for the number of years to complete the operation of a given installation up to 15 years. Thus, in the profitability analyses of different installations carried out with standard assumptions, revenue from the sale of electricity for each of the renewable energy generation technologies should be higher in the auction system than in the 'green certificates' scheme. Therefore, it could have been assumed that the auction system is absolutely superior to the system based on certificates of electricity production origin, as it guarantees higher return on investment and thus leads to the development of the RES market in Poland compared to the current situation. However, to determine whether this is the case in market reality, it is advisable to analyze the auctions that have already taken place and the ones that are planned within the framework of this system.

The first auctions in Poland were announced on the 30th of November 2016 and took place on the 30th of December 2016. These were auctions concerning the production of electricity in the following installations:

1. Existing installations with a power of no more than 1 MW using only agricultural biogas. Auction prices were between 502.23 PLN/MWh and 504.57 PLN/MWh.
2. Existing installations with a power greater than 1 MW using only agricultural biogas. The auction was not conducted because of too few bids.
3. New installations with a capacity of no more than 1 MW using other RES, such as photovoltaic, wind power, hydro power plants, etc. Auction prices received were between 253.50 PLN/MWh and 408.80 PLN/MWh.
4. Existing installations with an installed capacity of no more than 1 MW, meeting the criterion of the installed capacity of electric power above 3504 MWh/MW/year and with an emissivity of no more than 100 kg/MWh (in particular: some hydropower plants). Auction prices received were between 30.00 PLN/MWh and 468.00 PLN/MWh.

More auctions were announced on the 29th of May 2017 and took place on the 29th and 30th of June 2017. These were auctions related to the production of electricity in installations analogous to those in points 3 and 4 of the 2016 auctions presented above. The auctioned prices were at the level of 195.00-398.87 PLN/MWh and 290.00-474.00 PLN/MWh, respectively.

The other auctions scheduled for 2017 were announced on the 23rd of August 2017 and should have taken place on the 28th of September as well as on the 2nd, 4th and 6th of October 2017. These auctions were related to the production of electricity in existing installations:

1. with installed capacity of no more than 1 MW, meeting the criterion of the installed capacity of electric power above 3504 MWh/MW/year (in particular: non-agricultural biogas plants, biomass units and some hydro power plants),
2. with installed capacity of more than 1 MW, meeting the criterion of the installed capacity of electric power above 3504 MWh/MW/year (in particular: non-agricultural biogas plants, biomass units and some hydro power plants),
3. with installed capacity of no more than 1 MW using only agricultural biogas,
4. with installed capacity of more than 1 MW using only agricultural biogas.

However, due to the entry into force of the new regulation on the maximum quantity and value of electricity from renewable energy sources, which can be sold by auction in 2017, three of these auctions were cancelled (on the 2nd, 4th and 6th of October), and on the one, which actually took place, it was assumed that the volume of energy sales was 0 MWh.

After the first turbulent period, the auction system stabilized and the announced auctions were not canceled. However, this have not changed the fact that the prices obtained during these auctions has constituted a big

unknown for the owners of PV installations, especially those with a capacity above 1 MWp. In the auction announced on October 2, 2018, the maximum price obtained at the auction for PV installations with a capacity above 1 MWp was at the level of 216.99 PLN/kWh, while for installations with a capacity of up to 1 MWp, the price ranged from 288.99 to 364.99 PLN/MWh. Such a difference in no way reflects the difference in the unit costs of constructing a PV installation with a capacity below 1 MWp and above 1 MWp, which are comparable in both cases. However, it resulted mainly from the structure of the auction basket combining PV investments with wind farms and form the volume of energy intended for purchase under this auction.

Based on the analysis of prices obtained during the auctions in 2016 and in the mid 2017, it should be noted that they are significantly higher than those that could be obtainable under the green certificates scheme. However, the current functioning of the auction system indicates still a very high uncertainty of the RES market in Poland. Earlier, in the green certificates scheme, the uncertainty was related to the price of property rights and in the auction system it is related to the government preferred technology of energy production and quantity of contracted energy. For instance, photovoltaic technology for installations with a capacity of more than 1 MW in general is not foreseen for support in 2016 and 2017.

In the paper, however, it was decided to carry out an analysis of a photovoltaic installation with a power greater than 1 MW assuming that the technology would receive government support in the near future. In the absence of such support, the analysis remains valid as the investment and operating costs of installations of approximately 2 MW are proportionally higher than the most popular installations currently installed in Poland with a capacity of slightly less than 1 MW.

Method and assumptions

An important efficiency question related to the PV energy production arises: whether the larger incentive is sufficient to cause that in the conditions of the auction system, investors will create a photovoltaic farm based on the so-called 'trackers' (movable frames) instead of 'standard' power plant, in which cells are mounted on fixed racks. In order to answer this question a comparative analysis was conducted comparing financial parameters determining the profitability of investments involving construction of photovoltaic farm with a capacity of 1 MWp, where the cells are placed on a fixed racks, to the investments in the similar farms using 'trackers'. Main assumptions are presented in table 1.

Table 1. Assumptions used in the comparative analysis of financial parameters influencing the financial efficiency of a PV farm

Categories	fixed racks	mobile racks
Period of analysis [years]	15	
Interest rate (discount rate) [%]	4	
Investment costs [PLN]	2773522	3328226
PV panels, supporting construction, inverters, wires, etc. [PLN]	2511222	3021477
Supporting construction [PLN]	539016	1097992
Fence [PLN]	72450	101429
Monitoring [PLN]	43120	51744
Alarm system [PLN]	34230	41076
The design & paperwork for the project [PLN]	50000	50000
Connection to the energy grid [PLN]	62500	62500
Operational costs [PLN]	70625	125291
Insurance fee (0.4% of investment cost) [PLN]	10045	12086
Tax on construction (2% of the supporting construction value) [PLN]	10780	21960
Land mortgage [PLN]	20000	28000
Service [PLN]	12000	38325
Business activity property tax [PLN]	17800	24920
Subsidies (funding) [PLN]	1238505	1464189

Source: author's own work.

The presented in the table 1 financial assumptions are adopted based on the bidding offers from the constructors. The values represent the average values of 3 collected offers in 2019. A 15-years period of calculation is adopted due to the fact that the auction system guarantees the purchase of energy at a fixed price for 15 years starting from the launch of the electricity production facility.

Degradation rate of panels is estimated at the level of 0.8% per annum and it will be at the level of 80% of their performance after 25 years of usage, according to the warranty provided by the manufacturers about the performance of photovoltaic panels.

Insurance fee for a photovoltaic farm is assumed to be 0.4% of the value of the investment on the basis of information obtained from the insurance company Gothaer.

Tax on construction (2%) is calculated only with regard to the supporting structure according to the judgment of the Provincial Administrative Court in Opole of 13 June 2014 (ref. No. Act: I SA/Op 327/14).

The loan interest rate is assumed to be 4% based on the market analysis of investment credits for companies (adopted instalment annuity).

It is assumed that in the first year (year of the investment construction) it is necessary to take out a loan for the entire amount of gross investment. It is assumed that the repayment of the loan would occur after 2 months, when the funding from the European Union will be received.

To determine the amount of funding from the EU it is assumed that the entrepreneur obtains financing at level of 60% of the investment eligible costs, calculated on the basis of paragraph 41.6b of the EU Regulation No 651/2014. The regulation specifies that 'the cost of investment in the production of energy from renewable sources can be determined by reference to similar, less environmentally friendly investment, which would likely be carried out in the absence of the aid'. The difference between the costs of both investments determines the cost of renewable energy and constitutes the eligible costs of investment. The reference (benchmark) investment in the electricity production, according to the interpretation of the Polish Ministry of Infrastructure and Development, 'a traditional power plant with the same capacity in terms of effective production of energy' should be considered. Therefore, a power plant fuelled by natural gas, which is able to produce the same amount of electricity as a planned photovoltaic farm, is chosen as a benchmark investment in the analysis. So, according to the methodology the cost of natural gas power plant is deducted from the cost of the photovoltaic system (the specification of costs is based on the offer price of the manufacturer).

The calculations are made in fixed prices, the discount rate is assumed at 4% – based on the "Guidelines for issues related to the preparation of projects from 2014 to 2020". Depreciation is assumed linear at the level of 7%. However, it should be noted that from the point of view of calculating the income tax, only the part of the investment that has not been subsidized is subject to depreciation. It is assumed that in the case of 'trackers' the repair costs of moving parts amounts to an annual average of 1.5% of the total cost of frames (21 525 PLN). The initial price for 1 MWh of electricity is determined at the level of 385 PLN per MWh, based on the provisions of the polish Law on Renewable Energy Sources (paragraph 39.1) and based on a draft of Regulation of the Ministry of Economy on the reference price in 2019, specifying the reference price for this type of installation, according to presented auction mechanism.

Basically, for all the above assumptions, the following sales prices for electricity are taken into consideration:

- for PV installations in the 'green certificates' scheme:
  - 391.72 PLN/KWh – for both types of PV panels set up: fixed racks and trackers,
  - 247.21 PLN/MWh – average selling price of electricity on the competitive market according to Q2 2019 (Statement of the President of the Energy Regulatory Office),
  - 144.51 PLN/MWh – price of the contract PMOZE_A ('green certificate') on the5.11.2019,
- for PV installations with stationary frames in the auction system: 310.64 PLN/KWh,
- for PV installations with mobile racks in the auction system: 322.16 PLN/KWh.

Results

Taking into account the above assumptions, the basic financial parameters of investment in photovoltaic farm with installed capacity of 1 MWp with the fixed frames or with the 'trackers' are compared, both for the auction system and for the 'green certificates' system. The results are shown in table 2.

The analysis shows that the best investment in terms of earned income is the photovoltaic farm with mobile racks in the conditions of the green certificates. It is mostly due to the higher efficiency of the solution and higher electricity sales prices.

Just on the basis of electricity sales prices, it can be stated that, under current market conditions in 2019, a higher return on investment is guaranteed by the auction system compared to the 'green certificates' scheme. However, the efficiency related to the technology of installation (in this case the movable or fixed racks) is also important. Therefore, in order to assess changes in the costs and revenues related to the operation of the analysed PV systems, a sensitivity analysis of the financial results is carried out, recognizing the uncertainty surrounding the estimation of several parameters, which significantly affect the costs and return on investment. This enables to draw comprehensive conclusions about the impact of the current support system on the directions of development of photovoltaic power generation schemes in Poland.

Table 2. Comparison of discounted costs, revenues and profits from investment in PV 1 MWp farm with stationary (fixed) frames and mobile racks for both the auction and the 'green certificates' systems [PLN]

fixed frames in the 'green certificates' system															
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Revenues	391720	388586	385452	382319	379185	376051	372917	369784	366650	363516	360382	357249	354115	350981	347847
Discounted profit after tax	137065	135931	127900	120265	113006	106107	99549	93317	87397	81772	76429	71354	66535	61960	51701
Cumulative discounted profit from 15-years period								1 430 288							
fixed frames in the auction system															
Revenues	297535	295155	292774	290394	288014	285634	283253	280873	278493	276112	273732	271352	268972	266591	264211
Discounted profit after tax	63710	65961	61164	56617	52308	48225	44358	40695	37227	33944	30837	27897	25116	22486	14085
Cumulative discounted profit from 15-years period								624 628							
mobile racks within the 'green certificates' system															
Revenues	509236	505162	501088	497014	492940	488867	484793	480719	476645	472571	468497	464423	460349	456275	452202
Discounted profit after tax	161566	159992	150242	140979	132181	123824	115889	108355	101204	94416	87974	81862	76064	70564	58337
Cumulative discounted profit from 15-years period								1 663 449							
mobile racks in the auction system															
Revenues	397097	393920	390743	387566	384390	381213	378036	374859	371683	368506	365329	362152	358975	355799	352622
Discounted profit after tax	74227	76684	70784	65198	59912	54909	50177	45702	41470	37470	33691	30120	26749	23566	13550
Cumulative discounted profit from 15-years period								704 209							

Source: author's own work.

Sensitivity analysis was carried out taking into account the following parameters:

- annual costs associated with service and operation of mobile racks (in percentage of the supporting construction value),
- increase in energy yield when using mobile racks in relation to a fixed frames (in percentage),
- annual cost of land lease (in PLN per ha),
- annual rate of panels' degradation (in percentage),
- increase in investment costs of PV installation in case of the mobile racks in relation to the fixed frames (in percentage).

The results of the analysis are presented in table 3.

Table 3. Changes in the financial outcomes resulting from variations in selected parameters of the PV system

Parameter	fixed frames in the 'green certificates' system	fixed frames in the auction system	mobile racks within the 'green certificates' system	mobile racks in the auction system
Annual costs related to mobile racks (initially 1,5% of the supporting construction value)	0,1 percentage point increase of this costs leads to profit decrease of			
	not applicable	not applicable	1.78%	1.87%
Percentage increase in energy yield of PV installation with mobile racks in relation to the PV installations with fixed frames (initially 30%)	1 percentage point increase of the yield leads to profit increase of			
	not applicable	not applicable	1.83%	4.27%
Annual cost of land lease (initially 10000 PLN/ha)	1 percentage point increase of this cost leads to profit decrease of			
	0.13%	0.29%	0.15%	0.36%
Annual panel degradation rate (initially 0,8%)	for 0,1 percentage point (increase in the rate leads to profit decrease)			
	1.55%	3.58%	1.73%	4.12%
Percentage increase in investment costs of PV installations with mobile racks in relation to PV installations with fixed frames (initially 20%)	1 percentage point increase of this costs leads to profit decrease of			
	not applicable	not applicable	1.66%	3.91%

Source: own elaboration

It is important to determine the direction of the change with regard to parameters in table 3 when determining the change in return on investment. When several of the analysed parameters are considered at the same time, in order to obtain the final percentage change in the return on investment, it is sufficient to sum up the percentage changes in profit resulting from changes in individual parameters.

The conduced sensitivity analysis revealed that a change in each of the analyzed parameters would have a greater impact on the return on investment in case of the auction system than in case of the 'green certificates' scheme.

Discussion of results

It should be noted that the decisive factor for the profitability of investment in the photovoltaic farm with mobile racks is the cost of maintenance of the movable parts (frames). This cost has been adopted in the above calculation at the level of 1.5% of the initial value of the PV panels fixed system per year, but due to the short period of use of this technology and its marginal application in the climatic conditions of Poland, this value in the 15-years of operation can, in fact, differ significantly from the assumptions.

A photovoltaic farm with 'truckers', under the undertaken assumptions, will generate more profit than investment based on fixed frames, until the annual maintenance costs of movable parts will exceed approximately 2.2% of their initial value in the auction system and adequately 3.4% in the 'green certificate' scheme.

The analysed regulatory ecosystems of the PV investments (auction system versus 'green certificates' system) are among the important factors determining the profitability of PV investments. The slight changes in the conditions within such systems can have significant impacts on the investment profits.

Uncertainty applies to both green certificate prices (prices and their volatility cannot be predicted) as well as auction prices. In the second case, it is not known whether the auction for a given type of renewable energy will be announced, and when it is announced it is not known how the "basket" will be constructed (i.e., if wind and pv is included in one basket, this will lower the pv price). Another uncertainty concerns the reference price and another uncertainty is related to the price offered by other entities during the auction. Therefore, in both cases there are many factors that make the uncertainty of future prices high.

Conclusions

Under the current market conditions in Poland, the RES support scheme using auctions to determine the purchase price of electricity can generate lower returns on investments, from the construction of PV farm with a capacity of 1 MWp or more (assuming proportionality of investment and operating costs), than the RES support system using 'green certificates'.

The system of 'green certificates' creates a greater incentive to use movable frames in the construction of photovoltaic farm than the auction system, because the analysis showed that the profit in the system of 'green certificates' is greater by over 16% compared to fixed frames. Whereas in the case of the auction system and given the assumptions used in this analysis, the corresponding profit increase is over 12%.

For all the RES the auction system allows to perform much more accurate revenues forecasts than a system based on 'green certificates', in which the unpredictable parameter is the price of the property right.

Moreover, regardless of the RES support system, risk factor related to the level of additional maintenance costs of movable parts in the PV installations can limit the use of this technology. Given the uncertainty in the legal system in Poland concerning renewable energy sources and hence the structure of the support scheme, additional risk associated with the efficiency of technology with mobile racks might be too much for the investors to bear.

It should be remembered that the conducted analysis takes into account current market conditions for 2019. It is possible that the price of electricity on the free-competitive market will increase, and the reference prices, which are the initial value for the calculation of the adjusted price, will not change or will fall as a result of changes in the prices of technologies used in renewable energy sector. It is also possible that the price on the free-competitive market will fall and reference prices will rise, e.g. for political reasons. Therefore, from the point of view of the electricity producer, it is financially justified to use the auction system only when the energy price on the free-competitive market is lower than the adjusted price, which is calculated after taking into account the "correction" of the reference price related to co-financing per unit of energy produced in a contracted 15-year billing period. If the energy producer uses the "green certificates" system, the auction system will be more financially advantageous only if the adjusted price is higher than the sum of the energy price on the free-competitive market and the PMOZE_A price. Thus, green certificates will be more profitable than auctions as long as the price resulting from them (the price of the green certificate and the price of energy on the free-competitive market) is higher than the price from the auction.

The contribution of the authors

Both authors participated equally in conception, development, literature review, acquisition of data, analysis and interpretation of data.

Literature

Azofra D. et al. (2015), *Economical-environmental impact of subsidised renewable energy sources for electricity (RES-E) in the Spanish system*, "Energy for Sustainable Development" Vol. 29, p. 47-56, DOI: 10.1016/j.esd.2015.09.002

Bakhshi R., Sadeh J. (2016), *A comprehensive economic analysis method for selecting the PV array structure in grid–connected photovoltaic systems*, "Renewable Energy" Vol. 94, p. 524-536, DOI: 10.1016/j.renene.2016.03.091

Cervone A. et al. (2015), *Impact of regulatory rules on economic performance of PV power plants*, "Renewable Energy" Vol. 74, p. 78-86, DOI: 10.1016/j.renene.2014.06.037

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources

Dubel A., Trela M. (2014), *Efektywność finansowania elektrowni fotowoltaicznych*, in: M. Czyż, J. Dyduch (eds.), *Środowiskowe i finansowe uwarunkowania funkcjonowania podmiotów gospodarczych*, Wydawnictwa AGH, Kraków

Edenhofer O. et al. (eds.) (2014), *Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Intergovernmental Panel on Climate Change, Cambridge, New York

Energy (2020), *EU energy strategy*, European Commission, Brussels

Field C.B. et al. (eds.) (2014), *Climate Change 2014: Impacts, Adaptation, and Vulnerability, Part A, Global and Sectoral Aspects, Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge, New York

Frost, Sullivan (2016), *Global Solar Power Market – 2016 Update*, Solar PV Gains Momentum as a Globally Irreversible Mainstream Energy Source

Giacomarra M., Bono F. (2015), *European Union commitment towards RES market penetration: From the first legislative acts to the publication of the recent guidelines on State aid 2014/2020*, "Renewable and Sustainable Energy Reviews" Vol. 47, p. 218-232, DOI: 10.1016/j.rser.2015.03.006

GUS (2014), *Energy from renewable sources in 2013*, Central Statistical Office, Industry Division, Ministry of Economy, Energetic Department, Warsaw

Instytut na rzecz Ekorozwoju (2009), *Alternatywna polityka energetyczna Polski do 2030 r.*, Warszawa

Komisja Europejska (2011), *Rozporządzenie Parlamentu Europejskiego i Rady ustanawiające instrument "*Łącząc Europę*"*, Bruksela, dnia 19.10.2011, KOM(2011) 665

Kowara M., Lasocki K., Trepka M. (eds.) (2014), *Analiza polskiego systemu wsparcia produkcji energii elektrycznej z odnawialnych źródeł energii w postaci Zielonych Certyfikatów na podstawie prawa pomocy publicznej*, K&L Gates, http://www.

cire.pl/pokaz-pdf-%252Fpliki%252F2%252Fanaliza_polskiego_systemu_zc__publikacja.pdf [30-06-2016]

Krajowa Strategia Rozwoju Regionalnego 2010-2020: regiony, miasta, obszary wiejskie (2010)

Kylili A., Fokaides P.A. (2015) *Competitive auction mechanisms for the promotion renewable energy technologies: The case of the 50 MW photovoltaics projects in Cyprus*, "Renewable and Sustainable Energy Reviews" Vol. 42, p. 226-233, DOI: 10.1016/j.rser.2014.10.022

Liu X. et al. (2015), *Lifecycle climate impacts and economic performance of commercial-scale solar PV systems: A study of PV systems at Nevada's Desert Research Institute (DRI)*, "Solar Energy" Vol. 119, p. 561-572, DOI: 10.1016/j.solener.2015.05.001.

Mayr D., Schmidt J., Schmid E. (2014), *The potentials of a reverse auction in allocating subsidies for cost-effective roof-top photovoltaic system deployment*, "Energy Policy" Vol. 69, p. 555-565, DOI: 10.1016/j.enpol.2014.01.029

Ministry of Environment (2012), *Strategy of Energy Safety and Environment. Perspective to year 2020*, Project 28.06.2012 [Strategia Bezpieczeństwo Energetyczne i Środowisko. Perspektywa do 2020 r., projekt 28.06.2012], Warsaw

Moreira M.F.T., Martins J.S., Afonso J.L. (2003), *Renewable energy in Portugal: legislation, incentives and suggestions*, Department of Industrial Electronics, University of Minho, Portugal, http://www.icrepq.com/pdfs/MOREIRA406.pdf [31-10-2016]

Polish Energy Law from 10 April 1997

Polish Energy Policy until 2030 (2009), Polish Ministry of Economy, Warsaw

Polish Ministry of Economic Affairs (2009), *Polish Energy Policy till 2030* [Polityka energetyczna Polski do 2030 roku], Warsaw

Polish Ministry of Economic Affairs (2010), *National Plan of Action with regard to energy from renewable energy sources* [Krajowy plan działania w zakresie energii ze źródeł odnawialnych], Warsaw

Polish RES Law from 20 February 2015

Poputoaia D., Fripp M. (2008), *European Experience with Tradable Green Certificates and Feed-in Tariffs for Renewable Electricity Support*, Environmental Change Institute, University of Oxford, UK

Ragwitz M. (2013), *EU Renewable energy support schemes – Status quo and need for reform*, Workshop in preparation of Commission review of EU Guidelines on State Aid for Environmental Protection, 12.04.2013, Brussels

Ragwitz M. (2005), *Monitoring and evaluation of policy instruments to support renewable electricity in EU Member States*, Fraunhofer Institute Systems and Innovation Research, Germany

Ragwitz M. et al. (2005), *FORRES 2020: Analysis of the renewable energy sources' evolution up to 2020*, Karlsruhe, Germany

Rodrigues S. et al. (2016), *Economic feasibility analysis of small-scale PV systems in different countries*, "Solar Energy" Vol. 131, p. 81-95, DOI: 10.1016/j.solener.2016.02.019

Rodrigues S. et al. (2016), *Economic feasibility analysis of small scale PV systems in different countries*, "Solar Energy" Vol. 131, p. 81-95, DOI: 10.1016/j.solener.2016.02.019

Sánchez-Lozano J.M., García-Cascales M.S., Lamata M.T. (2016), *Comparative TOPSIS-ELECTRE TRI methods for optimal sites for photovoltaic solar farms. Case study in Spain*, "Journal of Cleaner Production" Vol. 127, p. 387-398, DOI: 10.1016/j.jclepro.2016.04.005

Trela M., Dubel A. (2014), *Efektywność ekonomiczna elektrowni fotowoltaicznych oraz uniknięte koszty zewnętrzne w wyniku ich funkcjonowania*, in: M. Czyż, J. Dyduch (eds.), *Środowiskowe i finansowe uwarunkowania funkcjonowania podmiotów gospodarczych*, Wydawnictwa AGH, Kraków

Verde S.F., Grazia Pazienza M. (2016), *Energy and climate hand-in-hand: Financing RES-E support with carbon revenues*, "Energy Policy" Vol. 88, p. 234-244, DOI: 10.1016/j.enpol.2015.10.013

Małgorzata **BURCHARD-DZIUBIŃSKA** • Tsolmontuya **MYAGMARJAV**

TRADITIONAL PASTORALISM OR MINING? CONFLICT OF INTEREST IN ACCESS TO NATURAL PASTURES IN MONGOLIA AND THE PROBLEM OF ECOLOGICAL AND ENVIRONMENTAL JUSTICE

Małgorzata **Burchard-Dziubińska,** Associate Prof. (ORCID: 0000-0001-5546-2032) – *University of Lodz*
Tsolmontuya **Myagmarjav,** PhD student – *University of Lodz*

Correspondence address:
Faculty of Economics and Sociology,
Rewolucji 1905 Street 41, 90-214 Łódź, Poland
e-mail: malgorzata.burchard@uni.lodz.pl

ABSTRACT: The article deals with the problem related to the growing conflict of interest in access to natural pastures, which is the basis of nomadic pastoralism in Mongolia. The discovery of significant mineral resources (inter alia: gold, copper and coal) resulted in a huge increase in interest in their extraction and use of this potential to accelerate the economic development of the country. The open-cast mining causes the degradation of natural pastures and permanently hinders the migration of animals between winter and summer stands. This is a serious threat to traditional pastoralism, which is of high importance not only from the economic point of view, but also from cultural one. The aim of the article is to show the specificity of the issue of ecological justice in Mongolia, and to find an answer to the research question: How can ecological justice in this country be restored? Until this day there are no effective solutions to ensure fair access to areas where fossil resources have been discovered. Simultaneously, due to air pollution, and degradation of water resources, environmental health became a problem of the highest importance among Mongolians' population. Ecological justice is becoming an increasingly pressing issue in the country, that has been so far considered an example of the most successful pro-democracy transformation in Central Asia.

KEY WORDS: ecological justice, traditional pastoralism, mining, Mongolia, conflict of interest

Introduction

Transition to a market economy which started in Mongolia in the early 1990s marked the beginning of profound structural and social changes. After years of economic collapse, Mongolia is currently one of the countries with impressive growth. GDP growth rate averaged 5.45 percent from 1991 until 2018, reaching an all-time high of 17.50 percent in 2011 (https://tradingeconomics.com/mongolia/gdp-growth). In the last few years, this vast but sparsely populated nation with 2.06 inhabitants per square km (2018) – has seen an astonishing boom (http://worldpopulationreview.com/countries/mongolia-population/). The most important source of this increase is the dynamic development of mining. It is expected that exploitation and export of mineral resources would stimulate further growth. Mining accounts for around a quarter of GDP and more than 80 percent of exports in Mongolia (Mongolia Mining Sector Overview, 2019). IMF predicts that by 2021 only Oyu Tolgoi copper-gold mine in the South Gobi region will contribute a third of Mongolia's GDP (Searching for another Oyu Tolgoi…, 2017). The country earned the nickname *Minegolia* (The Guardian 23 April 2014). Some warned of "the resource curse" (Moran, 2013), thus, the issue of ecological justice is particularly important.

In Mongolia the problem of environmental and ecological justice is a new issue. It has appeared and is growing due to the economic and social changes taking place in this country mainly due to two reasons: expansion of mining and climate change. They are a threat to traditional pastoralism, which for hundreds of years was the basic form of economic activity, provided livelihoods for thousands of shepherd families and ensured permanent access to natural pastures. The pastures were used as a common good in a way that enabled their natural regeneration.

The previous assumptions regarding the finding of many precious mineral resources in Mongolia have been confirmed by large-scale geological research conducted since the 1990s. The inflow of foreign capital enabled the expansion of the old and the construction of new mines. Discovering of new gold deposits stimulated also illegal mining operated by artisanal or so-called "ninja" miners. Questions about the social and ecological costs of both legal and illegal mining expansion gain in importance.

In the article, the issue of ecological justice is discussed in relation to the threats that the expansion of legal and illegal mining brings to nomadic shepherding. The aim of the discussion is to show the specificity of the issue of ecological justice in Mongolia and to find an answer to the research question: How can ecological justice in this country be restored?

Methods of research

The research was conducted in 2019. The following methods were used:

- literature studies related to history of ecological justice,
- analysis of statistical data on mining and pastoralism in Mongolia in 1995-2018 based on: yearbooks; reports written by IMF, the World Bank, and the Bank of Mongolia,
- searching for online sources to identify social protests against the appropriation of pastures by mines,
- questionnaire survey among herders who lost their livestock.

Collected data made it possible to assess the situation among Mongolian shepherds who cannot continue nomadic shepherding because of the conflict with the mining sector.

Definition of ecological justice – literature review

The discussion about ecological justice was initiated in the USA in the 1960s and resulted mainly from the deterioration of the environmental living conditions of the colored population. This was connected initially with the location of landfills, including hazardous waste, in the neighborhood of districts inhabited by Afro-Americans. However, the environmental justice has a wider dimension. It also covers the problem of appropriation of land belonging to the indigenous population by mining, transport or agricultural enterprises. This is usually the beginning of a degradation of nature and the cause of numerous conflicts in which the original inhabitants are in a hopeless position. This is especially true for both Americas and Australia. For the indigenous people, the possession of land is of great economic and cultural importance. Hunting, fishing and gathering are the main sources of their livelihood. These areas are also a treasury of memorabilia of the past, a place of burials of ancestors and religious cult (Krysińska-Kałużna, 2002, p. 39; Surrallés and Hierro, 2004).

Since 1990s the ecological justice has been broadly discussed in literature. It is worth to mention publications of Eckersley (1992), Pulido (1996), Dobson (1998, 1999), Low and Gleeson (1998). Eckersley focused on a broad environmental political theory, in turn, Pulido described issues of environmental justice struggles in the US southwest. She has argued that environmental movements of the poor focus not only on economic justice, but also on cultural identity and survival as an element of environmental justice (p. 29-30). The differences between the ideas of environmental justice and ecological justice have been discussed. The first is often used to describe the relationship among people regarding environmental goods and bads, while

the second is used to discuss the relationship between people and the rest of the natural world (Low and Gleeson, 1998). The environmental justice, is focused primarily (but not entirely) on human health, and ecological is focused on our treatment of nature. In turn Dobson examined the relationship between distributive notions of social justice and understandings of environmental sustainability. He argues, poverty is often identified with environmental degradation, and relative wealth determines access to environmental goods or, (at least) avoidance of bads (1998, p. 17).

In accordance with Environmental Protection Agency from US, where the term *ecological justice* was born, it is defined as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies". This goal is achieved when everyone enjoys:

- The same degree of protection from environmental and health hazards, and
- Equal access to the decision-making process to have a healthy environment in which to live, learn, and work (EPA, https://www.epa.gov/environmentaljustice).

Fair treatment means no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies.

In the context of ecological justice, Mongolia has appeared as a subject of scientific inquiry only recently. When the Mongolian nomads declare that natural steppe is their pharmacy, market, university, factories and warehouses of household appliances, they speak about economic reality, hardly understandable by those, who do not live from traditional pastoralism. Another important aspect is the cultural dimension of the inhabited space. It is filled with elements of symbolic and spiritual significance. Territory is not just the sum of the resources it contains. The use of land and natural resources always has two interrelated aspects: material and cultural. The first is responsible for survival in the physical sense, the second for the possibility of continuing the traditional lifestyle and preserving spiritual and religious values.

The issue of property rights is of key importance to the emergence of problems with fair access to the environment. Groups potentially or actually exposed to the negative impact of the changes in natural environment, are usually not entitled to participate in deciding on the ways and scope of its use. They also have no guarantee that their needs and expectations will be considered accordingly with a sense of ecological justice (Hill, 2014).

As regards natural goods which for centuries have been used as common goods, property rights had never been formally specified. The use of pastures in Mongolia by nomadic herders was so far free of the "Tragedy of the commons", described by G. Hardin (1968). It met standards discussed among others by E. Ostrom (1990). Nowadays governments treat such land as state-owned and dispose of them freely without paying attention to the property rights of aboriginal users and herd owners. The ecological (and environmental) justice issue arose because of a lack of respect for traditional ownership of natural pastures and degradation of nature in mining regions.

Pastoralism and mining in Mongolia in the light of statistical data

In Mongolia there are over 100 types of pastures, on which more than 2,000 different grasses and herbs grow (Enkhtuvshin, 2001, p. 20). It gives a unique opportunity for breeding animals, which stay whole year in the steppe. For centuries, herders led the nomadic lifestyle wandering across the grasslands with their animals, building, packing, and rebuilding their traditional gers. As a consequence of the privatization process in agriculture since 1990s, the total number of livestock animals has increased significantly. According to Mongolian Statistical Information Service data, in 1970 there were 22.5 million livestock, in 1980 – 23.7 million, in 1990 – 25.8 million, in 2000 – 30.2 million, and in 2018 – 66.5 million, including: sheep 30.5 m, goats 27.1 m, cows 4.4 m, horses 3.9 m and camels 0.5 million (Mongolian Statistical Information Service, http://www.1212.mn/stat.aspx?LIST_ID=976_L10_1).

Currently, the land management of pastures is regulated by the Land Act, which was passed in 1994. In general, land is state-owned and used jointly by shepherds in specific administrative areas. This means that pastures are treated as a good with free access, which is associated with the lack of sufficient care for their condition. The 38th resolution of the State Great Khural (parliament) in 2003, stressed the need to create a new law regulating the principles of using pastures. The issue came back in 2010 in connection with the implementation of the Mongolian herds program. Despite the fact that the matter is crucial for the functioning of a very important sector, nothing has been determined so far. With the increase in the population of livestock, the problem of a significant deterioration of the condition of land and pastures arose due to the existing system of land ownership. Mongolia is one of the most sparsely populated countries in the world with population barely over 3 million inhabitants of which the third part lives in the capital Ulaan-

baatar. Over 153,000 herder families live in the country, for whom shepherding in not only business but also a lifestyle (Vernooy, 2011). The dynamic changes taking place nowadays in Mongolia's economy are based mainly on the extraction of minerals. For a long time it has been known that the country is rich in mineral resources. The searches carried out on a large scale in 1990s confirmed the earlier assumptions. The country's richest resources are the following minerals: coal, copper, fluorite, gold, iron ore, lead, molybdenum, oil, phosphates, tin, uranium, and wolfram. According to estimates, the value of reserves of the 10 largest mineral deposits in Mongolia exceeds USD 1.3 trillion. There are approximately 8,000 deposits, including 1,170 deposits of over 80 different minerals. Because only 27 percent of the country's area has been surveyed, many locations of raw materials can still be discovered (Overview of Mongolia's Mining Industry**,** http://sesprofessionals.com/overview-of-mongolias-mining-industry/). The Mineral Resources Law was first issued in 1997, and since that time it has been revised in 2006 and amended in 2009 and 2014. The Law regulates the relations between the activities of the mining sector and environment and socio-economic sectors. The changes were due to the need of a more tailored approach, which would take into account Mongolia's unique location and development trajectory. According to the Mineral Resources Law, mineral resources are the State's property. They were divided into three groups according to their importance and use in the economy: strategic, common and conventional. A deposit is considered strategic when its potential affects national security and the economic and social development of the country or when its exploitation may provide more than 5 percent of the total GDP of the country. The Government of Mongolia considered as strategic 15 deposits of coal, copper, molybdenum, uranium, gold, silver, phosphorus, zinc and lead (art. 4.1.12.). Whereas a common deposit (Article 3.3) is a deposit of sediments and stones used as building materials. Other deposits are included in conventional deposits (http://www.legalinfo.mn/law/details/63?lawid=63).

In 2008, the new standards on restoration of mining sites and "A guideline and methodology to identify ecological and economic damages resulted from adverse environmental impact of mineral resource exploration and exploitation" were introduced.

On 1 July 2014, the Great Khural passed amendments to the Mineral Resources Law which reflect the new State Minerals Policy. This policy aims to:

- establish a stable investment environment,
- improve the quality of mineral exploration, mining and processing,
- encourage the use of environmentally friendly and modern technology,
- strengthen the competitiveness of the Mongolian mining sector in the international market.

This document emphasizes the importance of the mining sector in the country's economy. The environmental issues are mentioned but without caring about ecological justice.

The mining sector has been dominated by three main actors – Tavan Tolgoi (coal producer), Oyu Tolgoi (gold and copper) and Erdenet (copper and molybdenum) (International Journal of u- and e- Service, Science and Technology, 2016). Due to huge deposits of mineral resources Mongolia has become the object of interest of foreign investors. It was a chance for the country to enter the pace of a rapid growth. In 2013, three large-scale mining projects were launched. Extractive companies such as Rio Tinto (Australia), Turquoise Hill Resources (Canada) and Erdene Resources (Canada) are expanding their operations in the country. To date, Rio Tinto and its partners are investing more than USD 5 billion in an underground expansion project that will extract 560,000 tonnes annually from 2025 to 2030 (Mongolia Foreign Investment, FDI in Figures).

According to the Bank of Mongolia, FDI flow to Mongolia amounted to USD 2.1 billion in 2018, up from USD 1.4 billion in 2017, due to higher metal prices (Investment Protection Council). It is worth emphasizing that as much as 79 percent of FDI were located in mining sector (https://montsame.mn/en/read/13323).

Conflicts between herders and mining companies

Unrestrained movement of shepherds and their herds becomes more and more difficult not only because of opencast mines which have appeared on their way. Mining, exhausting water resources which until now were the basis for the functioning of local communities destroy traditional pastoral economy. As mentioned by M. Tolson (2012), Oyu Tolgoi and the coal mine Tavan Tolgoi only in their exploitation phase, together use four times more water than all herders' livestock combined in the Gobi provinces. This is aggravated by the diversion of river courses and the influx of migrant workers to the region, who are employed at the mine. As a result over 20 wells and springs in the area have dried up.

Table 1 presents the data about demonstrations of herders against mining companies. From the administrative point view Mongolia is divided into ajmags, soums and baghs where bagh is the smallest administrative territorial division comprising a population of approximately 500 people and soum –of about 3000 on average. Large mining soums comprise 15,000 people.

Table 1. Demonstrations of herders against mining companies 2013-2019

Place	Location area	Number of herders	Date	Mining company name	Reason of demonstration
Javhlant bagh /South Gobi aimag/	250 km^2	90 herders	01-July-2013	"Rio Tinto, Ivanhoe Mines and Erdenes" LLC	The herders' families were negatively impacted by the project.
Gavlit bagh /South Gobi aimag/	250 km^2	90 herders	01-July-2013	"Rio Tinto, Ivonhoe Mines and Erdenes" LLC	Water, pasture and reserve pasture, winter and summer camps were affected by the projects.
Galuut soum, Bagh #3 /Bayankhongor aimag	6 km^2	120 herders	09-Oct-2017	"Tulga Jargalant" LLC	Herders and livestock's water wells and pasture were affected by the projects.
Noyon, Bayandalai and Gurvantes soum /Umnugobi aimag/	140 km^2	Citizenry of three bagh's	03-Sept-2018	"Javhlant Ord" LLC, "Terra Energy" LLC, "Usuh Zoos" LLC	Mining dust affects herders' and livestock's health. Animals with black lungs were found or herders had a chronic cough.
Durvuljin soum / Zavkhan aimag/	*	Whole bagh's citizenry / around 400 people	March-2019	Unknown LLC	Herders' winter camps were destroyed by the mining projects. No place for keeping herds during harsh winter and protect from cold wind.

Sources: author's own work based on: https://news.mn/r/511749/; https://www.ebrd.com/downloads/integrity/OT_addition_to_the_complaint_4.2014.pdf; https://www.facebook.com/SBNMongolia/videos/; http://unuudur.mn/; http://www.bolod.mn/mobile.php?nid=94829

Although the number of protests and their participants mentioned in the Table 1. may seem small, we must remember that Mongolia belongs to the least populated countries in the world (for example, around 180 shepherds keeping mostly goat, sheep and camel, live in two baghs Javhant and Gavlit (South Gobi province) on an area of about 250 km^2). The hotspots of the protests varied. Oyu Tolgoi – one of the biggest copper-gold mines in the world, caused a lot of controversy. The mine is located in one of the driest areas in Mongolia. Herders worry that Oyu Tolgoi is draining the region's water supply, since it uses more than four billion liters of water a month (Searching for another Oyu Tolgoi). Explaining how this has changed the lives in the region, a local herder says: "Water levels are decreasing; our household can only sustain 60 animals instead of 200. This is not sufficient for earning a living; it is even hard to feed the family." Another said: "I was not resettled by (Oyu Tolgoi), but I am one of many who had to move without compensation, because of no water." The company's answer to these problems is to shift the responsibility to the herders asking them to reduce the amount of animals to save water (The Guardian, 9 March 2015).

The complaints also relate to negative impacts caused by construction and use of all project-related roads associated with two financed mining operations: (1) Oyu Tolgoi LLC's copper mining operation; and (2) Energy Resources LLC's coal mining operation at Tavan Tolgoi. The protests in the period July–September 2013, were conducted by nomadic herders of Javhlant bagh in Khanbogd soum, and of Jargalant, Uekhii bagh in Manlai soum. Herders have also sent written complaints and e-mails with the help of Oyu Tolgoi Watch – the knowledge hub involved in realization of UN Convention to Combat Desertification (https://minewatch.mn/?lang=en).

The 105-kilometer Oyu Tolgoi-Gashuun Sukhait route – an unpaved road – has been used by investors since around 2010 to deliver materials to the Oyu Tolgoi site from China. The death of a brother of one of the complaining herders in an accident with a road construction truck along this road due to low visibility caused by dust was an impulse for the protest.

In desert regions, heavy vehicles driving on unpaved roads raise huge amounts of dust. It adversely affects the health of herders and results in an increase in respiratory illnesses, such as bronchitis. In addition, dust, noise and water pollution directly harm the health of livestock. Due to emotional stress animals are experiencing poor weight gain and low fat gain, which makes it less likely that they will survive the harsh South Gobi winter. Livestock that graze near the roads are dying off and, in most cases, are found with black lungs as result of inhalation of dust. The decrease in quantity and quality of livestock has an adverse economic impact on herders. These factors provoked protests against "Tulga Jargalant" LLC in the Galuut bagh (Bayankhongor province), and against "Javhlant Ord" LLC, "Terra Energy" LLC, "Usuh Zoos" LLC in the Noyon, Bayandalai and Gurvantes soum in Umnugobi aimag.

The mining sector brings significant economic benefits to Mongolia, but their distribution is uneven. When poverty in country dropped by more than 11 percent between 2010 and 2012, predominantly within cities, nomadic people and rural communities continue to live in high levels of poverty, with very limited access to running water or electricity (Searching for another Oyu Tolgoi, 2017). To meet the growing public interest in the possibility of benefiting from profits from the mining boom in 2008 Great Khural passed a National Development Strategy and created a Human Development Fund (HD-Fund) with the ambitious goal of bringing Mongolia's human development status to the same level as that of the developed countries by 2020. In 2009 the HD-Fund was established. Initial capital for it was drawn from the Oyu Tolgoi mine project. The goal of the fund was to transfer a portion of natural resource revenues on an ongoing basis to the entire population. The fund gives out cash, pays tuition fees, and possibly engages in other social

expenditures. In 2010 every citizen received two cash handouts equivalent to approximately USD 90 per year. In 2011 cash handouts equaled about USD 180 per year, with one-quarter in the form of tuition fee support (Moran, 2013, p.4.) Unfortunately the fund has stopped working on 5 February 2016 (https://www.legalinfo.mn/law/details/559).

Conclusions

In the past two decades, Mongolia has experienced an enormous mining boom. There are dozens of large-scale mines with many more being planned. However, the country and particularly the Gobi Desert is more than a vast store of mineral deposits. It is also home to people, mostly herders' families, and to many plants and animals now endangered because of rapid environmental degradation. The greatest challenge for the next generations of Mongolians is to strive for ecological justice. As it was confirmed in research conducted in recent years mostly by foreign civil society organizations the lack of ecological justice is becoming a huge problem in this country with a young democracy. Particularly it is a threat to the indigenous people living in the Oyu Tolgoi region, where one of the world's largest projects of extraction of copper and gold has been developed. Some communities don't have access to clean water, safe living conditions, and environmental protection. The degraded regions are called "sacrificed zones". The nomads and mining companies are competing with each other for the same resources – land and water. The nomads need the land and water to sustain their herds and livelihoods, while the mining companies search for more land to expand their extraction sites, and need large quantities of water to perform mining operations. Too little attention is paid to the risk of resource nationalism in Mongolia, which is a growing and serious concern. The environmental and social impact of resource extraction on natural pastures and herders' families has not only been underestimated. It seems it has been ignored by politicians in Ulaanbaatar. The destructive impact of mining is amplified by the climate change.

The ecological justice is focused on the treatment of nature by the people. In turn, the goal of environmental justice is to ensure, that all people are protected from disproportionate impacts of environmental hazards. It is important to maintain a healthy environment, especially for those who have developed, and were able to protect nomadic culture for over 3000 years. In Mongolia, the lack of both environmental and ecological justice is growing rapidly due to the expansion of mining on an unprecedented scale. Rehabilitation of land after exploitation is very costly; therefore most mining companies leave exploited area without its revitalization. To enhance environmental and eco-

logical justice, Mongolia needs government policies, not only environmentally friendly, but also nomadic culture friendly. The suffering of the many pays for the luxury of the few. So far there are no effective solutions to ensure fair access to areas, where fossil resources have been discovered. The collapse of the Mongolian's Human Development Fund after few years of its functioning is the best evidence of weakness of the political institutions in this country. Answering the research question: How can ecological justice in this country be restored?, it is recommended: development of a law protecting land ownership enabling a fair distribution of the benefits of exploiting Mongolia's natural resources – both minerals and natural pastures; capacity building for land degradation neutrality, sustainable land management, and combat desertification. It is also worth considering re-launching the human development fund. Funds should be collected to ensure long-term sustainability in line with the principles of ecological and environmental justice.

The contribution of the authors

Małgorzata Burchard-Dziubińska – 50% (theoretical part and methodology of research).

Tsolmontuya Myagmarjav – 50% (research part).

Literature

A Useless Shame – A Review of the Oyu Tolgoi Copper/Gold Mine, Environmental and Social Impact Assessment (2012), Oyu Tolgoi Watch, Accountability Counsel, Urgewald, CEE Bankwatch Network, London Mining Network, and Bank Information Center

Daly J.C.K. (2011), *Mongolia's rare earth reserves draw foreign investor interest*, Central Asia – Caucasus Institute Analyst

Dobson A. (1998), *Justice and the Environment: Conceptions of Environmental Sustainability and Theories of Distributive Justice*, Oxford University Press, Oxford

Dobson A. (ed.) (1999), *Fairness and Futurity: Essays on Environmental Sustainability and Social Justice,* Oxford University Press, Oxford

Eckersley R. (1992), *Environmentalism and Political Theory: Toward an Ecocentric Approach*, State University of New York Press

Enkhtuvshin B. (2001) *Nomads: Culture, Civilizations and Development,* Nomad Studies, International Institute for the Study of Nomadic Civilizations, No. 2, Ulaanbaatar

Hardin G. (1968), The Tragedy of the Commons, "Science" No. 162(3859), p. 1243-1248

Hill B.E. (2014), *Environmental Justice: Legal Theory and Practice*, Washington D.C., p. 3-4

http://mongoliagrowthgroup.com/wordpress/wp-content/uploads/2012/01/ResCap_Mongolia101.pdf [11-04-2019]

http://unuudur.mn/ [11-04-2019]

http://worldpopulationreview.com/countries/mongolia-population, [11-09-2019]

http://www.bolod.mn/mobile.php?nid=94829 [11-04-2019]

http://www.legalinfo.mn/law/details/63?lawid=63 [11-04-2019]

https://minewatch.mn/?lang=en [11-04-2019]

https://news.mn/r/511749/ [11-04-2019]

https://www.ebrd.com/downloads/integrity/OT_addition_to_the_complaint_4.2014.pdf [11-09-2019]

https://www.epa.gov/environmentaljustice [11-09-2019]

https://www.facebook.com/SBNMongolia/videos/ [10-09-2019]

https://www.legalinfo.mn/law/details/559 [11-09-2019]

Foreign Direct Investment in the Mongolian Mining Sector (2016), "International Journal of u- and e- Service, Science and Technology" Vol.9, No.3

Investment Protection Council, http://ipc.gov.mn/news.php?n=5 [15-09-2019]

Krysińska-Kałużna M. (2012), *Yamashta czyli ten, Który Prawie Umarł*, Oficyna Naukowa, Warszawa

Low N., Gleeson B. (1998), *Justice, Society and Nature: An Exploration of Political ecology,* Routledge, London and New York

McGrath F. et al. (2011), *Spirited away- Mongolia's mining boom and the people that development left behind*, CEE Bankwatch Network, Urgewald, Bank Information Center, Oyu Tolgoi Watch

Mining and geology statistics (2015), Mineral Resources Authority of Mongolia, mid-year data, p. 30

Mongolia Foreign Investment, FDI in Figures, https://en.portal.santandertrade.com/establish-overseas/mongolia/investing-3?&actualiser_id_banque=oui&id_banque=40&memoriser_choix=memoriser [11-09-2019]

Mongolia Mining Sector Overview, Webinar 31 January 2019, Australian Government Austrade, https://www.austrade.gov.au. [11-09-2019]

Mongolian Coal Association, www.coalmining.mn (5.08.2014) [26-06-2019]

Mongolian News Agency, http://montsame.mn/en/read/13323 [26-06-2019]

Mongolian Statistical Information Service, http://www.1212.mn/stat.aspx?LIST_ID=976_L10_1, [26-04-2019]

Moran T.H. (2013), *Avoiding the "Resource Curse" in Mongolia*, Peterson Institute for International Economics, Washington, Number PB13-18JU

Ostrom E. (1990), *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge University Press, Cambridge

*Overview of Mongolia's Mining Industry***,** http://sesprofessionals.com/overview-of-mongolias-mining-industry/, [26-04-2019]

The Report Mongolia (2015), Oxford Business Group, https://oxfordbusinessgroup.com/mongolia-2015

Pulido L. (1996), *Environmentalism and Social Justice:* Two Chicano Struggles in the Southwest (Society, Environment, and Place), The University of Arizona Press, Tucson

Searching for another Oyu Tolgoi: Mongolia's big mining expansion, Mining Technology Analysis, 9 May 2017, https://www.mining-technology.com/features/fea-

turesearching-for-another-oyu-tolgoi-mongolias-big-mining-expansion-5805870/[26-06-2019]

Surrallés A., Hierro P.G. (eds.) (2004), *Tierra adentro. Territorio indígena y percepción del entorno*, Iwgia-grupo Internacional de Trabajo Sobre Asuntos Indígenas, https://www.researchgate.net/publication/28183305_Tierra_adentro_Territorio_indigena_y_percepcion_del_entorno_Alexandre_Surralles_y_Pedro_Garcia_Hierro_eds [26-06-2019]

Tolson M. (2012), *Uncovering the Gobi 'Watergate'*, The UB Post, October 25th, http://ubpost.mongolnews.mn/?p=1590 [29-04-2019]

Vernooy R. (2011), *How Mongolian herders are transforming nomadic pastoralism*, "Solutions" No. 2(5), p. 82-87, https://www.researchgate.net/publication/285975565_How_Mongolian_herders_are_transforming_nomadic_pastoralism [27-04-2019]

Watts J. (2007), *Mongolian 'ninja' miners*, "The Guardian", https://www.theguardian.com/news/gallery/2007/oct/04/internationalnews1 [27-05-2019]

When I was herding I had a plentiful life… (2015), "The Guardian", https://www.theguardian.com/global-development-professionals-network/2015/mar/09/mongolian-nomads-displacement-mining-impact-development-projects

Olena HETMAN • Olga IERMAKOVA • Oleksandr LAIKO • Oksana NIKISHYNA

ECO-INNOVATIONS UNDER CONDITIONS OF GLOCALIZATION OF ECONOMIC AND SUSTAINABLE DEVELOPMENT OF THE REGIONAL ECONOMY

Olena **Hetman,** PhD (ORCID 0000-0002-7404-3738) • Olga **Iermakova,** Associate Prof. (ORCID 0000-0002-9815-3464) • Oleksandr **Laiko,** PhD (ORCID 0000-0001-7082-0862) • Oksana **Nikishyna,** PhD (ORCID 0000-0002-7172-3551) – *Institute of Market Problems and Economic & Ecological Research of the National Academy of Sciences of Ukraine*

Correspondence address:
Frantsuzkyi boulevard, 29, 65-044, Odesa, Ukraine
e-mail: helenagetman24@gmail.com

ABSTRACT: The aim of the study is to indicate the essence and increasing importance of the ecologization of innovative development in the glocalization of economic processes as well as the potential benefits of eco-innovation for long-term objectives of regions development. The study systematize the knowledge on this topic, and indicate the necessity of their continuous development. The applied methodology is based on an analysis of scientific literature European countries. The research methodology is systematization of approaches to the direction of innovation processes for the development, creation and implementation of innovations in the form of new products, technology, method, form of production organization, etc., which directly or indirectly contributes to reducing the environmentally destructive effects of production and consumption on the environment and solving environmental problems. The authors hypothesis is that the glocalization on the basis of the implementation of environmental innovations will contribute to the sustainable development of the economy of the regions. This is a new way of looking at the region development, i.e. that looks at how ecologization of innovative development should be used for strategic advantage of region and how processes of ecologization of innovative development of the region can be a catalyst for the processes of market glocalization and promote sustainable development of the regional economy.

KEY WORDS: ecologization of innovative development, ecological innovations (eco-innovations), glocalization

Introduction

Strengthening of regions' economy, creation of their competitive priority based on innovations as well as capability to cooperate with the state and private structures working in the region, involvement of the population to an innovative process is a direction of a current development policy of the European Union determined in a new economic EU strategy "Europe 2030".

As the main priority objectives of ecologization of innovative development, there are considered most often the goals related to the changes in socio-economic development of the economic system, which, along with the positive socio-economic effect, improve the state of the environment or significantly minimize the negative impact on it. Therefore, under the ecologization of innovative development of the regions, reference is made to the innovative processes for the development, creation and implementation of innovations in the form of new products, technology, method, form of production organization, etc., which directly or indirectly assist to minimize the negative impact of production and consumption on the environment and dealing with the ecological problems. Ecologization of the innovative development of the region is a complex process, in which certain tasks need to be addressed: formation of the concept of environmentalization of socioeconomic development; development of the system of organization and financing of ecologization of innovative development of the region; legal regulation at the international, state, regional and local levels; – harmonization of socio-economic and biotechnological decisions.

The main principle of glocalization is the priority of national or local interests and the focus on local resources, subject to the consideration of global trends. The glocalization of economic processes requires a change in the paradigm of regional innovation policy, which consists in moving away from the distribution of financial resources and the widespread creation of innovation infrastructure to stimulating, the formation of a favorable business climate and institutional environment, the integration of regional innovation systems into global networks. Innovation policy should be varied in line with the specificity of the innovative development of each region.

In the conditions of the stagnation of global demand for commodities, the state faces the task of modernizing market policy in the internal and external dimensions in order to maximize the use of benefits of glocalization while simultaneously minimizing its negative effects. It is expedient to shift the emphasis of internal market policy in support of regional producers of quality and environmentally safe processed products, to assist them in certification for export to the EU and other countries of potentially competitive goods. It is expedient to direct the vector of the foreign market policy of the state on

implementation of export potential of high value-added goods markets by strengthening the position of exporters in the traditional and development of new external markets.

The aim of the article is to indicate the essence and growing importance of ecologization of innovative development of the regions as well as the achievable benefits resulting from the use of eco-innovations in glocalization processes. The study presents a theoretical review of selected aspects of ecological innovations and their analysis and effect of implementation.

General characteristics of ecologization of economy

Ecological and socio-economic concepts have evolved to a certain extent independently of each other. In our opinion, the main principle approaches to the study of socio-economic and environmental relations are (Hetman, 2019a; Socio-economic development..., 2016):

- systematic research,
- streamlining (balancing) of economic-ecological relations,
- problem-oriented (smart) management.

The priority task at the present stage is to activate the process of incorporating the ecological component into the system of indicators of "basic production" at both macro and micro levels.

Indeed, it is not possible to deny the objective fact that environmental costs are socially necessary.

In the theoretical and methodological terms there are no unambiguousness and identity, firstly, with regard to the conceptual definition of the ecological component, and secondly, by the methods of evaluation and accounting in the context of the system of indicators of the international system of accounts, which entails the incompatibility of the "true" development of economics of different countries.

In Ukraine, the legal framework for transition to a new system of management for economic and environmental relations has been established. The administrative and economic management methods are allocated. The administrative ones include environmental expertise, environmental audit, environmental licensing, etc. To administrative methods belong the following: taxes on the use of resources and pollution of the environment, methods of monetary valuation of damage, natural resource potential, methods of economic and environmental justification of investment projects, promotion of innovative ecological-oriented activity, etc. However, such a division is an arbitrary one, since administrative acts provided for by legal acts are based on the use of economic methods. In our view, the systematization of manage-

ment methods in two groups deserves attention: the methods of accounting and control over the behavior of a managed economic and ecological system (information provision of the management process: cadastre-registering of natural resources and emissions of pollutants into the environment, environmental monitoring) and methods of impact on the managed system (administrative ones: environmental expertise, environmental audit, licensing, standardization and valuation, regulations and rules, certification; economic ones: payments by nature usage, compensation of losses, methods of price valuation of ecological component accounting at macro and micro levels, methods of stimulation of ecologically oriented development, methods of economic and ecological substantiation of innovation and investment projects (including environmental protection).

Despite this radical reorientation of methods of managing economic and environmental relations in general, a qualitatively new existing mechanism does not contribute to a real improvement of the resource and ecological situation in the country. In our opinion, one of the main principles of constructing methods for managing economic-ecological relations is the principle of functional definition of the goal, which proceeds from the methodology of the system approach. This principle involves consolidating the implementation of state strategic objectives in the field of resource use and environmental protection by a specific management method. This will promote interconnectivity, interdependence and complementarity of management tools and will eliminate current duplication and paradoxicalness in the current Ukrainian regulatory economic base of managing economic and environmental systems.

Strategic public tasks are the following: reducing the nature and waste generation of the economy. The economic mechanism should be aimed at their solution, thus ensuring the preservation of the natural resource potential of the country for present and future generations.

One of the most important indicators of the sustainability of the economic systems development at the macro level is the correlation between environmental costs and economic losses in relation to the gross domestic (national) product and the pace of its growth. Under the ecological cost we mean the productive costs of protection and the rational use of natural resource potential. These are the investments required in the economy, aimed at preserving the "quality of the environment" (the cost of reproduction of natural resource potential). The economic damage means economic losses as a result of deterioration of the "quality of the environment".

In the developed countries of Europe, the ecological component in the gross national product is 1-2%, the economic damage in relation to the same indicator – 6% with the growth rate of GNP – 1-2%. The most favorable pic-

ture is in Japan: the environmental component and the economic loss are one and the same percent in relation to GNP – 2%. In Ukraine, with the same share of environmental costs, the magnitude of the damage is more than 20% (and according to individual estimates – even more), while the growth rate of GDP is 3%. This is a very unfavorable trend, which shows that in our country it is necessary to spend more financial means for the ecologization of production, mainly for implementation of the progressive, less resource-intensive and retarded technical equipment, of technologies that meet international standards. Otherwise, further degradation of the "quality of the natural environment" will continue, presenting an ecological threat to the life of the regions and the state as a whole (Hetman, 2019b; Gusev, 2011; EIO Europe in transition, 2013).

An important issue is the provision of stable financial sources for the implementation of state environmental programs. In this case, the current system of payment for nature use in Ukraine is of particular importance: taxes on the use of natural resources (land, water, forest, fish, minerals, including continental shelf) and pollution of the environment (on the emission of harmful substances into the atmosphere by stationary and mobile sources of pollution, pollution of water facilities, waste disposal). The system of payment is considered in Ukraine in the context of tax policy. Environmental taxes are the mandatory taxes for economic entities, regardless of their ownership form.

The methodology of tax formation for the usage (use) of natural resources was based on the ideology of the two components of these payments: medium- forming and rent. The medium-forming component should be considered analogically to amortization deductions as a payment for the consumed cost of natural resource potential, or as a fee for quantitative and qualitative deterioration of natural resource potential. Its main functional purpose is the accumulation of financial resources for the reproduction of natural resource potential. In this regard, these charges acquire a strictly targeted nature of their use. The rental component should reflect the excess profits of economic entities from the use of natural resources, which are the best in quality and location of. Its withdrawal corresponds to the implementation of the goal of equalizing the economic conditions of economic entities. In this case, the excess profits must belong to the owner of natural resources. Property relations should be at the heart of the processes of collecting, distributing and using these charges. At the same time, the modern development of the normative basis for collecting charges for the use of natural resources does not correspond to the original ideology and indicates the lack of systematic formation of these charges for the use of natural resources (Iermakova et al., 2019, p. 35; Bönte, Dienes, 2013).

The main functional purpose of ecological taxes is the following: formation of environmental protection funds at the local and state levels for solving the problems of preventing the pollution of natural objects (atmosphere, water, land resources). In fact, the collection of these fees is intended for the implementation of defensive expenditures; encouraging business entities to implement environmentally-friendly, low-cost technical equipment and technologies.

However, in practice, none of these functions is performed. The basic tax rate is lower than the minimum costs for preventing emissions of pollutants. For example, the tax for atmospheric pollution with 1 tonne of CO_2 is 10 UAH. At the same time, the minimum costs for measures to prevent 1 tonne of CO_2 – more than 40 UAH. As a result, it is easier for the polluter to pay for pollution than to implement measures to reduce these emissions. The size of these fees does not provide the financial basis for the implementation of state programs in the field of reducing the flow of pollutants into the natural environment. It should be noted that this situation is due, in our opinion, to a scientifically biased "lossmaking" approach chosen to determine the basic standards for pollution tax. The basis of this system should be a program targeted approach, which allows to make pollution prevention as the tax rate basis. The loss-making approach in this case is related to the unacceptable duplication of the pollution tax with the compensation mechanism for the damage compensation.

As for the compensation mechanism itself, it should be noted as well the imperfection of the theoretical and methodological foundations of the estimation of economic losses, which leads to ambiguity of the cost estimation of the same ecological damage under various operating methods. First of all, the lack of complexity in the assessment of economic damage should be noted. The damage is economic losses to third parties. In the methodological sense, the compiling a list of these "third parties" has not been resolved; unequivocal approaches to assessing their economic losses are not defined officially. Current methods of calculating losses, as a rule, allow only to assess partially (incompletely) the state or industry's economic losses, but not the detriment to specific legal entities, individuals, citizens of the country.

It is tax changes that can promote the ecologization of the economy to realize and implement measures for reforming industry, agriculture, financial and non-financial services. One of such levers can be an environmental tax credit, which was actively implemented in many European countries.

Ecologization of innovative development under conditions of glocalization of economic

The ecologization of innovative development is directly linked to the creation of more favorable conditions and additional opportunities for investments in the economy that need to be addressed:

- in the sphere of production,
- in the environmental complex (in the system of treatment facilities, waste recycling complexes, ecological monitoring, etc.),
- in manufacture of environmental products using advanced scientific and technological developments (technologies),
- in research and technical research, designed to provide the resource-ecological safety of society,
- in the social and infrastructural component (education system, legislation, information provision of society).

In present-day conditions there is a certain imbalance between the level of complexity of environmental problems and the instrumentarium used for their analysis and resolution. This situation is due, at least, to three reasons: the lag in development of environmental knowledge; the lack of awareness of the importance of using environmental innovations; the fundamental distinction between the implementation of the achievements of science and technology, on the one hand, and environmental technologies – on the other.

The complex process of planning environmental innovations consists of three main stages:

1. Creation or development of innovative ecologically oriented ideas.
2. Bringing of innovative ecologically oriented ideas from the source of their origin to the participants of the social system.
3. Changes occurring within the social system as a result of the implementation or abandonment of environmental innovations.

At the same time, the environmental innovations may be incompatible with the existing social structure of society for the following reasons. Innovations can be in conflict with existing public perceptions. When environmental innovation comes into conflict with the generally accepted social principles, the several consequences are possible:

a) ecological innovation is simply rejected by society or social group,
b) ecological innovation is accepted along with its conflicting features, but these features from time to time cause a protest that makes its adoption unsustainable.

The ecologization of innovative development should include such an aspect as the dissemination of environmental innovations.

It is a process by which the innovations are distributed from the source of their origin among the participants in the social system.

Without integration of the mechanism of environmental innovations into the system of economic relations, it will be impossible to transform knew knowledge into a dominant factor of economic development. Thus, the main task of the ecologo-economic mechanism of innovation type is minimization of the expenses for implementation of environmental innovations. Figure 1 presents the results of ecologically oriented innovative development and the economic component of the effect of implementation.

Ecologization of innovative development of the region is a systemic dynamic process of creation, implementation and dissemination in the region as environmentally oriented innovations so as raising the level of environmental friendliness of innovations, penetration of the environmental world view into all areas of economic activity of the region, inclusion of the environmental component in the system of financial and economic relations, formation of environmental infrastructure and education (Circular Economy Strategy, 2019).

The final result of ecologization of innovative activity in the region is a positive socio-ecological and economic effect, which ensures balanced sustainable development of the region and the state as a whole.

Integration of regional socio-ecological and economic systems into national and global networks is possible by facilitating access to them and creating opportunities for their use by appropriate institutional support and financial incentives.

The development of modern economic systems is characterized by two opposing trends: globalization and localization of markets. The result of their interaction and synthesis is the process of market-based glocalization, which is one of the characteristics of the post-industrial economy.

The initial stage of market glocalization is the expansion of product market boundaries by the emergence of production of innovative products with specific properties that are in demand not only on local but also global markets. The next step is the export of these products, which, on the one hand, helps to establish and strengthen the integrative links between the local and global markets, the interpenetration of the local market in the world market space, on the other hand, leads to the expansion of the geographical boundaries of the market, that is, its glocalization (Iermakova, 2017; Institutional principles…, 2017).

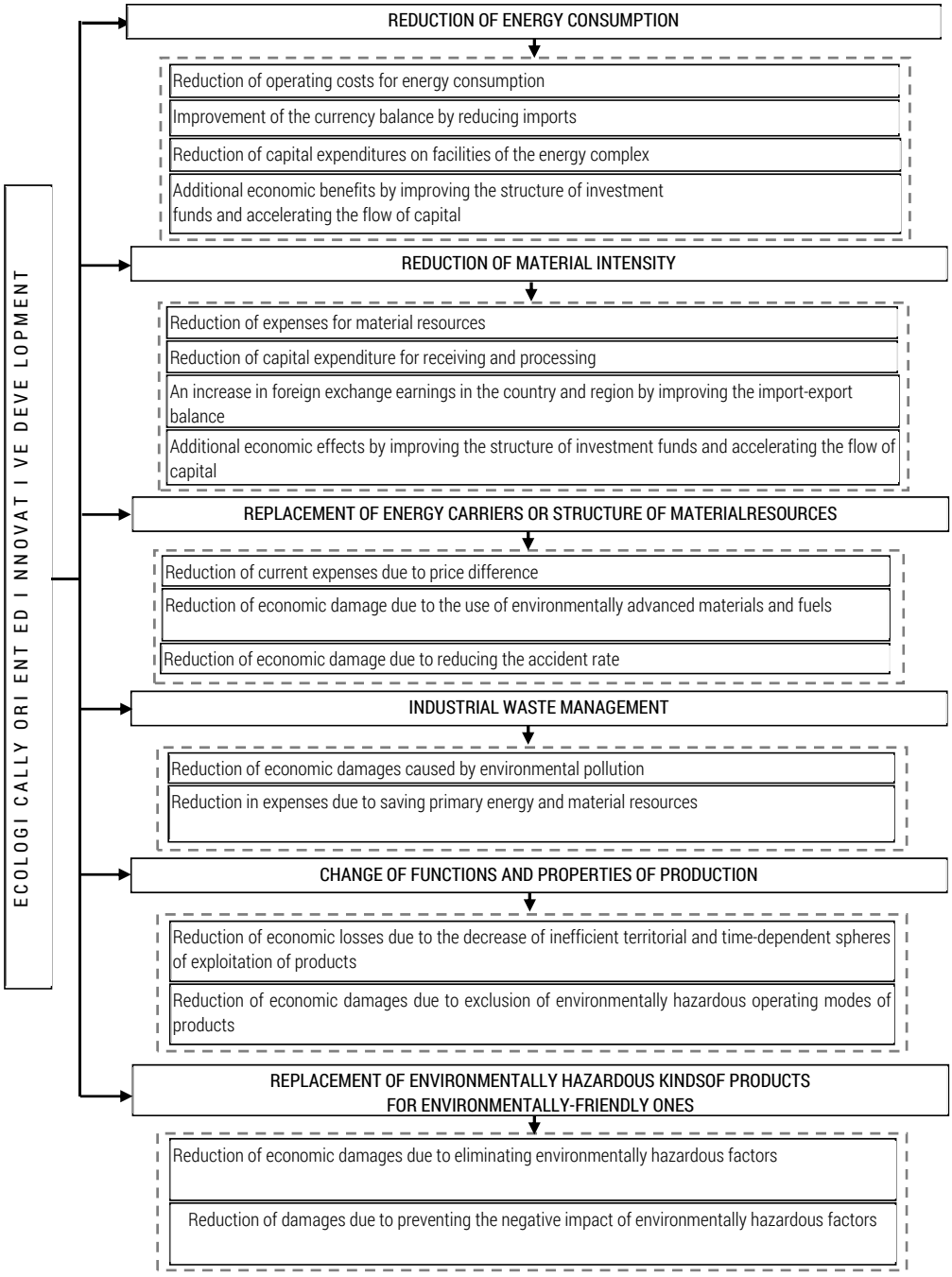


Figure 1. Ecologically oriented innovative development and economic component of the effect of implementation

Source: author's own work based on Prokopenko, 2008, p. 140.

The author hypothesis is that the glocalization of commodity markets on the basis of the implementation of environmental innovations will contribute to the sustainable development of the economy of the regions. We propose to consider environmental innovations as a catalyst for the processes of market glocalization in the internal and external dimensions. In the conditions of implementation of the principles of sustainable and balanced development of national economies, the environmental component of market glocalization becomes of paramount importance, determining the direction, peculiarities and nature of glocalizational processes. Further expansion of commodity and territorial boundaries of local markets will be possible due to the active implementation of environmental innovations by market actors focused on the formation of closed reproductive cycles, the development and production of new environmentally friendly goods, the use of resource-saving and low-waste technologies, new organizational forms, etc.

Environmental innovations are able to intensify and transform the processes of market-based glocalization, harmonize its socio-economic and environmental guidelines, change the type of market (for example, from local to regional or state), price and quality parameters of the product, characteristics of supply and demand, and significantly expand the markets (Nikishina, Zarudna, 2018; Nikishina, Bibikova, 2018).

Also, environmental innovations are able to increase the competitiveness of commodity producers through the reduction of their costs by saving resources, giving them the advantage of expanding the territorial boundaries of the market, entering into global value added chains, etc.

The environmental factor in ensuring the competitiveness of both economic entities and domestic commodity markets is becoming increasingly important and receives financial support.

In the sectoral dimension in Ukraine in 2017, 44% of the capital environmental investment in the state accounted for electricity, gas, steam and air-conditioning sector, 23.1% for the processing industry and 13.3% for the extractive industry (table 1). During the period 2014-2017 gg. there have been structural changes in the direction of reducing the share of electricity supply sector and processing industry in parallel with the growth of the extractive industry, water, public administration and defense sectors. Despite the growing trend, the share of agriculture in capital environmental investments is still insignificant (0.5%), which reduces the agrarian sector's ability to implement environmental innovations.

Thus, the analysis of environmental investment trends in Ukraine has demonstrated a growing trend in the cost of environmental protection, domination in their current cost structure, direction of about 40% of capital investment in integrated technology.

Table 1. The structure of capital investment in environmental protection by types of economic activity in Ukraine [%]

Types of economic activity	2014		2015	2016	2017		2017 in % till 2014
	UAH mln.	%			UAH mln.	%	
Total	**7959.9**	***100.0***	**7675.6**	**13390.5**	**11025.6**	***100.0***	**138.5**
1. Agriculture, forestry and fishery	26.2	***0.3***	22.4	43.7	50.4	***0.5***	192.4
2. Extractive industry	663.3	***8.3***	544	503.6	1467.7	***13.3***	221.3
3. Processing industry	2421.7	***30.4***	1730.9	2832.5	2551.6	***23.1***	105.4
4. Electricity, gas, steam and air-conditioning supply	4434.8	***55.7***	4433.7	8542.9	4847.4	***44.0***	109.3
5. Water supply; sanitation, waste management	180.1	***2.3***	502.9	750	930.8	***8.4***	5.2 times
6. Wholesale and retail trade; repair of vehicles	0	***0***	4.7	30.9	58.6	***0.5***	–
7. Transport, warehousing	78	***1.0***	59.5	96.7	65.3	***0.6***	83.7
8. Public administration and defense; compulsory social insurance	88	***1.1***	320.9	443.4	748.7	***6.8***	8.5 times
9. Other activities	67.8	***0.9***	56.6	146.8	305.1	***2.8***	4.5 times

Source: author's own work based on the State Statistics Service of Ukraine, 2018; Prokopenko, 2018.

Conclusions

The essence and growing importance of ecologization of innovative development of the regions as well as the achievable benefits resulting from the use of eco-innovations in glocalization processes is the modern accelerator of the glocalization of economic processes, in the nature of which there are incentives for self-development, reproduction, generation of innovative ideas, production of new technologies, goods and services, ensuring the balancing of the socio-ecological and economic potential of the region and the country as a whole, which determines the direction, peculiarities and nature of the processes of glocalization. Scientific novelty of the research is to develop the theoretical principles of the glocalization of economic processes by substantiating the role of environmental innovations as a catalyst for modern processes of market glocalization (internal and external), capable of transforming the nature, parameters and direction of the glocalization of commodity markets, harmonizing its socio-economic and environmental tar-

gets, and intensifying the processes of the environmentally oriented type of glocalization in order to ensure sustainable balanced development of the economy of the state and its regions.

The concept of our investigation is that ecological compatibility of innovations intensifies local and global positions of the region in an innovative domain and is one of modern tools to advance glocalization processes. It is one of the best tools corresponding to overcoming obstacles for expanding product limits of strategic markets as well as their integration into global chains of the added value. Ecologization of innovative development of regions on the principles of glocalization requires a number of own new and active measures, involvement of all levels of the public administration, science, business, public representatives for taking into account social needs and interests.

The final result of ecologization of innovation activity is a positive socio-ecological and economic effect, which ensures balanced sustainable development of the region and the state as a whole. Thus, the modern accelerator of the glocalization of economic processes is the ecologization of innovation development, in the nature of which there are incentives for self-development, reproduction, generation of innovative ideas, production of new technologies, goods and services, ensuring the balancing of the socio-ecological and economic potential of the region and the country as a whole, which determines the direction, peculiarities and nature of the processes of glocalization.

Ecologization of innovative development of regions on the principles of glocalization demands a strategic approach to its practical realization.

Traditionally selected stages of strategizing, adapted to the peculiarities of regional innovation policy in terms of glocalization, are the following: preparation for the strategizing, analysis, design, implementation, popularization. The peculiarity of the proposed process of the strategizing of innovative development on the basis of glocalization is that it takes into account the distinct methodological principles, in particular the cross-sectoral partnership, which manifests itself in attracting all interested actors (power, business, science, community) to all stages of this process. This approach increases the perceptions of policy in society, the attraction of promising ideas on the principles of crowd sourcing and the accumulation of social capital, manifested in the growth of trust and cooperation among all actors of regional innovation policy. Also there is inducted the project stage of the strategizing that will ensure the effectiveness of the strategy, the practical implementation of strategic goals and objectives.

The presence in the regions of innovative development strategies, with account of the principles of smart specialisation, opens for them the pros-

pects of joining the Smart Specialisation Platform and opening access for the regions of Ukraine to the Platform's tools, which will allow to determine the economic and innovative specialisation of the regions, improve cooperation with the EU regions in the thematic areas (industrial modernisation, agri-food, energy), to expand access to EU structural funds, to increase synergy between different policies of Ukraine and the EU, as well as to effectively involve public and private investments.

Acknowledgements

The publication was prepared within the framework of the scientific project "Development of Strategies of Innovative Development for the Regions of Ukraine on the Principles of Glocalization (by the Example of the Odessa Region)" at the expense of the budget program "Support of the development of priority areas of scientific research" (КПКВК 6541230).

The contribution of the authors

Olena Hetman – 25% (concept and objectives, literature review, research etc.).
Olga Iermakova – 25% (concept and objectives, literature review, research etc.).
Oleksandr Laiko – 25% (concept and objectives, literature review, research etc.).
Oksana Nikishyna– 25% (concept and objectives, literature review, research etc.).

Literature

Bönte W., Dienes Ch. (2013), *Environmental Innovations and Strategies for the Development of New Production Technologies. Empirical Evidence from Europe*, "Business Strategy and the Environment" No. 22, p. 501-516, https://doi.org/10.1002/bse.1753

Circular Economy Strategy (2019), *Environment Directorate-General of the European Commission website*, http://ec.europa.eu/environment/circular-economy/index_en.htm [10-06-2019]

EIO Europe in transition (2013), *Paving the way to a green economy through eco-innovation. Eco-innovation*, Observatory Founded by the European Commission, Brussels

Gusev V. (2011), *State innovation policy: methodology of formation and implementation: monograph*, Donetsk, Southeast, p. 624

Hetman O.L. (2019a), *Ecology of the innovative development of the regions. Collection of scientific articles on the materials of the V All-Ukrainian scientific-practical conference on international participation*, NMetAU, Dnepr, p. 16-19

Hetman O.L. (2019b), *Mechanisms of ecologization management of innovation and technological development. Management of innovative development at macro, meso and macro levels: Collection of scientific articles on materials of the V international scientific and practical Internet conference*, Odessa National Polytechnic University, Odessa, p. 29-31, https://economics.opu.ua/files/science/innov_roz/2019/tezy.pdf

Iermakova O.A. (2017), *Institutional levers to improve Ukraine's regional innovation policy in the context of global challenges*, IMPEER NASU, Odesa, p. 394

Iermakova O.A. et al. (2019), *Methodical Toolkit of Strategizing of Innovative Development of Regions on the Principles of Glocalization of Economic Processes*, IMPEER NASU, Odesa, p. 55

Institutional principles of ecologization of development of sectors of the national economy (2017), IPREED NAN Ukrayiny, Odesa, p. 564

Nikishina O.V., Zarudna O.P. (2018), *Globalization of commodity markets: theoretical and applied aspects. Economy of the food industry*, T.10(2), p. 9-21

Nikishina O.V., Bibikova N.O. (2018), *Formation and development of regional servicing cooperatives in the grain market: an integration approach*, IREPR NAS of Ukraine, Odesa, p. 230

Prokopenko O.M. (eds.) (2018), *Environment of Ukraine Statistical collection*, State Statistics Service of Ukraine, p. 225

Prokopenko O.V. (2008), *Ecologization of innovation activity: motivational approach*, VTD UK

Socio-economic development of the Ukrainian Black Sea region: challenges and opportunities (2016), IPREED NAN Ukrayiny, Odesa, p. 810

STUDIES AND MATERIALS

STUDIA I MATERIAŁY

Arnold BERNACIAK • Anna BERNACIAK

THE IMPLEMENTATION OF THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS BY PROCESSES OF PARTICIPATORY BUDGETING: DEVELOPMENT OF THE TRANSPORT SYSTEM AND ROAD SAFETY (THE CASE OF THE CITY OF POZNAŃ, POLAND)

Arnold **Bernaciak,** Associate Prof. (ORCID: 0000-0003-1099-286X) – *WSB University in Poznan*
Anna **Bernaciak,** PhD (ORCID: 0000-0001-8603-1323) – *Poznan University of Economics and Bussines*

Correspondence address:
Powstańców Wielkopolskich Street 5, 61-895, Poznań, Poland
e-mail: arnold.bernaciak@wsb.poznan.pl

ABSTRACT: Transport systems in cities must be constantly adjusted to accommodate the ongoing changes in the environment. Apart from life quality expectations, civilizational growth requires also meeting certain requirements in terms of safety and environmental protection. The aim of this study is to determine the extent of the implementation of the postulates of Target 2, Goal 11. of the UN Agenda for Sustainable Development through the projects submitted to participatory budgeting. When analysing the projects submitted by city dwellers, special attention was paid to those intended to introduce changes in the city's transport system. The study takes into account all of the previously implemented participatory budgets. Amongst the total of 1478 projects submitted in the years 2013-2019 316 concerned transportation issues. 46 of them were selected by vote by city dwellers. They were mostly projects concerning the construction and extension of bicycle paths and increasing the safety of pedestrians. The study findings show how big interest city dwellers have in transport and communication issues. The selection of projects submitted in this regard can contribute greatly to increasing safety, reducing the impact on the environment and, in effect, improving the quality of city life.

KEY WORDS: participatory budgeting, social participation, transport system, road safety

Introduction

One of the major tasks of city authorities is to provide city dwellers with the possibility to move around the city to perform their daily activities. The transport systems that fulfil the obligation must be effective and efficient. At the same time the systems must be safe for all the dwellers, both those using the systems and those not using them. These days, a major challenge concerning transport systems is the reduction of their environmental impact. City authorities are facing increasing demand on the part of legal requirements and social protests to apply adequate measures aimed at reducing the environmental impact exerted by public transport.

The public transport issues are dealt with by the authors of the UN Agenda for Sustainable Development (the UN General Assembly, 2015). Postulates in that respect are defined in Development Goal 11 Make cities inclusive, safe, resilient and sustainable. Target 2 of Goal 11 sets out as follows: "by 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport". Special attention must be paid to "the needs of those in vulnerable situations, women, children, persons with disabilities and older persons."

The activities that render possible the implementation of the postulates of the UN Agenda for Sustainable Development can be implemented by various entities and institutions through a variety of processes. A remarkable form of taking action is participatory budgeting. It is exceptional in being a direct reflection of the actual needs of city residents. Here, a question arises: do city dwellers understand the need for making changes to the way that transport systems operate? Are the projects submitted to participatory budgeting connected with the way transport systems operate; and if so, what aspects of their operations? This leads us towards the key question of this study: do the submitted projects correspond with the goals of the Agenda for sustainable Development? The aim of the article is to determine the level of the implementation of those postulates through projects submitted facultatively by city residents. Focusing attention on the tasks implemented under participatory budgeting makes it possible to speculate about the consistency of the residents' needs and expectations with the UN goals of sustainable development of city transport. From the practical aspect, the study helps identify the needs of city dwellers in terms of transport and road safety, and also recognise the types of the tasks requested and their time variability.

An overview of the literature

Participatory budgeting is becoming an increasingly important tool for managing public finance in cities across Poland. Under a new law passed in 2018, it is obligatory for all county towns to create participatory budgeting (the Act of 11 January 2018 amending some other Acts with a view to increasing the role of citizens in the process of electing, operating and controlling some public bodies, the Journal of Laws of 2018, item 130 as amended, art. 1, point 1, let. A). The obligation to implement participatory budgeting has been sanctioned by law with regard to 66 towns.

In September 2015, the UN General Assembly voted through the document Transforming Our World: the 2030 Agenda for Sustainable Development (the UN General Assembly, 2015). Its key content is composed of 17 goals referred to as Sustainable Development Goals. The goals are strictly connected with 169 targets which showcase the scale and character of the UN 2030 Agenda. Goal 11 of that strategy refers directly to cities and their versatile functions.

The relatedness of the above issues fits in the framework of research on participatory budgeting seen as the tool for inclusion, shared responsibility and shared decision making, as well as the implementation of the provisions of sustainable development. Amongst the most significant studies in this respect are those conducted by Cabannes (2004, 2015), Sintomer et al. (2008, 2010) and Dias (2018). A number of studies dealing with the issue cover a broader context of participatory democracy, e.g. the works of Boulding et al. (2010), Touchton and Wampler (2014). A great number of studies deal with certain selected elements of public participation, mainly with regard to particular areas of living in the city or the operations of spatial units (Avritzer, 2010; Livengood and Kunte, 2012). Furthermore, authors have also worked on numerous case studies of particular cities and countries (Menegat, 2002; Makau et al., 2012; Gonçalves, 2014). In Poland, the issue is also gaining an increasing popularity among researchers. Some interesting studies have been conducted by Burchardt-Dziubińska (2016), Pabiś (2017), Bernaciak, Sobol and Rzeńca (2017, 2018). An attempt at analysing the issues of public participation from the viewpoint of the implementation of Sustainable Development Goals was also undertaken by Fuldauer et al. (2019), McLaren et al. (2017), Bednarska-Olejniczak et al. (2019), and Chądzyński et al. (2017). However, all of the studies fail to examine the extent to which the projects submitted to budgeting and implemented under public vote meet, directly or indirectly, the detailed elements of Sustainable Development Goals (the 169 corresponding targets in particular).

Therefore, no attempt has yet been made to analyse the projects submitted to participatory budgeting with regard to city transport. This area appears to be of particular importance given the totality of transport investment in cities and towns across Poland, the role of transport in the economy, as well as the dilemmas concerning the sustainability of transport solutions (Platje et al., 2018; Paradowska, 2017; 2016; 2014). It should also be noted that research on the communization of the decision-making on the development of transport systems and improving road safety is being conducted for selected cities in Poland, but those studies do not always cover the implementation of the postulates of Sustainable Development Goals (Beim, 2012; Glazińska, 2018; Mroczek, 2018). Thus, this study falls into the broad research on participatory budgeting viewed as a tool for shared decision-making and implementing the provisions of sustainable development as well as sustaining transport systems and improving safety in cities following the guidelines of the UN Agenda for Sustainable Development.

Research methods

In order to solve the question under analysis and achieve the goals set, the method of researching documents was used. The subject of the analysis was the projects submitted to the participatory budgeting of the city of Poznań, Poland. The research covered all of the projects submitted so far. In the years 2013-209, 1479 projects were submitted, the aggregate sum of which totalled PLN 1,235,075,648. Following a number of public votes, 202 projects were accepted for implementation, the aggregate sum of which totalled PLN 146,542,522. The goals of the projects were subject of a detailed analysis. They were compared to the postulates of Target 2 (Goal 11) of the UN Agenda for Sustainable Development. The postulates stress the importance of access to "safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons."

The analysis was conducted in a dynamic manner. The number and worth of transport-related projects was identified for subsequent years. Two types of projects were distinguished: a) all of the projects submitted to participatory budgeting, b) the projects voted through by city residents. A ratio was used to calculate and show the proportion of the number and worth of the projects selected against all projects submitted. An internal structure of transport projects was also presented, breaking it down into four categories. Projects concerning pedestrian transport, bicycle transport, public transport

and individual motor transport were regarded as discrete categories. The results of the analysis are presented in the text form as well as in the form of tables and graphs.

Results of the research

In the years 2013-2019, a total of 1479 projects were submitted to the participatory budgeting of the city of Poznań. 316, i.e. 21 per cent of them, were projects involving the issues of overall transport systems. By vote, city dwellers chose 202 projects to be implemented, of which 46, i.e. 23 per cent, concerned transport issues. The number of submitted projects was steadily rising. By 2017 the number did not exceed 50, while in 2018 and 2019 the figure was over 60 (figure 1).

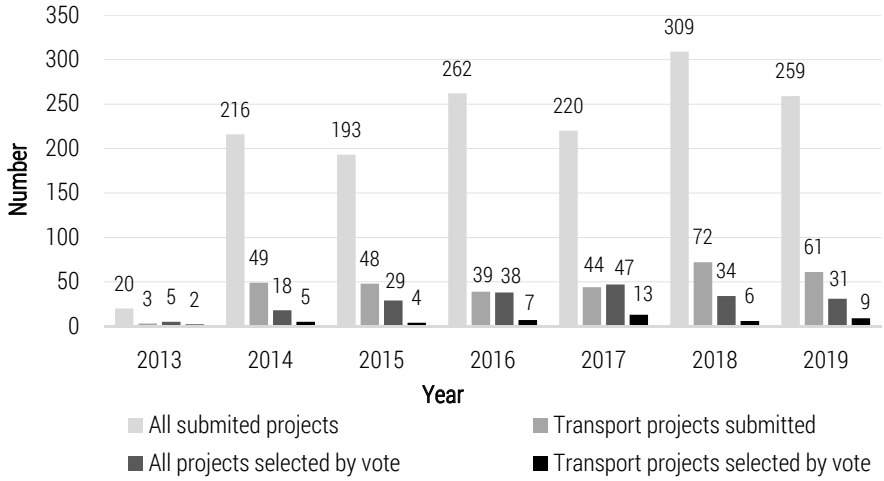


Figure 1. The number of transport projects submitted and selected by vote under the Poznań participatory budgeting in the years 2013-2019

Source: author's own work.

The proportion of transport projects in the Poznań participatory budgeting must be considered significant. With regard to the submitted projects the proportion was between 15% and 25%. The average annual figure was 21%. The projects selected by residents by vote constitute a similar proportion. Transport projects accounted for 14%-40% with the annual average proportion of 25% (figure 2).

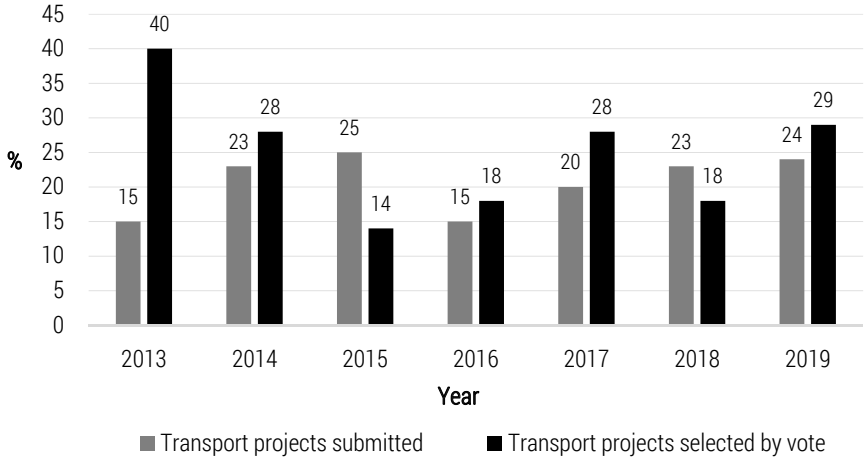


Figure 2. The proportion of transport projects submitted and selected by vote under the Poznań participatory budgeting in the years 2013-2019

Source: author's own work.

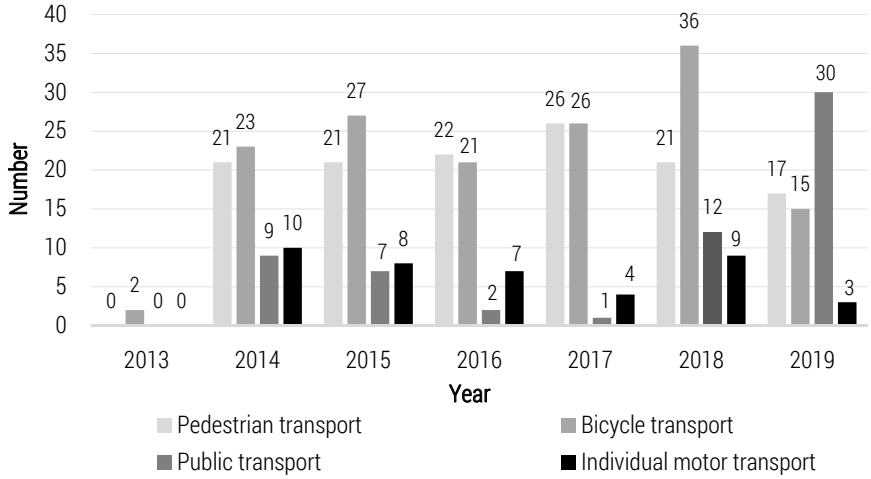


Figure 3. Transport projects submitted to the Poznań participatory budgeting in the years 2013-2019, according as per category

Source: author's own work.

Amongst all the transport projects submitted to participatory budgeting there are four different categories: pedestrian transport, bicycle transport, public transport and individual motor transport. Some of those projects implemented the goals of two of the above categories. The biggest number of projects concerned the category of bicycle transport (150). Pedestrian trans-

port projects took the second place with 128 projects submitted. Relatively few projects were submitted within the categories of public transport (61) and individual motor transport (41) (figure 3).

The categories come in a similar order in terms of the projects selected by residents for implementation. However, there are significant disparities among the categories themselves. In the years 2013-2019, 38 bicycle transport projects were selected for implementation, accounting for 25% of all projects submitted in that respect. As regards pedestrian transport, 22 projects were selected, accounting for 17% of all projects selected in that respect. When it comes to public transport, only 3 projects were selected, and as far as individual motor transport is concerned, only 2 projects were selected (accounting for 5% of projects in both categories respectively).

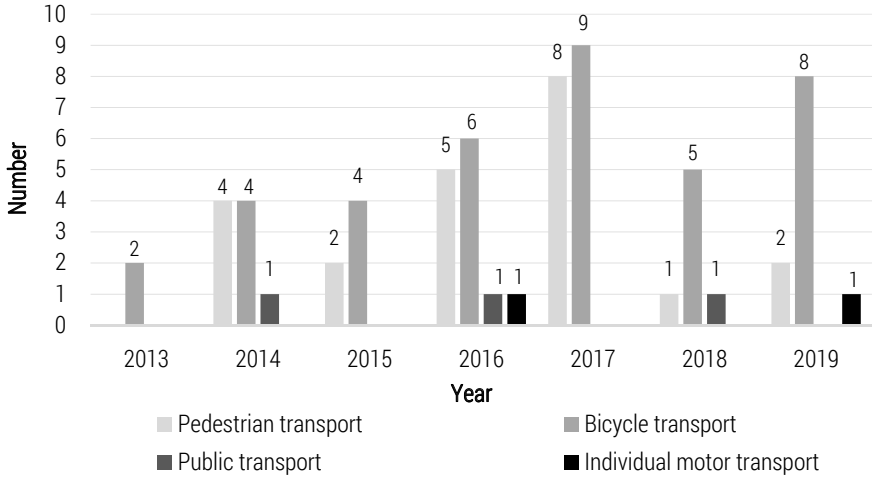


Figure 4. Transport projects selected for implementation under the Poznań participatory budgeting in the years 2013-2019, as per category

Source: author's own work.

Conclusions

The research findings reveal that residents of the city under analysis show a lot of interest in improving the existing transport systems. City residents manifest their interest in two ways. First, they submit a great number of projects to be implemented under the participatory mechanism. Second, transport projects win huge support of residents in public vote. The large number of projects showcases the big role played by local leaders as well as formal and informal residents' associations. Thanks to their activity and

mobilization a lot of projects that fulfil the postulates of residents in terms of bettering city transport systems can be implemented under the participatory budgeting mechanism. Furthermore, a great number of votes cast by city dwellers on transport projects shows how important improvement in transport systems is to them. The analysis findings show also that transport projects take a bigger proportion of projects selected by vote (23%) among all the projects sent to implementation than all the projects submitted (21%). The findings show an increasing demand for active leaders who would verbalize the needs of city residents by drawing up projects that showcase their expectations in terms of improving city transport systems.

The projects submitted and selected under the Poznań participatory budgeting meet explicitly the transport postulates formulated by the UN Agenda for Sustainable Development (Goal 11, Target 2). The projects most often submitted and most often selected reflect the expectations of city residents with regard to the development and extension of bicycle and pedestrian paths. The development of bicycle paths is instrumental in the residents' safe cycling around the city. The readiness of bicycle paths encourages city dwellers to change their daily commuting routine in terms of their travelling to and from work as well as leisure activities. Thus, the development of bicycle paths helps reduce the impact that individual motor transport exerts on the environment. Road safety standards are also raised thanks to the numerous investment projects covering pedestrian transport. The development, extension and repairs of pavements contribute to improving safety and comfort of life of the groups listed in the Agenda as particularly vulnerable, i.e. children, the elderly, and the disabled.

Interestingly, the projects on individual motor transport are enjoying a relatively little interest on the part of city dwellers. Over the period under analysis, only two projects of that type were selected. Both were aimed at regenerating the existing road solutions, slowing down the traffic and improving safety, thus helping realize the postulates set out by the United Nations.

Of the four transport categories under analysis, public transport is the category that failed to gain any significant support that would be otherwise possible through the implementation of the submitted and selected projects under participatory budgeting. In the period under analysis, only three projects of that type were implemented. Public transport is managed by independent private business operators at operational level. Apparently, city residents' believe they have no influence on changing any solutions in this respect. However, the actual provider of public transport, responsible for its development and any changes at the strategic level is city authorities with residents having a real influence on their decisions. Changes in this area

would only be possible if the leaders of local communities became more active and made city dwellers more aware of their right to have their postulates realized by city authorities.

In the light of the above presented study findings, participatory budgeting can be regarded as an effective mechanism for implementing the postulates of the UN Agenda for Sustainable Development in terms of transport systems. The needs and expectations of the self-organizing local communities are in line with the postulates of the Agenda. Because the study findings are rather narrow – they only cover the case of a single city – it is hard to make any broader conclusions. The theses put forward in this study will be only verified if the research can be also conducted in more cities in Poland and other economic and political systems.

The contribution of the authors

Arnold Bernaciak – 50% (conception, data acquisition, data analysis, interpretation discussion).

Anna Bernaciak – 50% (literature review, data analysis, interpretation, discussion).

Literature

Avritzer L. (2010), *Living under a Democracy: Participation and Its Impact on the Living Conditions of the Poor*, "Latin American Research Review" No. 45, p. 166-185

Bednarska-Olejniczak D., Olejniczak J., Svobodová L. (2019), *Towards a Smart and Sustainable City with the Involvement of Public Participation – The Case of Wroclaw*, "Sustainability" No. 11, 332, DOI: 10.3390/su11020332

Beim M. (2012), *Polityka rowerowa Fryburga Bryzgowijskiego*, "Transport Miejski i Regionalny" No. 1, p. 30-38

Boulding C., Wampler B. (2010), *Voice, Votes, and Resources: Evaluating the Effect of Participatory Democracy on Well-being*, "World Development" No. 38, p. 125-135, DOI: 10.1016/j.worlddev.2009.05.002

Burchard-Dziubińska M. (2016), *Budżet obywatelski jako narzędzie realizacji rozwoju zrównoważonego na poziomie lokalnym – Przykład Łodzi*, "Studia i Prace WNEIZ US" No. 46, p. 235-246, DOI: 10.18276/sip.2016.46/1-18

Cabannes Y. (2015), *The impact of participatory budgeting on basic services; municipal practices and evidence from the field*, "Environment and Urbanization" No. 27, p. 257-284, DOI: 10.1177/0956624781557229 7

Cabannes Y. (2004), *Participatory budgeting: a significant contribution to participatory democracy*, "Environment and Urbanization" No. 16, p. 27-46, DOI: 10.1177/095624780401600104

Chądzyński J. et al. (2017), *Aktywności mieszkańców Łodzi na rzecz ochrony środowiska*, "Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu" No. 477, p. 49-58

Dias N. (2018), *Hope for Democracy. 30 Years of Participatory Budgeting Worldwide*, Epopeia Records & Oficina coordination & Nelson Dias, Faro, Portugal

Fuldauer, L.I. et al. (2019), *Participatory planning of the future of waste management in small island developing states to deliver on the Sustainable Development Goals*, "Journal of Cleaner Production" No. 233, p. 147-162, DOI: 10.1016/j.clepro.2019.02.269

Gazińska O. (2018), *Changes in road infrastructure in smart city development model of Szczecin, Poland*, "Przestrzeń i Forma" No. 36, p. 177-190, DOI: 10.21005/pif.2018.36.C-05

Gonçalves S. (2014), *The Effects of Participatory Budgeting on Municipal Expenditures and Infant Mortality in Brazil*, "World Development" No. 53, p. 94-110 DOI: 10.1016/j.worlddev.2013.01.009

Livengood A., Kunte K. (2012), *Enabling participatory planning with GIS: a case study of settlement mapping in Cuttack, India*, "Environment and Urbanization" No. 24, p. 77-97, DOI: 10.1177/0956247811434360

Makau, J., Dobson S., Samia E. (2012), *The five-city enumeration: the role of participatory enumerations in developing community capacity and partnerships with government in Uganda,* "Environment and Urbanization" No. 24, p. 31-46, DOI: 10.1177/0956247812438368

McLaren D., Agyeman J. (2017), *Sharing cities for a smart and sustainable future*, in: T. Haas, H. Westlund (eds.), *In The Post-Urban World: Emergent Transformation of Cities and Regions in the Innovative Global Economy*, Routledge, p. 322-335

Menegat R. (2002), *Participatory democracy and sustainable development: Integrated urban environmental management in Porto Alegre, Brazil*, "Environment and Urbanization" No. 14, p. 181-206, DOI: 10.1177/095624780201400215

Mroczek M. (2018), *Infrastruktura rowerowa w budżecie obywatelskim miasta Łodzi*, "Autobusy-Technika, Eksploatacja, Systemy Transportowe" No. 11, p. 22-29

Pabiś Ł. (2017), *Zrównoważony rozwój w kontekście nowych koncepcji zarządzania publicznego: New Public Management i Public Governance*, "Zeszyty Naukowe Politechniki Częstochowskiej" Zarządzanie No. 25, p. 7-22, DOI: 10.17512/znpcz2017.1.2.01

Paradowska M. (2014), *Problematyka budowy instrumentów na rzecz kreowania zrównoważonych zachowań transportowych*, "Zeszyty Naukowe WSB we Wrocławiu" No. 39, p. 255-275

Paradowska M. (2016), *Wyzwania dotyczące współpracy interesariuszy na rzecz zrównoważonego rozwoju transportu w polskich miastach*, in: K. Kociszewski (ed.), *Rozwój trwały i zrównoważony,* "Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu" No. 452, p. 229-241

Paradowska M. (2017), *Measuring socio-economic welfare and sustainable transport – selected dilemmas*, "Ekonomia i Środowisko" No. 60, p. 19-27

Platje J., Paradowska M., Kociszewski K. (2018), *Ekonomika transportu – teoria dla praktyki*, Wydawnictwo WSB we Wrocławiu, Wrocław

Sintomer Y. et al. (2010), *Learning from the South: Participatory Budgeting Worldwide – An Invitation to Global Cooperation*, InWent, Berlin, Germany

Sintomer Y., Herzberg C., Rocke A. (2008), *Participatory budgeting in Europe: Potentials and challenges,* "International Journal of Urban and Regional Research" No. 32, p. 164-178, DOI: 10.1111/j.1468-2427.2008.00777.x

Sobol A., Bernaciak A., Rzeńca A. (2017), *Participatory budgeting as a tool of environmental improvements in Polish cities*, "Economic and Environmental Studies" No. 17, p. 893-906, DOI: 10.25167/ees.2017.44.16

Sobol A., Bernaciak A., Rzeńca A. (2018), "*New" Public Urban Space: Citizens' Initiatives in Participatory Budgeting in Katowice, Łódź and Poznań*, "Miscellanea Geographica – Regional Studies on Development" No. 22, p. 197-202, DOI: 10.1478/mgrsd-2018-0028

Touchton M., Wampler B. (2014), *Improving Social Well-Being through New Democratic Institutions*, "Comperative Political Studies" No. 47, p. 1442–1469, DOI: 10.1177/0010414013512601

United Nations General Assembly (2015), *Transforming our world: the 2030 agenda for sustainable development*, New York

The Act of 11 January 2018 *amending some other Acts with a view to increasing the role of citizens in the process of electing, operating and controlling some public bodies* (The Journal of Laws of 2018, item 130 as amended)

Agnieszka RZEŃCA • Rafał MYSIALA

LOW-EMISSION ECONOMY PLANS – PLANNING AND IMPLEMENTATION DILEMMAS. THE CASE OF CITIES IN THE LODZ METROPOLITAN AREA

Agnieszka **Rzeńca**, PhD (ORCID 0000-0003-1167-1363) – *University of Lodz, Faculty of Economics and Sociology*
Rafał **Mysiala**, Msc

Correspondence address:
POW Street 3/5, 90-255, Łódź, Poland
e-mail: agnieszka.rzenca@uni.lodz.pl

ABSTRACT: Undoubtedly, each city is an anthropogenic environment filled with multiple human activities and sometimes suffering from limitations resulting from them. In particular, the exacerbating problems of poor air quality pose serious risk to the quality of life in a city. Contemporary cities should be able to successfully face the challenge and stimulate the development of low-emission economy. Low-emission Economy Plan is an instrument addressed to local authorities expected to respond to problems and needs of cities with this respect. This paper compares methodologies of drafting Low-emission Economy Plans and identifies their role in developing contemporary cities. Towns of the Lodz Metropolitan Area have been selected for the case study as cities with industrial heritage mostly coping with environmental problems triggered by the stormy growth of textile industry in the 19th and 20th centuries as well as social and economic developments currently taking place in the Lodz Metropolitan Area (in Polish: Łódzki Obszar Metropolitalny).

KEY WORDS: low-emission economy, Low-emission Economy Plan, local development, metropolitan area

Introduction

Postulates advocating the stabilisation of air pollution and, above all, restrictive limitations of greenhouse gas emissions (*United Nations Framework Convention on Climate Change,* Rio de Janeiro 1992; *the Kyoto Protocol to the UN Framework Convention on Climate Change,* Kyoto 1997) have not produced expected results. Reduction of national emissions was interpreted as a way to ensure global "public good", a benefit that would be available to all countries with simultaneous strong temptations for free-riding (Falkner, 2016). As a result, the uncertainty of nations states as to the behaviour of other countries (emittents) and, in particular, the absence of mutual trust restricted ratification and execution of international regulations on climate change and limitation of air pollution.

Omnipresent climate and energy related postulates, which previously had not been universally approved by the nation states, brought about concrete initiatives at regional and local levels. Concrete measures were also taken by the European Union and by local authorities of the EU Member States. In the *EU "Europe 2020"* strategy, for smart, sustainable and inclusive growth one of the five principal goals deals with climate and energy. This goal has been reflected in a number of EU documents concerning the building of low-emission society (*Roadmap for moving to a competitive low-emission economy in 2050*), improving energy security (*Energy efficiency action plan*), and sustainable transport (*White Paper. Roadmap for a Single European Transport Area – Towards a competitive and resource efficient transport system*).

The above EU declarations and documents triggered practical measures undertaken by local authorities. In 2008 the European Commission initiated the Covenant of Mayors (CoM) initiative for local sustainable energy[1] whose goal was to stimulate voluntary measures aimed at reducing the CO_2 emissions by at least 20% until 2020 (compared to the level of emissions reported in 1990). Sustainable Energy Action Plan (SEAP) drafted by local authorities and delineating directions and priorities of activities was an instrument that operationalised the adopted assumptions but at the same time a formal requirement that had to be met to join the Covenant. In 2015 the Covenant of Mayors (whose name was changed to the Covenant of Mayors for Climate and Energy) adopted new goals, much more restrictive than the previous ones

1 Covenant of Mayors brings together local authorities. In 2009 five Polish cities joined the Covenant: Warsaw, Bielsko-Biała, Raciechowice, Niepołomice, and Lubianka. Today the Covenant consists of 74 units from Poland the total population of over 5 million. Currently over ca. 9 K cities/municipalities in Europe (as at 09.10.2019), https://www.porozumienieburmistrzow.eu/about-pl/cov-initative-pl/cov-figures-pl.html

(CO_2 emission (and perhaps also emissions of other greenhouse gases) lower by at least 40% by 2030). These goals are to be achieved through the implementation of the Sustainable Energy and Climate Action Plan 2030 (SECAP) which specifies actions required of stakeholders and is identical with the SEAP although its scope is much wider (e.g. climate change adaptation measures) (http://dev.eumayors.eu/IMG/pdf/ CoM_leaflet_pl_web.pdf).

EU initiatives have been approved and reinforced by the Paris Agreement (2015) which:

1. highlighted global emission reduction as well as the need to transform the energy sector,
2. provided the roadmap in which low-carbon economy has become a long-term growth strategy at transnational as well as local levels (Burchard-Dziubińska et. al., 2017, p. 16),
3. stressed that dynamic developments in the field of climate observed in many countries mobilise more countries and entities to collective international efforts even if the majority still opposes mandatory emission restrictions (Falkner, 2016).

Deepening air quality crisis and directly visible negative effects of climate change have mobilised societies to re-orientate their approaches towards making their economies more environmentally-friendly, especially to decarbonise them. In the EU programming period 2014-2020, low-carbon economy has been identified as one of four key areas to which the Member States and regions should direct their investment projects to carry out the currently binding cohesion policy. One of eleven priorities (the so called thematic objectives) of the cohesion policy for the period 2014-2020, goal 6 dealt with supporting the shift towards low-carbon economy in all sectors.

The development of low-carbon economy depends on the performance of instruments adopted to reduce energy consumption, improve energy efficiency, diversify energy sources, eliminate fossil fuels, promote public transport, etc. Measures in the field of energy, environmental protection, climate, as well as in-depth transformation of the economic system are still left without any credible response of public bodies, including local authorities. Low-emission Economy Plan (LEP) can be a breakthrough as it seeks to design complex interventions intended to reduce air pollution and its sources and direct the development of a municipality/city towards resource efficient and low-carbon economy. The LEP is a new instrument dedicated to the territorial self-government which may importantly stimulate, initiate, and support innovative measures.

The main goal of the paper is to compare the methodology of drafting the LEPs and their validation against the adopted assumptions (procedures), as well as identification of shortcomings and gaps in their preparation.

An important aspect includes specifying the role of LEPs in the shaping of urban policies in contemporary cities. Cities of the Lodz Metropolitan Area (Polish abbr. LOM) have been selected for the case study. LOM consists of 32 territorial units, including 12 cities. The Area struggles with serious environmental problems, in particular with air pollution, exposing major portion of its population to negative health effects of poor aero-sanitary condition of air, and the intensity of unfavourable occurrences stemming from the cumulation of air pollution in strongly urbanised areas (intensified emission of transport-borne pollution, big concentration of the sources of emission within a small area, poor ventilation in densely built-up areas). In addition, the study was motivated by the wish to double check how active the cities are in working for the low-carbon economy. In 2013 as few as 1/3rd of cities covered by the study reported such measures[2] while all of them declared they wanted to draft the LEP and most of them stressed they would need financial support. Importantly, 7 of the cities covered by the study planned to draw up a Plan for sustainable urban mobility or include references to mobility in the Low-emission Economy Plan, if a LEP was to be prepared.[3] Only a couple of years later the situation changed and in 2018 all cities within the LOM had adopted their own LEPs.

Towards low-carbon economy – An overview of literature

The robber economy in the 19th and 20th centuries, mass and irrational intake of raw materials and intensifying ecological threats (including pollution) imposed even more stringent environmental limitations on the social and economic development and forced out searches for new solutions and methods of limiting and neutralizing pollution. The literature on the subject writes about the ecologization of development, which consists in striving for structural changes in the whole economy and transformation of its individual sectors in order to reduce the consumption of energy, raw materials and water, reduce the amount of produced pollutants and their arduousness for the environment and society. The so-called ecological economics – a system that optimises the flow of goods and services in order to maximise the use of raw materials and reduce the amount of waste to a minimum – is gaining in importance (Famielec, 2015, p. 15). Nowadays, ecologization is a feature of

2 Although most probably LOM cities and towns had already conducted activities, such as, e.g., thermo-modernisation of public buildings, providing cycling infrastructure, etc. before.

3 Questionnaire-based studies were carried out in LOM municipalities over the period 2013-2014 as part of the exercise aimed at drafting the Development Strategy for the Lodz Metropolitan Area 2020+ [2014]. Studies based on a formalised questionnaire-based interview were conducted by M. Burchard-Dziubińska and A. Rzeńca.

market economy development, and its main attributes include: creation of markets, integration of activities with other policies, cooperation with other policies, observation of market formation, stimulation/support of pro-environmental market transformations, conscious abandonment of activities harmful to the environment (Graczyk, 2013, p. 376).

Seeking to ensure high environmental protection through ecologization of the economy is nothing new, nevertheless currently it takes on a new and a very deep meaning as a result of loudly voiced postulates of circular economy (OECD, 2011), low-carbon economy (*Budowa*..., 2016; Burchard-Dziubińska et al., 2017), or climate change adaptation (Adger et al., 2005). Characteristically, ecologization deals with economic processes (micro and macro), as well as social life at a local level where the users of the environment have direct impact upon the scope and scale of anthropopressure, where negative external effects of their activities emerge, such as: overproduction of waste, appropriation and degradation of space, as well as low-stack emission from, e.g.: expanding private transport and local furnaces.

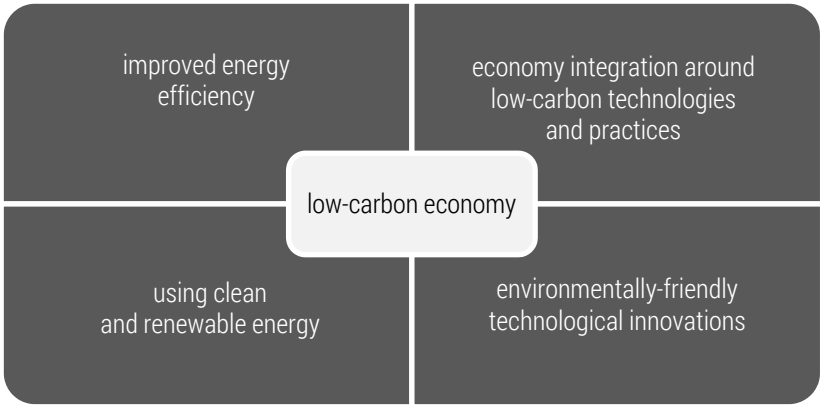


Figure 1. Key areas and goals of low-carbon economy

Source: author's own work.

Ecologization of development links, above all, with working out new economic and decision making criteria on the allocation of resources as well as consumer choices that would be rational from economic and environmental point of view. Low-carbon economy is a specific area, in which development takes place as a result of integration of all aspects of the economy around low-carbon technologies and practices, efficient energy solutions, clean and renewable energy, as well as environmentally-friendly technological innovation (*Budowa*..., 2011; Dzikuć, 2017). It deals with aspects of energy efficiency, sustainable transport, diversification of heat energy and electricity

sources, reducing sources of low-stack emission, environmental awareness but also changing habits in households, public institutions, and businesses (figure 1).

Low-emission Economy Plan: origins, substance, and functions

The EU engagement into the development of low-carbon economy and counteracting climate change coupled with intensified research dealing with air quality in Polish cities triggered some activities in this field in Poland. Impulse towards them and an undisputed argument for Polish local authorities to develop interest in low-carbon economy came from concentrating funds on measures designed to improve energy efficiency and launching support for drawing up a planning instrument called Low-emission Economy Plan (LEP). LEP's history as an instrument targeting local authorities (but also unions, associations or agreements of several units of territorial self-government) is rather short and its drafting is not required by law but is one of the requirements specified by the National Fund for Environmental Protection and Water Management (Polish abbr. NFOŚiGW)[4] in its calls for proposals. The goal of the plan is to examine the scope of feasible undertakings which, if implemented, would change the structure of energy sources and reduce energy consumption leading to gradual reduction of CO2 emissions (one of major greenhouse gases) within a municipality/city. Its main objective is to direct the intervention to low-carbon measures, efficient use of resources, and creating "zero-emission" economy. Having a LEP is a pre-condition for applying for the EU subsidies, as well as for national or regional funds in the financial perspective 2014-2020.

A LEP covers the entire territory of a municipality/municipalities (special attention should be paid to areas earmarked for intensive use which will impact the increase in energy consumption). In its construction and methodology LEP makes references to the SEAP; according to guidelines for the call of proposals it is a document consisting of 4 elements:

4 In 2013, the NFOŚiGW announced call for proposals for municipalities concerning the drawing up of low-carbon economy plans for which they could get subsidies from the Cohesion Fund (85% of eligible costs). Annex 9 to the rules of the Call for Proposals No. 2/PO IiŚ/9.3/2013 under priority axis 9 of the Operational Programme Infrastructure and Environment for the period 2007-2013 "Environmentally Friendly Energy Infrastructure and Energy Efficiency", measure 9.3. "Thermo-modernisation of public buildings and low-emission economy plans", http://pois.nfosigw.gov.pl/pois-9-priorytet/ogloszenie-o-naborze-wnioskow/w-ramach-dzialania-93-konkurs-2/. In this call for proposals, eligible costs were those incurred after 1.01. 2013 in relation with: drawing up new or updating the already existing low-emission economy plans, creating databases for baseline inventory of CO_2 emissions and training courses for municipality officials in supervision and delivery of measures in the area of energy efficiency.

1. Summary.
2. General strategy (strategic and detailed goals, current state of affairs, identification of problem areas, organisational and financial aspects (organisational structures, human resources, engaged parties, budget, sources of investment financing, financial resources for monitoring and evaluation).
3. Results of the baseline inventory of CO_2 emissions (BEI).
4. Measures/tasks and resources planned for the period covered by the plan (long-term strategy, objectives and obligations, short-/medium-term measures/tasks (description, bodies responsible for the implementation, timetable, costs, indicators) (Annex 9 to the rules of the Call of Proposals No. 2/PO IiŚ/9.3/2013).

The LEP is viewed as a confirmation that a municipality is aware of its energy situation and has planned adequate actions for some years to come. Database about energy consumption and CO_2 emissions across a municipality, its public and private sectors, is crucial for planning actions for the future (*Poradnik*..., 2003). The database should include: final heat energy and electricity consumption in municipal buildings, service and industrial facilities, houses (municipal and private), municipal street and road lighting and final energy consumption in transport (municipal transport stock (e.g. company cars, garbage trucks, police vehicles and other vehicles), public transport, private and commercial transport on municipal roads, local ferries, off-road transport (e.g. agricultural and construction machinery)[5].

An answer to the above-mentioned inventory comes in a long-term strategy and identification of complementary short/medium-term tasks (figure 2). In plans local authorities may outline the scope of operating activities covering the nearest 3-4 years following the adoption of the plan. Nevertheless, it is advisable to take account of the long-term perspective, in particular in the context of suburbanisation and new planned investment projects. However, a LEP should not be seen as a finite document. It evolves over time, the database should be updated at least twice a year and activities need to be examined on a continuous basis. The plan should also be monitored and updated against identified needs.

5 On 18.03.2015 Annex 9 to the rules of the Call for Proposals "Detailed recommendations on the structure of low-emission economy plan" was changed by deleting provisions concerning the exemption of entities engaged in the delivery of low-emission economy plan installations covered by the EU ETS system. This change enabled installations covered by the EU ETS system and entities responsible for them can be taken into account in low-emission economy plans. The structure of LEP remained unchanged.

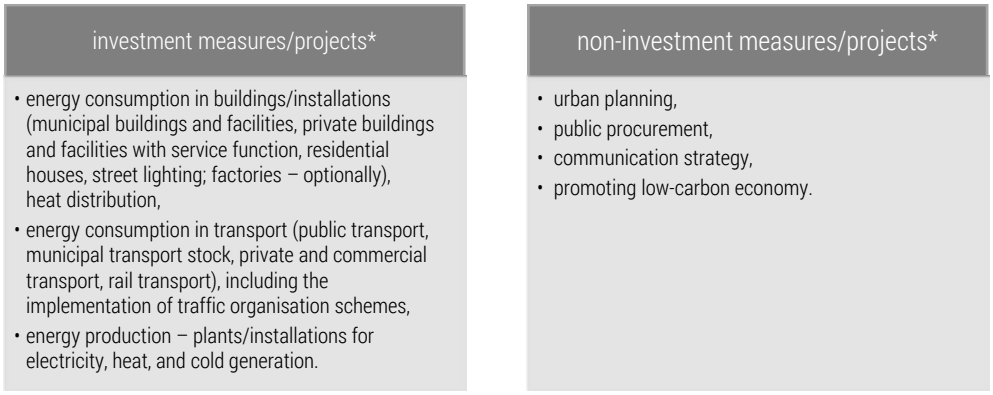


Figure 2. Scope of potential measures identified in LEP in LOM cities

*A municipality which plans pro-energy measures to be put in place in waste management or water-sewage management should include them in the LEP.

Source: author's own work based on Annex 9 to the rules.

Research methods

Spatial scope of the studies covers towns and cities within the Lodz Metropolitan Area (Polish abbr. LOM), i.e., Aleksandrów Łódzki, Brzeziny, Głowno, Koluszki, Konstantynów Łódzki, Łódź, Ozorków, Pabianice, Rzgów, Stryków, Tuszyn, and Zgierz linked by the history and tradition of the textile industry and sharing today's environmental problems (All of them are members of the Lodz Metropolitan Area Association). The timeline of the research covers LEP drawn up and adopted in the period 2015-2018.

To accomplish the research goal, we compared drawn up and adopted LEPs. They were compared against border conditions for the LEP which are decisive for its substance, i.e.:

1. Substantive scope taking account of the complexity of the plan assessed through the lenses of the complementarity of investment and non-investment tasks (measures/projects).
2. Scope and correctness of the baseline CO_2 emission inventory (BEI) and performance indicators (monitoring indicators; for instance, CO_2 reduction compared to previous years (1990 or any other for which an inventory could be carried out), reduction in final energy consumption compared to the base year, proposed monitoring of indicators based on the methodology corked out by the Joint Research Centre (JRC) of the European Commission in cooperation with the DG ENER and the Office of the Covenant of Mayors included in the guide "How to develop a Sustainable Energy Action Plan (SEAP)".

3. Stakeholder engagement at the stage of preparation and implementation (engaging energy producers and/or consumers in particular in activities within the public but also private sector).
4. Coherence between actions included in the LEP and Air Protection Programme (APP) and Short-Term Action Plan (STAP).

Results of the research

By the end of 2018, twelve towns and cities of the LOM worked out their LEPs in accordance with the guidelines for the call of proposals. Technically, LEPs have a similar structure. No city decided to draw up a LEP in cooperation with another city. In the majority of cases (7 cities) plans were developed by external companies.

With reference to the comparison criteria, below we present crucial results of the studies:

1. Substantively, the thematic scope of plans, their complexity and level of details are highly diverse. We need to bear in mind that it is not the effect of individual circumstances in each town or city but a derivative of how the plan was drawn up in its individual parts, i.e., the diagnosis of the present situation, baseline emissions inventory, and measures adopted to reduce emissions. Measures included in the operational part of the plans can be divided in two groups: common and incidental. Common measures are mostly short-term hard investment projects (planned for a particular period), mainly public. Most of them deal with thermo-modernisation of houses and public buildings, extension of cycling infrastructure, installing solar panels on public and private buildings, as well as investments in urban supply networks. There is a small group of innovative measures, such as, green public procurement, installing dust sensors, smart energy management systems in buildings or managing street lighting. Much less frequently cities plan soft projects and even if they are proposed they are usually presented as demonstration/pilot projects (e.g., carpooling and carsharing). Financing formats are described at different level of detail, e.g., Brzeziny and Aleksandrów Łódzki prepared a financial forecast earmarking funds for individual tasks while Głowno identified only tasks and sources of funding without specifying the amounts. The LEP completely ignores the private sector (cooperation, support, disseminating best practices).
2. From the viewpoint of the dynamics of low-carbon economy development, baseline inventory of emissions is crucial for drafting a LEP and identifying a package of corrective actions. Unfortunately, the commis-

sioning of LEP to external companies unaware of local circumstances brings about incomplete and often contradictory outcomes. Each of LOM towns and cities followed a different research methodology and adopted a different base year. The scope of BEI study differs with respect to detail and the form of data presentation. Towns and cities described their CO2 emissions in great detail (e.g., Aleksandrów Łódzki, Konstantynów Łódzkie, Pabianice, Łódź, Zgierz, and Stryków) broken down by sectors: transport, public buildings, private buildings, street lighting, and businesses and/or by types of fuel. Other towns and cities (e.g., Tuszyn, Koluszki, and Brzeziny) provided very fragmented and incomplete data which is why we cannot consider them reliable. For instance, in Brzeziny, where air quality is very poor (Polish Smog Alarm), CO_2 emission is the lowest. That is because when the plan had been drafted, emissions from transport and industry were ignored since they were considered little relevant and having minor impact on air quality. In general, the lack of standard inventory in many towns and cities resulted in the absence of CO2 emission forecast in many plans which adversely affected the estimates of future emissions and, consequently, prevents their monitoring.

3. Unfortunately, a weak point of LEP lies in the lack of stakeholder engagement. Even if we have been told about social consultations, e.g., in the form of questionnaire-based studies, we have not been informed about certain data concerning the number of filled questionnaires or the dates of consultations. While when plans are being drawn up participatory measures are considered, the final plan misses provisions (solutions) on co-participation or cooperation, e.g., with the private sector in the execution of the plan.
4. All LEPs highlight cohesion with other documents, among others, APPs and STAPs, unfortunately, not all solutions and instruments have been transferred to the LEPs. Thus, the cohesion concerns only the goals not the undertaken activities. The lack of synchronisation between these documents hinders their effectiveness.

Conclusions

Development towards low-carbon economy is an opportunity for the local population and economy in particular in the context of the quality of life, building a competitive position, and creating the image of a city/town. One may expect that the LEPs will be important documents testifying to the innovative approach of local authorities to development, as well as an expression of care for the environment in which their residents live. Conducted studies identified a number of LEP shortcomings at the stage of planning.

In the light of these studies, attention should be drawn to low quality of prepared documents and narrow approach to the subject at hand. LEPs are not a multi-platform for action for the development of low-carbon economy at local and supra-local scale. Local authorities exhibit an instrumental approach to plans, viewing them through the lenses of acquiring funds for concrete investment projects. LEPs neither identify nor recommend solutions that would support the triggering of market processes leading to the low-carbon economy. The absence of a comprehensive approach, reliable studies on the inventory of pollution, and actions that would be adequate to them reduces the efficiency of the plan. The omission of participation and private sector stakeholder and residents' engagement weaken the position of the document. Benefits resulting from LEPs are limited to necessary albeit standard investments while the LEP potential is much bigger and deals with the overcoming of information, technological or awareness barriers, as well as stimulating the low-carbon economy at local level.

The contribution of the authors

Agnieszka Rzeńca – 70% (concept, research method, literature review, analysis and conclusions).

Rafał Mysiala – 30% (literature review, data analysis and conclusions).

Literature

Adger N., Arnell N.W., Tompkins E.L. (2005), *Successful adaptation to climate change across scales*, "Glob. Environ. Change" No. 15(2) pp. 77-86, 10.1016/j.gloenvcha.2004.12.005

Budowa gospodarki niskoemisyjnej: podręcznik dla regionów europejskich (2011), Regionalne Centrum Ekologiczne na Europę Środkową i Wschodnią, p. 7

Budowa gospodarki niskoemisyjnej. Praktyka na poziomie lokalnym w Polsce i w Niemczech (2016), Polski Klub Ekologiczny Okręg Mazowiecki, Warszawa, p. 10

Burchard-Dziubińska M., Stępniewska Z., Tarnowski M. (2017), *Gospodarka niskoemisyjna*, Wydawnictwo Texter, Warszawa, pp. 46-47

Dzikuć M. (2017), *Ekonomiczne i społeczne czynniki ograniczania niskiej emisji w Polsce*, Wydawnictwo Difin, Warszawa, p. 107

Graczyk A. (2013), *Instrumenty rynkowe polityki ekologicznej. Teoria i praktyka,* Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu, Wrocław, p. 376

Falkner R. (2016), *The Paris Agreement and the new logic of international climate politics*, https://onlinelibrary.wiley.com/doi/full/10.1111/1468-2346.12708 [14-09-2019]

Famielec J. (2015), *Ekologizacja jako paradygmat rozwoju społeczno*-gospodarczego, in: M. Kożuch (ed.), *Ekologizacja gospodarki*, Fundacja Uniwersytetu Ekonomicznego w Krakowie, Kraków, p. 15

Poradnik inwentaryzacji emisji dla programów ochrony powietrza i oceny jakości powietrza (2003), Instytut Zarządzania Informacjami Środowiskowymi EMI, Opole

OECD (2011), *Towards green growth: Monitoring progress OECD indicators*, OECD Green Growth Studies, OECD Publishing, Paris, p. 9

Strategia Rozwoju Łódzkiego Obszaru Metropolitalnego 2020+ [Lodz Metropolitan Area Development Strategy 2020+], http://www.lom.lodz.pl/strategia-rozwoju-lodzkiego-obszaru-metropolitalnego-archiwum/ [02-10-2019]

Załącznik nr 9 do Regulaminu Konkursu [Annex 9 to the rules of the Call for Proposals], No. 2/PO IiŚ/9.3/2013, http://pois.nfosigw.gov.pl/pois-9-priorytet/ogloszenie-o-naborze-wnioskow/w-ramach-dzialania-93-konkurs-2/ [10-06-2019]

https://www.porozumienieburmistrzow.eu/about-pl/cov-initative-pl/cov-figures-pl.html [09-10-2019]

http://dev.eumayors.eu/IMG/pdf/ CoM_leaflet_pl_web.pdf [02-10-2019]

Iwona **FORYŚ** • Ewa **PUTEK-SZELĄG** • Beata **ZIEMBICKA**

ENERGY INTENSITY OF A BUILDING IN THE PROCESS OF ESTIMATING THE MARKET VALUE OF A RESIDENTIAL UNIT

Iwona **Foryś,** Prof. (ORCID 0000-0002-2294-0672) – *University of Szczecin*
Ewa **Putek-Szeląg,** PhD (ORCID 0000-0002-2294-0672) – *University of Szczecin*
Beata **Ziembicka,** PhD (ORCID 0000-0001-8540-2866) – *Operat Beata Ziembicka*

Correspondence address:
Mickiewicza Street 64, 71-101, Szczecin, Poland
e-mail: iwona.forys@usz.edu.pl

ABSTRACT: Under current Polish legislation, the valuation of real estate should take into account the results of energy performance certificates and indications of for potential improvement of this performance which are economically viable and technically achievable. The Polish market of energy certificates is young. However, there are energy-intensive data that can be included in property valuation in the absence of energy performance certificates, especially in the case of residential units. The article proposes a way to assess the multi-family building's and its individual units' energy performance on the basis of information such as the location of the unit in the building, the consumption of heating units, the unit's (its living room's) sun exposure. Based on the analysis of the local real estate market (selected homogeneous housing estate in Szczecin), statistically significant relationships between the transaction price of a flat and its pricing features were sought, in particular those characterizing the energy intensity parameters of flats and buildings. The research is devoted to the current and important problem of including energy values in property valuation, but first of all it is important to improve the awareness of buyers and real estate professionals about the costs of heat energy and their impact on sustainable development.
KEY WORDS: property value, energy intensity of buildings, sustainable development

Introduction

In the European Union buildings account for about 40% of the demand for non-renewable primary energy PE and are also responsible for more than a third of carbon dioxide emissions into the environment. Therefore, the main objective of the EU policy implemented in the construction sector is to become independent of non-renewable energy sources and improve the energy performance of buildings, while reducing carbon dioxide emissions to the environment. In 2008, EU countries introduced stricter regulations (climate and energy package) aimed at setting an indicative target value for energy efficiency, based on the national consumption of primary energy PE or final energy FE. Member States have been obliged to achieve a certain level of energy savings and environmental benefits by 31 December 2020. Objectives and tools to support the implementation of the above commitments have been included in subsequent communications and directives of the European Union, particularly Energy Performance of Buildings Directive, the so-called EPBD Directive and the Directive on the Energy Performance of Buildings (Directive of the Parliament..., 2010). Under the assumption of the above documents, to obtain reliable information about the building on the basis of energy performance certificates, Member States have to use harmonised calculation methods and energy classes (labels), based on consistent EU rules of assessment that take into consideration local climatic conditions, diversifying facilities by the national and regional level, available energy resources and legal regulations. The mandatory requirements of both directives have been incorporated in such legal acts as the Polish construction law (the Construction Law Act, 1994) and the Real Estate Law (the Act on the Real Estate Management..., 1997). The requirement to include energy performance certificates in the process of property valuation was also laid down in the European Valuation Standards (EEE, 2016). In Poland, a number of energy performance certificates issued for secondary market properties is still low. Therefore, in the absence of a market for energy performance certificates, it is not possible to make a comparative analysis of premises from the adopted database regarding the features describing energy efficiency.

Faced with an immature market of energy performance certificates for residential units, and in principle the lack of these documents in market trading, buyers are looking for alternative parameters of multi-family buildings and their individual units that are responsible for heat losses (Kazak et al., 2018, p. 1653-1661). These parameters are used for comparison with other offers on the market. They allow for informed decisions in the context of environmental care. Similarly, property appraisers need alternative tools to evaluate properties on sale. Their toolbox requires comparative attributes of

properties from the transactional database, including those that relate to energy intensity.

The purpose of the study is to identify features and their variants that describe a multi-family building and its residential units in terms of energy intensity. In the article, an attempt is made to change the view on property valuation and to verify the existing approach to the valuation process which does not include the analysis of features related to energy intensity of buildings. The authors' aim is to answer the question whether the energy performance of a multi-family building (and individual flats) in the form of the previously ignored attributes responsible for heat consumption influences the value of residential units and whether it should be taken into account in the valuation of market rights to residential units.

An overview of the literature

Awareness of the importance of climate and natural phenomena creates the need to conduct analyses and make models of rational use of environmental goods, including in the issue of depletion of natural resources. Research on the implementation of sustainable development principles on the basis of real estate value theory (Burchard-Dziubińska, 2007, p. 220-221; Foryś, Putek-Szeląg, Ziembicka, 2019) has a special role to play. However, the principles of pro-ecological sustainable development on the property market should be considered broadly, taking into account such sectors of the economy as construction, being a part of the investment process of "physical" creation of buildings. Modern, efficiency-oriented ecological solutions that slow down the process of value loss as a result of technical wear and tear meet ecological standards, minimize the environmental impact of the building throughout its life cycle, but also affect the value of the property. They provide healthier conditions for users by improving the quality of air inside the building (Batóg et al., 2019) and the spatial layout of the property (Belniak, Głuszak, Zięba, 2013, p. 122-127).

The pro-environmental dimension of the property market reflects the desire to increase the value of real estate, taking into account: environmental protection including the need for clean air, better quality of life as well as improved economic growth (Czarnecki, Karpoń, 2012, p. 304). It is also a search for a compromise between "inviolability" of the natural environment, for present and future generations (sustainable development) and social and economic development (Jaworowicz-Rudolf, 2010, p. 46-53). According to Siemińska, each new investment project brings changes to the environment and interferes with the existing balance (Siemińska, 2013, p. 62), hence sustainable development involves, among other things, the design and construc-

tion of buildings to be harmoniously inscribed in the environment as environmentally friendly, maintaining their functionality and durability, using as little energy as possible and ensuring comfort of use. In turn, Kryk points out "the necessity of ecoconsumption conditioned by people's perception of ecological needs and the level of their ecological awareness" (Kryk, 2007, 116-117). The environment is treated by the users as a utility.

Environmentally friendly property market sets out mutually complementary directions and their harmonious interactions in the following dimensions: social, economic and environmental, while meeting the criterion of limiting the consumption of domestic energy within the limits of profitability. These are the objectives set by the European directives, which provide for the reduction of energy demand of buildings by minimising losses through building envelope and effective use of heat gains and of renewable energy resources. It is a pursuit of energy self-sufficiency of buildings achieved through the implementation of energy-optimal structural, material and installation solutions (Czarnecki, Karpoń, 2012, p. 309). Energy intensity can be attained with standardised tools for the assessment of buildings' environmental performance that set out detailed rules and requirements for the economic assessment of their characteristics (based on, inter alia, functionality and technical parameters) as well as for the detailed inspection of their results (PN-EN 15643-4, 2012).

Economic growth contributes to an increase in energy consumption and CO_2 emissions to the environment, therefore raising individual consumers' and entrepreneurs' awareness is of great importance for the externalisation of environmental costs (Burchard-Dziubińska, 2007). It is one of the objectives of ethical principles of sustainable development with regard to the natural environment (Rogall, 2010, p. 394-403). It is not the amount (in strict sense) of consumed energy that reflects the economic development and innovativeness, but the efficient use of resources, with particular stress on the use of renewable resources (Michalak, 2009). Therefore, when looking for solutions stimulating efficiency, one should remember that it stems from energy-saving solutions relating to technical activities, the aim of which is to achieve economic benefits (energy-saving). In a broader sense, the issue can also be extended to environmental protection measures.

The consumed energy can ensure the material well-being of an individual, at different levels. For example, Germany consumes 170 GJ of final energy per capita (EK), the USA 328 GJ, and Japan 171 GJ per capita (Rogall, 2010, p. 404). Differences may result from cultural and climatic conditions, but also from different efficiency of technical facilities. Domestic heating (about 74%) and hot water preparation (about 12%) have the highest share in final energy consumption of households. Therefore, it is important to increase energy

efficiency of new and existing buildings (Kazak et al., 2018). Energy performance assessment applies to the design, construction and operation of buildings and applies to buildings and their technical systems (Broniewicz, 2018, p. 36-48). With regard to "old" buildings, thermal upgrading is of crucial importance, while in the case of newly built ones, higher standards of thermal protection is of crucial importance.

Efficiency is the subject of many studies, analyses and discussions and is usually associated with productivity, as it is a result of the actions taken, representing the relation of the produced effects to the incurred outlays. As an economic category, efficiency is usually associated with economic and effective implementation of measures leading to growth (economic in the sense of optimising cost expenditures; effectiveness measured by the level of achievement of an desired objective). From an ex post point of view, efficiency is the result of activities performed, whereas from an ex ante point of view it is a forecast of anticipated effects, with the involvement of specific resources at a given time. When relating the effect to the outlay, the dynamics and level of growth depend on the adopted efficiency measure. In economic decision-making, the outlay is expenditure necessary for the implementation as well as for the maintenance of an investment. In a broader sense, a measure which produces the best results at the lowest cost may be considered effective (Solińska, Soliński, 2003, p. 95-109). The Ministry of Investment and Development (www.miir.gov.pl) indicates that "energy efficiency of a building, or energy performance, is the degree to which a building is prepared to ensure comfort of use in accordance with its intended use, with the lowest possible energy consumption by that building". The efficiency assessment includes an analysis of characteristics of the building and its fitting-out that have an effect on its energy consumption. The main principles in energy-efficient construction include the choice of the smallest possible area with an assumption that the building is compact in shape (rectangular or square plan), abandonment of cellars and attics, the choice of a simple one- and two-way roof, optimal location in relation to the directions of the world, optimal quantity of built-in installations and evaluation of thermal insulation of building envelope (walls, ceilings, roof, ground floor).

The Energy Efficiency Act (2016) defines it as the ratio of the utility effect of a facility, appliance or installation produced under typical conditions to the amount of energy absorbed by the facility. The measure of energy efficiency is the utility effect, which is e.g. lighting and the level of users' thermal comfort. According to the EU directives, the efficiency should be analysed together with the estimated economic life cycle of the building (if an energy performance certificate is required). Energy efficiency should therefore be analyzed in the context of energy intensity (consumption) in the "top-down"

perspective, as an integrated system covering a number of issues including: use of energy from available renewable sources, implementation of the best possible technological and installation solutions (optimal in terms of energy and economically viable), the building's physics and its thermal diagnostics throughout its life cycle, the environmental effect including CO_2 emissions to the environment, promotion of energy efficiency, inspection of socio-economic effects of energy efficiency improvements, and creation of municipal policy instruments (Geryło, Mańkowski, Piasecki, 2012, p. 323-330).

Energy efficiency can be linked to economic and environmental efficiency so that the whole could form a "hybrid" of a technical solution balancing the economic cost, the environmental cost and the savings effect for the customer and the environment. According to the current regulations, it poses a challenge for residential property managers whose duty is to manage their resources in the right way by choosing an optimal method of distributing the total costs of heat purchase which is settled on a per unit basis. This method, after considering the compensating factors of energy consumption for heating purposes, should contribute to stimulating energy-saving behaviours for each flat depending on its position of the building, regarding the residents' thermal comfort and normative ventilation of flats. The measure of efficiency can also be the discounted rate of return on investment for renovation in the fixed period of time (net present value).

During the long-term operation of a building, its energy quality may change, depending on many factors (Koczyk et. al., 2009, p. 95-498):

- building's geometry, its geographical location and layout of the rooms,
- thermal quality of materials used for the building envelope and exterior joinery,
- effective protection in summer against heat losses and radiation,
- diffusion and airtightness of the building,
- architectural details eliminating the influence of thermal bridges,
- the ability of the structure to use natural ventilation and cooling solutions for the building,
- the good practice of continuous maintenance and repair of the building together with technical facilities.

An energy-efficient building is one that is equipped with highly efficient installations, emitting as little heat as possible to the environment. Energy consumption is considered to be low when it is 50% less than in traditional buildings according to the standards in force at the time of construction (Alsabry, Pigalski, Maciejewski, 2010). Meeting these standards depends on the climate zone for which the assessment is made, including the variability of external air temperature, wind speed and solar intensity. The value in use of a building is therefore determined by actions that aim to reduce the con-

sumption of operating energy, without compromising the thermal comfort and well-being of users (Jaworowicz-Rudolf, 2010), while maintaining visual comfort and extending the service life (durability).

In the nearest future the Polish construction industryis expected to change its philosophy of designing and maintenance of low-energy houses (Ziembicka, 2016). However, potential buyers do not yet perceive the energy certificate as an attribute that adds value to the transaction. In their research, the authors indicate that in the central location of the city of Szczecin, the condition of the facade of the building in confrontation with an attractive location does not matter much (Putek-Szeląg, Ziembicka, 2016, p. 409-417), while in the case of buildings outside the city, the process of thermal upgrading of buildings may, however, contribute to a higher price of properties on the market (Foryś, 2006, p. 55; Bełej, Gulmontowicz, 2009). The property managers' experiences shows that the key factor influencing the effeciency is the shape of the building, location of the residential unit on offer, thermal quality of the building envelope, the type of ventilation, window and door woodwork, as well as the layout of rooms adapted to climatic conditions (Sujkowski, 2014). Settlements of heat energy costs take into account heat gains in the heating season, while in the case of residential units, the energy demand of rooms in the summer season is ignored.

Research methods and data

The article searches for the relationship between the transaction price of residential units and the factors determining the energy intensity of buildings and these units. To evaluate these relationships, elements of structure analysis are used to determine the basic descriptive statistics of the sample. Average values, standard deviation and quartiles are analysed. Due to the fact that the data are ordinal variables the Spearman rank correlation coefficient is used to verify the dependency. The Spearman's rank correlation coefficient is calculated as follows (Aczel, 2000):

$$\rho_{xy} = \rho_{yx} = 1 - \frac{6 \cdot \left(\sum_{i=1}^{n} d_i^2 + T_x + T_y\right)}{n \cdot (n^2 - 1)}, \tag{1}$$

$$d_i = \text{rank}\, x_i - \text{rank}\, y_i,$$

$$T_x = \frac{1}{12} \sum_j \left(t_j^3 - t_j\right),$$

$$T_y = \frac{1}{12} \sum_k \left(u_k^3 - u_k\right),$$

where:

t_j – number of observations in the sample having the same j-th value of the characteristic rank x,

u_k – number of observations in the sample having the same k-th value of the characteristic rank y,

n – number of observations.

The coefficient takes values from <-1;1> and informs about the strength and direction of the dependency. The closer the absolute value of the coefficient to unity, the stronger the relationship (positive or negative).

Using the indicated measures and basing on the analysis of the local property market (a selected homogeneous housing estate in Szczecin), statistically significant dependencies between the transaction price of a flat and its pricing characteristics are sought, in particular those concerning the parameters of energy efficiency of flats and buildings.

For this purpose, to the classical characteristics of units which are included in the valuation as a standard, we propose three characteristics to assess the buildings and units located in them, in terms of their energy intensity, i.e.: sun exposure of the unit (living room), consumption of heating units, position of the unit in the building. Data from the Housing Cooperative "Dąb", public statistics, databases and our own research were used for the analysis. The research covered selected buildings in the Housing Cooperative's stock – erected in the years 1979-1984, in a prefabricated concrete slab technology (mainly the Szczecin system). We analysed transactional data from the secondary market of flats in the above mentioned buildings for the years 2008, 2011, 2014, 2017 and data concerning readings of units of heating energy consumption in individual flats. The research area covered the following streets: Jasna, Kostki Napierskiego, Rydla, Łubinowa and Lniana. The choice of the "Słoneczne" housing estate for the study was conditioned by:

- homogeneous location,
- a homogeneous housing stock in terms of construction time and building technology,
- similar heat transfer coefficient U for all buildings,
- a homogeneous and most efficient source of heating,
- diversified position of the buildings in relation to the directions of the world,
- various types (shapes) of buildings,
- position of flats in the building (central or end wall position).

The above conditions and characteristics allowed for a detailed analysis of the impact of each of them on the transaction price of residential units, with regard to the energy efficiency of buildings and units located in them. The buildings were grouped into four types depending on their height and shape, i.e. high buildings: star-shaped (three arms form cubic blocks of tall buildings), ordinary-shaped (cube), cascade-shaped (sloping cubic blocks) and all low-shaped (up to five storeys) buildings. Seven low buildings and eighteen high-rise buildings were observed, including: nine buildings forming three stars, two cascade buildings and seven ordinary buildings.

The residential units were divided into two categories, i.e. the ones located centrally in the building and those at the end wall. The central position of the unit in a building was considered to be more advantageous in terms of energy savings, while the end wall position was considered to be less advantageous. The following number of units was observed in each year of the study, broken down into end wall and central units:
2017: 10 end wall, 74 central units,
2014: 8 end wall, 47 central units,
2011: 5 end wall, 57 central units,
2008: 11 end wall, 80 central units.

Due to right-skewed distributions, four variants based on positional measures were adopted for the heating energy consumption characteristic: first and third quartiles and the median, minimum and maximum (for subsequent intervals respectively 0, 1, 2, 3).

The last of the adopted characteristics concerned the sun exposure, but it was assumed that the comparisons would focus on the living room in which residents spend the longest time during the day. The three additional characteristics mentioned above that describe the building and premises in terms of energy intensity and that can be added to the analysis of the local market are proposed intuitively, basing on professional experience and technical knowledge (Ziembicka, 2019; Foryś, Putek-Szeląg, Ziembicka, 2019).

Results of the research

In the first step of the analysis, descriptive statistics of variables describing the transactions of residential units in the analysed years were determined. The results for the unit transaction price, unit floor area and the consumption of heat units in a given heating season are presented in the table below (table 1).

In individual years under analysis, the highest minimum unit price was recorded in 2017 (PLN 2591.84 per sqm) and the lowest in 2011 (PLN 1677.85 per sqm). The highest maximum unit price for residential units was paid in 2008 (PLN 5709.68 per sqm), while the lowest – in 2014 (PLN 4528.30 per sqm). The highest dominant was recorded in 2008 (PLN 4268.04 per sqm) and the lowest in 2014 (PLN 3427.67 per sqm). Regarding floor area, the highest dominant was 53 sqm (in 2011, 2014 and 2017), and in 25% of observations the flat size was not higher than 48.50 sqm. 75% of flats were at least 63.60 sqm (2011, 2014), and in 2008 and 2017 – at least 59.40 sqm.

Table 1. Structural parameters of the transaction prices of dwellings, floor areas and the quantities of consumed heating units in the years under study

	Average price [PLN/sqm]							
Year	Mean	Quantity	Standard deviation	Min	Max	Quartile 1	Median	Quartile 2
2008	4238.48	91	666.99	1951.22	5709.68	3958.76	4268.04	4639.18
2011	3901.66	62	578.64	1677.85	4867.92	3603.77	4020.62	4207.12
2014	3430.27	55	505.16	2230.97	4528.30	3114.48	3427.67	3670.10
2017	3859.28	84	519.29	2591.84	5257.73	3543.06	3811.19	4320.12
2008-2017	3813.99	685	602.19	1443.30	5709.68	3404.67	3820.75	4226.80
	floor area [sqm]							
2008	51.06	91	13.41	30.90	85.40	48.50	48.50	59.40
2011	53.53	62	14.23	30.90	82.00	48.50	53.00	63.60
2014	55.32	55	11.41	30.90	77.00	48.50	53.00	63.60
2017	52.70	84	13.54	30.20	85.40	48.50	53.00	59.40
2008-2017	52.68	685	13.31	30.20	85.40	48.50	49.00	59.40
	consumption of heating units in given heating period [unit/sqm]							
2008	8.00	91	8.61	0.00	39.30	1.35	5.23	11.63
2011	6.49	62	7.50	0.00	29.96	0.66	3.03	10.65
2014	4.43	55	4.47	0.00	21.54	0.86	3.10	6.66
2017	7.51	84	9.18	0.00	38.63	0.55	3.21	13.70
2008-2017	6.43	685	7.31	0.00	39.30	0.84	3.70	9.84

Source: author's own work.

Unit heat consumption varied and averaged from 4.43 unit/sqm in 2014 to 8.0 unit/sqm in 2008, with the highest dominant recorded at 5.23 unit/sqm in 2008, and the lowest at 3.03 unit/sqm in 2011. In 25% observations, the consumption of heating units was not higher than 0.55-0.86 unit/sqm, and in 75% observations it reached the value of at least 6.66-13.7 unit/sqm of floor area of a residential unit.

Table 2. Mean transaction prices of residential units [PLN thousands/m^2]

Item	Building type	2008	2011	2014	2017	2008-2017
1.	B1 (ordinary high-rise)	4 125.6	3 673.9	3 469.6	3 685.2	3 640.6
2.	B2 (star high-rise)	4 184.8	3 845.3	3 362.8	3 663.2	3 774.9
3.	B3 (cascade high-rise)	4 290.1	3 985.6	3 176.1	4 213.7	3 950.7
4.	B4 (all low)	4 339.9	4 190.3	3 597.2	3 972.7	3 927.8

Source: author's own work.

In 2008, in the housing stock under study the highest unit transaction prices were recorded for flats in low buildings and the lowest prices – in block-shaped high-rises. In 2011, prices were significantly lower than in 2008. The same situation was observed in 2014, when unit prices of flats in all types of buildings were low in comparison to 2008 and 2011. The prices rebounded only in 2017, while in cascade type high-rises the unit transaction price was comparable to 2008, while in other types of buildings (B1, B2, B4) the price was marginally lower than in 2008. On average, in the analysed period of 2008-2017, in the B3 and B4 type buildings the prices of 1 sqm of residential units were higher than in other types of buildings.

Table 3. Mean consumption of heating energy units by building types [unit/m^2]

Item	Building type	2008	2011	2014	2017	2008-2017
1.	B1 (ordinary high-rise)	8.27455	10.30033	4.87786	10.40431	8.408831
2.	B2 (star high-rise)	7.96346	2.91844	3.39900	5.93681	5.394915
3.	B3 (cascade high-rise)	6.226179	3.968422	1.239359	4.770988	4.805913
4.	B4 (all low)	9.95980	6.89071	6.79422	6.72087	7.010627

Source: author's own work.

The data summary in table 3 shows that in the analysed years the highest average consumption of heating energy units, i.e. 8.41 units per square meter, was recorded in ordinary block-shaped buildings (B1), while the lowest, i.e. 4.81 units per square meter, in the cascade type buildings (B3). The difference was significant (75%). When analysing the data, the coexisting weather conditions should be taken into account. In 2017, the lowest recorded temperature of the external environment was -7°C and was observed as temporary in four autumn-winter months of the heating season. In 2014, temperatures recorded were lower than in 2017, but they prevailed over a shorter period. Most often, in autumn and winter months the temperature oscillated

around 0°C. In 2011, the situation was similar, i.e. the lowest temperature of -15°C was recorded at the end of December, but for the rest of the season it oscillated between 0°C to -5°C. The winter of 2008 was the warmest of all the years under study. The lowest temperature of -10°C was recorded in February, but from November to December the temperature usually ranged between 0°C and -5°C. In 2008 high heating energy consumption readings in all the buildings could be blamed for the use of older heat substations which were successively modernised in all the buildings in the following years. The most similar results in each year, and at the same time the highest values, were recorded in low buildings. The highest differences in results were found in B3 type buildings. In 2014 in the buildings of B1 and B3 types extreme values were recorded which significantly differed from the others. The same applies to data from 2011 collected for star-shaped high-rise buildings (B2).

The analysis of transaction prices in the years under study shows significant differences both in reference to the most frequently occurring price (empirical dominant) as well as the strong left-skewed distributions in 2008 and 2011 and symmetrical price distributions in subsequent years. In 2008 and 2011 prices were mostly in the range of PLN 4-4.5 thousand per sqm. In 2014, prices dropped to PLN 3-3.5 thousand per sqm, while in 2017 they rose to PLN 3.5-4 thousand per sqm.

The research into correlation between unit prices and price formation characteristics was carried out in two stages: for all the characteristics in total and in selected years, as well as for selected years by the type of building. The study of total correlation for all the buildings in subsequent years showed the effect of the building type on the unit price of a flat. Equally important turned out to be the variable of the floor space and of the position of the residential unit in the building. In 2017, a negative relation was found between the property environment ad the price. Over the whole period under study the public transport access in the remained in a weak negative relation with the variable (table 4).

Since the unit price and building type correlation turned out to be statistically significant (table 4), the next step was to look for the correlation between the transaction price and price shaping characteristics in particular building types. A positive correlation between the unit price and the usable floor area was found here. It was statistically significant in the case of the B1 and B2 type buildings. In the B1, B2 and B3 buildings, unit prices were positively correlated with the position of a residential unit in a building. In the B3 type buildings prices were positively correlated with the neighbourhood while negatively with the sun exposure of the living room (table 5).

Table 4. Pearson's rank correlation coefficients of transaction price and variables characterizing residential units sold in years 2008-2017

Variable	2008	2011	2014	2017	2008-2017
Building type	0.172	0.358	-0.025	0.281	0.199
Neighbourhood	0.188	-0.003	0.180	-0.220	-0.013
Access to public transport	0.064	-0.040	0.259	-0.204	-0.081
Position on storey	0.055	-0.028	-0.237	-0.030	-0.022
Floor size	0.492	0.549	0.514	0.241	0.384
Energy consumption per 1 m^2	-0.027	-0.051	0.086	-0.140	-0.029
Position in building	0.367	0.088	0.361	0.123	0.219
Living room sun exposure	-0.091	-0.234	0.099	0.016	-0.046

Source: author's own work.

Table 5. Pearson's rank correlation coefficients of transaction price and variables characterizing residential units sold in years 2008-2017 by building type

Variable	Type of building			
	B1	B2	B3	B4
Neighbourhood	0.000	0.000	0.205	0.087
Access to public transport	0.000	0.090	0.000	0.000
Position on storey	-0.048	-0.008	-0.017	0.080
Floor size	0.494	0.460	0.291	0.294
Energy consumption per 1 m^2	-0.013	-0.061	0.020	-0.002
Position in building	0.197	0.252	0.172	0.006
Living room sun exposure	-0.090	0.047	-0.334	0.010

Source: author's own work.

Conclusions

The paper attempts to determine the impact of energy performance of buildings on the estimated market value of residential units in one of the housing estates in Szczecin in a situation when the property valuer does not have the energy performance certificate of the unit under valuation as well as the units adopted for comparison. For this purpose, the authors proposed three features enabling the valuation of buildings and their residential units,

which are included in the valuation as standard in terms of energy intensity, i.e.: sun exposure of the unit (its living room), consumption of heating units, position of the unit in the building. First of all, the analysis of the correlation between the price of a residential unit and the price shaping characteristics showed a significant importance of the property size, while the position of the flat in the building turned out to be positively correlated with the characteristics related to energy efficiency. Only in B3 type buildings the sun exposure of the living room was negatively correlated. The analysis of correlations showed the significance of the building types classified according to their shape and height.

The most beneficial in terms of heat exchange with the environment turned out to be the star-shaped high-rises buildings and cascading buildings. It is also important to notice that the wind exposure of the gable walls of all the studied objects (north-west wind) significantly reduces the heat loss of the whole building due to the smaller surface area of these walls. The bigger the building external walls, the greater the heat loss. Such a regularity can be observed on the example of energy consumption by units in low buildings. Moreover, attention should be paid to the different levels of thermal comfort experienced by users and vacant flats in each of the buildings – therefore, the maintained indoor temperature in residential units differs from the design temperature, which is 20°C in rooms and 24°C in bathrooms.

The results obtained are a contribution to further research on the impact of the energy performance-relate characteristics of buildings and residential units on the market price. Significant correlations should then be taken into account in the process of estimating the value of the property.

Acknowledgements

The project is financed within the framework of the program of the Minister of Science and Higher Education under the name "Regional Excellence Initiative" in the years 2019-2022. project number 001/RID/2018/19. the amount of financing PLN 10.684.000.00.

The contribution of the authors

Iwona Foryś – 33.33%
Ewa Putek-Szeląg – 33.33%
Beata Ziembicka – 33.33%

Literature

Aczel A.D. (2000), *Statystyka w zarządzaniu*, Wydawnictwo Naukowe PWN, Warszawa

Alsabry A., Pigalski W., Maciejewski T. (2010), *Teoretyczne a rzeczywiste zapotrzebowanie energetyczne na centralne ogrzewanie i wentylację mieszkań w budownictwie wielorodzinnym*, "Przegląd Budowlany" Vol. 11, Warszawa, p. 39-45

Batóg J. et al. (2019). *Investigating the Impact of Airport Noise and Land Use Restrictions on House Prices: Evidence from Selected Regional Airports in Poland*, "Sustainability" No. 11(2):412, DOI: 10.3390/su11020412

Belniak S., Głuszak M., Zięba M. (2013), *Budownictwo ekologiczne. Aspekty ekonomiczne*, Wydawnictwo Naukowe PWN, Warszawa, 122-127

Bełej M., Gulmontowicz P. (2009), *Analiza wpływu prac termomodernizacyjnych na wartość rynkową lokali mieszkalnych w zasobach wielorodzinnych*, "Acta Scientiarum Polonorum. Administratio Locorum" Vol. 8(3), p. 16

Broniewicz M. (2018), *Refurbishment, strengthening and durability of existing building structures,* "Ekonomia i Środowsko" Vol. 4(67), p. 36-48

Burchard-Dziubińska M. (2007), *Ekologiczne determinanty rozwoju gospodarczego*, in: R. Piasecki (ed.) *Ekonomia rozwoju*, Polskie Wydawnictwo Ekonomiczne, Warszawa, p. 220-221

Czarnecki L., Karpoń M. (2012), *Ocena środowiskowa budynków a zrównoważone budownictwo*, "Budownictwo i inżynieria środowiska Zeszyty Naukowe Politechniki Rzeszowskiej" Vol. 59(3), p. 304

Dyrektywa Parlamentu Europejskiego i Rady 2010/31/UE z dnia 19 maja 2010 r. w sprawie charakterystyki energetycznej budynków

European Valuation Standards- ESW (2016), The Europem Group of Valuere's TEGoVA, Printed in Belgium by Gillis nv/sa

Foryś I. (2006), *Opłacalność procesów termomodernizacyjnych na przykładzie spółdzielczych zasobów mieszkaniowych*, "Studia i Materiały Towarzystwa Naukowego Nieruchomości" Vol. 14(1), p. 55

Foryś I., Putek-Szeląg E., Ziembicka B. (2019), *An attempt to determine the impact of energy intensity on the market value of residential premises on the example of selected multi-family buildings*, "Real Estate Management and Valuation", in print

Geryło R., Mańkowski S., Piasecki M. (2012), *Efektywność energetyczna rozwiązań konstrukcyjno- materiałowych- strategiczny projekt badawczy*, "Budownictwo i inżynieria środowiska Zeszyty Naukowe Politechniki Rzeszowskiej" Vol. 59(3), p. 323-330

Jaworowicz-Rudolf A. (2010), *Prawo do środowiska należytej jakości jako urzeczywistnienie koncepcji zrównoważonego rozwoju*, in: M. Burchard-Dziubińska, A. Rzeńca (eds.), *Zrównoważony rozwój na poziomie lokalnym i regionalnym*, Wydawnictwo Uniwersytetu Łódzkiego, Łódź, p. 46-53

Kazak J. et al. (2018), *Indicator-based analysis of socially sensitive and territorially sustainable development in relation to household energy consumption*, "Engergy Rural Development" Vol. 17, p. 1653-1661, doi:10.22616/ERDev2018.17. N045

Koczyk H. et al. (2009). *Ogrzewnictwo praktyczne. Projektowanie. montaż. certyfikacja energetyczna. Eksploatacja*, Wydawnictwo Systherm, Poznań, p. 495-498

Kryk B. (2007), *Potrzeby a wiedza ekologiczna konsumentów,* "Zeszyty Naukowe Uniwersytetu Szczecińskiego. Prace Katedry Mikroekonomii" No. 11, p. 116-117

Michalak P. (2009), *Badania efektywności energetycznej budynku użyteczności publicznej wykorzystującego odnawialne źródła energii*, doctoral thesis, Akademia Górniczo- Hutnicza Wydział Inżynierii Mechanicznej i Robotyki, Kraków

PN-EN 15643-4 (2012), *Sustainability of construction works – Assessment of buildings* – Part 4: Framework for the assessment of economic performance

Putek-Szeląg E., Ziembicka B. (2016), *Analiza wpływu przeprowadzenia termomodernizacji na cenę lokali mieszkalnych na przykładzie budynku z wielkiej płyty na szczecińskim rynku nieruchomości*, "Studia i Prace WNEiZ Uniwersytet Szczeciński" Vol. 45(1), p. 409-418

Rogall H. (2010), *Ekonomia zrównoważonego rozwoju*, Wydawnictwo Zysk i s-ka, Poznań, p. 394-404

Rozporządzenie Ministra Infrastruktury i Rozwoju z dnia 27 lutego 2015 r. w sprawie wyznaczania charakterystyki energetycznej budynku lub części budynku oraz świadectw charakterystyki energetycznej (Dz.U. 2015, item 376 as amended)

Rozporządzenie Rady Ministrów z dnia 29 czerwca 2005 r. w sprawie powszechnej taksacji nieruchomości (Dz.U. of 2005 Nr 131 item 1092)

Siemińska E. (2013), *Ryzyka inwestowania i finansowania na rynku nieruchomości w kontekście etyki i społecznej odpowiedzialności*, Wyd. Naukowe Uniwersytetu Mikołaja Kopernika, Toruń, p. 62

Solińska M., Soliński I. (2003), *Efektywność ekonomiczna proekologicznych inwestycji*, Uczelniane Wyd. Naukowo- Dydaktyczne AGH, Kraków, p. 95-109

Sujkowski Z. (2014), *Ocena efektywności energetycznej budynków na przykładzie spółdzielni mieszkaniowej*, "Rzeczoznawca Majątkowy" Vol. 4(109), p. 22-32

Ustawa 1997 z dnia 21 sierpnia 1997 r. o gospodarce nieruchomościami (Dz.U. 2018 item 121 as amended)

Ustawa z dnia 15 kwietnia 2011r. o efektywności energetycznej (Dz.U. 2016, item 831 as amended)

Ustawa z dnia 7 lipca 1994 r. prawo budowlane (Dz.U. 1994 no 89. item 414 as amended)

Ziembicka B. (2016), *The influence of the technical condition of a building on the property's market value*. "Folia Oeconomica Stetinensia" Vol. 16(1), p. 197-207

Ziembicka B. (2019), *Szacowanie wartości nieruchomości z uwzględnieniem efektywności energetycznej budynku*, PhD dissertation, University of Szczecin, Szczecin

Marta NALEWAJKO

THE POSSIBILITY OF USING WASTE MATERIALS IN BUILDING MATERIALS

Marta **Nalewajko,** MSc (ORCID: 0000-0002-2458-7147) – *Białystok University of Technology*

Correspondence address:
Daliowa Street 20, 16-010, Nowodworce, Poland
e-mail: m.nalewajko@doktoranci.pb.edu.pl

ABSTRACT: In recent years, great emphasis has been placed on the implementation of the principles of sustainable construction and environmental protection. Decreasing amount of natural resources and increasing amount of industrial waste have made it necessary to produce products with the use of recycled materials. A number of studies conducted allow us to state that artificial aggregates, industrial ashes and waste from the wood industry are widely used in the production of construction products. The aim of the article is to show that the use of waste materials will allow to reduce the weight and absorbability of concrete chips by using artificial aggregate type Certification and improve the thermal insulation of products through the use of sawdust and wood chips. A 2 factorial experience with a rotational experimental plan was planned. The article presents the results of physical and mechanical properties tests and statistical interpretation of the obtained results.

KEY WORDS: urban ecosystem waste raw materials, ash aggregate, concrete chipboard, lightweight concrete

Introduction

The demands placed on today's construction products are increasingly stringent. In addition to their high strength properties, they must also have good thermal and acoustic insulation properties and be environmentally friendly. Integration with ecology is not only focused on the lack of negative impact on the environment, but also on the use of waste for their production, which causes slow degradation of the environment. In order to meet these requirements, numerous studies are carried out to modify the composition of light concrete by adding appropriate amounts of waste materials and thus not impairing its physical and mechanical properties.

A series of tests carried out on lightweight concrete with modified composition allowed us to conclude that they meet the requirements for modern concrete (Chandra, 2013). In addition to the testing of strength properties, the focus has also been on thermal insulation, which is becoming more and more important today and the requirements of the government are becoming more and more stringent. The results showed that waste concrete has good thermal insulation properties (Kim, 2003; Demirboğa, 2007; Benazzouk, 2008; Alengaram, 2013; Yong, 2014; Oktay, 2015; Zhu, 2015; Liu, 2014; Mo, 2017). The selection of an appropriate amount of waste aggregate as well as the type and quality of this aggregate had an impact on the good results of the research. Various waste aggregates were used, such as waste aggregate from coconut oil production (Alengaram, 2013), pumice stone, expanded perlite or waste rubber aggregates (Oktay, 2015). In addition to artificial aggregates, additives such as sawdust, wood shavings, straw or reed are also used to produce modern concrete modified with waste materials.

This paper presents the results of chipboard concrete tests, in the production of which artificial aggregate of the Certyd type was used. The aim of the research was to reduce the weight and absorbability of chip-concrete by using artificial aggregate of the Certyd type.

Chipboard concrete production process based on secondary raw materials

The development of construction and, consequently, concrete consumption, has made it necessary to improve their formulas in order to be able to use substitute raw materials. Therefore, the properties of alternative aggregates are increasingly being investigated.

A number of studies focus not only on the properties of the aggregate itself, but also on the product produced with it. Recently, recycling aggregates

have become more and more recognizable as a type of aggregate of the Certification type. It is an artificial raw material, an ash-ash produced in accordance with the new technology consisting in sintering the ashes produced during the combustion of hard coal. This process allows to obtain light, porous ceramic aggregate with high thermal insulation and high resistance to atmospheric and chemical factors, fungi, insects and rodents. It is an odourless, highly resistant and relatively low absorbability material (Bardan, 2016). Due to its properties, it is used in construction, road construction, geotechnics and gardening. For a long time it has been used in the production of concrete, allowing to obtain a product with reduced weight and much better strength parameters. Artificial aggregate type Certification of fractions 0-4 mm, 4-8 mm and 8-16 mm was used for testing.

Sawdust with 0-2 mm fraction and wood chips with 2-10 mm and 10-20 mm fractions obtained from a sawmill were also used in the production of concrete chipboard. Before adding organic filler to concrete mix, it must be properly prepared by mineralization, which increases the adhesion of the given chips to the cement slurry and enables proper bonding of the mix and hardening of concrete. The mineralization process also prevents the rotting of chips in the finished concrete chipboard product, ensures its proper durability and reduces shrinkage. Aluminum sulphate $Al_2(SO_4)_3$ and calcium hydroxide $Ca(OH)_2$ were used in this study. The amount of the mineralizer was dictated by the experimental plan adopted at the beginning, in which its amount was included as a variable value, maintaining the ratio between $Al_2(SO_4)_3$ and $Ca(OH)_2$, which was 2:1.

The composition of the chip-concrete mixture was determined on the basis of a two-factor plan for rotationalgom, which was considered optimal due to the following criteria:

- the feasibility criterion – the possibility of implementing the plan,
- information technology criterion – possibility of obtaining data necessary to achieve the objective research,
- efficiency criterion – possibility to perform an experiment at minimum cost for implementation,
- X – fine aggregate fraction content 0-2 mm,
- Y – the aggregate content of the coarse fraction 4-8 mm and 8-16 mm.

Constant values:

- cement content – const.
- water content – const.

Table 1 presents the experimental plan for the production of a particle concrete product with the use of an artificial aggregate of the Certyd type. Quantity of organic aggregate and artificial aggregates were adjusted proportionally to the amount of cement and water in the crop. It was assumed that

organic aggregate will completely replace natural aggregate in the concrete mix. Then, according to the experimental plan, a percentage of organic aggregate was replaced with artificial aggregate of the type Certyd.

Table 1. Experimental plan

Series No.	Coded values		Actual values	
	X	Y	X – fine aggregate	Y – bulky aggregate
1	-1	-1	29.28	29.28
2	+1	+1	70.72	70.72
3	-1.414	0	0	50
4	+1.414	0	100	50
5	0	-1.414	50	0
6	0	+1.414	50	100
7	0	0	50	50
8	-1	+1	29.28	70.72
9	+1	-1	70.72	29.28
10	Control sample			

Source: author's own work.

The quantity of components per 1 m^3 was calculated based on the quantity of components per series. It was assumed that 10 samples were made for each series. Earnings water was divided into three parts. Two of them were used for mineralization and the third one for addition in the last phase of mixing. The preparation of the chip-concrete mixture consisted in weighing the organic aggregate according to the recipe and placing it in a mixer, where it was stirred dry for one minute and then subjected to the mineralization process, which was carried out in two stages. After initial mixing of dry components consisting of sawdust and chips of two fractions, an aqueous solution of aluminium sulphate at a concentration consistent with the experimental plan was added. The mixing of the filler with the mineralizing agent lasted about three minutes, followed by a 15-minute break. After that time, a calcium hydroxide solution was added to the mineralized organic aggregate in the amount of twice the mass of aluminium sulphate and all the components in the mixer were mixed for three minutes. The order of dosing the components resulted from the need to saturate the organic aggregate with the mineralizing agent and then neutralize the acidic reaction formed by the action of aluminium sulphate. After a 15-minute break, following the second stage of mineralization, cement and Certyd type aggregate were added to the

mixer. All the ingredients were mixed thoroughly for the next three minutes, obtaining a ready-made mixture of chip-concrete with the addition of Certyd type aggregate, ready to be formed.

Steel moulds of dimensions 10x10x10x10 cm complying with the PN-EN 12390-1 standard were used for moulding. The walls of the moulds had previously been covered with a release agent in order to protect them against the adhesion of the chip-concrete mixture. Due to the type of materials used, it was decided to manually compact the moulds in two layers using a 1.8 kg compactor. For each layer 16 impacts of the compactor from a height of about 10 cm were accepted. The samples were stripped after 24 hours and placed on special wooden grids in air-dry conditions for 28 days. After this period they were subjected to the following tests: compressive strength, absorbability and bulk density.

Testing of chip-concrete samples using waste materials and their statistical analysis

Analysis of compression strength

The compression strength test was carried out on 46 specimens. For each series the mean compression strength was determined and the standard deviation was calculated, variance

and coefficient of variation. The results of the analysis are presented in table 2.

The average compression strength ranged from 3.47 MPa to 11.04 MPa. The standard deviation for each series was from 0.21 to 0.81. Among all the samples, the lowest level of differentiation was observed for the samples from series 4 containing the aggregate Certification of fractions 0-2 mm in the amount of 84.62 kg/m^3, fractions 4-8 mm in the amount of 22.02 kg/m^3, fractions 8-16 mm in the amount of 22.68 kg/m^3, fractions 8-16 mm in the amount of 22.68 kg/m^3, fractions 2-10 mm in the amount of 22.02 kg/m^3 and fractions 10-20 mm in the amount of 22.68 kg/m^3. This means that the 4-series samples are the best with the least different compression strength results. In the 5 series, the results are the most varied.

Table 2. Results of statistical analysis of compressive strength of cement composites based on artificial aggregate type Certification and organic aggregate

Series No.	Average compression strength [MPa]	Standard deviation S_x	Variation S_x^2	Coefficient of variation V_x [%]
I	5.82	0.26	0.02	4.41
II	7.65	0.33	9.08	4.27
III	6.02	0.21	0.06	3.50
IV	7.73	0.16	16.60	2.01
V	3.47	0.72	29.87	20.86
VI	8.60	0.41	36.07	8.16
VII	5.04	0.81	3.77	15.97
VIII	11.04	0.46	-	4.19
IX	3.90	0.65	20.12	16.58
X	5.97	0.60	0.02	10.11

Source: author's own work.

Using linear regression to estimate the effect of X and Y variables on the compression strength of particle concrete specimens after 28 days of maturation, the regression model proved significant (F = 27.587) and explained about 78% of the dependent variable (R^2 = 0.7751). The results of linear regression analysis are presented in table 3.

Table 3 Linear regression analysis of compressive strength testing of cement composites based on organic and artificial aggregate

N=46	Regression analysis of the dependent variable: Compressive strength R= 0.88045373 R^2= 0.77519878 Amendment R2= 0.74709863 F(5,40)=27.587 p					
	b*	Stand. error z b*	b	Stand. error z b	t(40)	p
Free word			5.50683	0.37001	14.8826	0.00000
X	-0.10239	0.07543	-0.26638	0.19624	-1.3573	0.18226
Y	0.81581	0.07543	2.12239	0.19624	10.8148	0.00000
XX	0.27823	0.08355	0.82349	0.24728	3.33020	0.00187
YY	0.13578	0.08355	0.40186	0.24728	1.62514	0.11198
XY	-0.11725	0.07520	-0.46257	0.29667	-1.55921	0.12682

Source: author's own work.

The form of the regression equation and the graphical interpretation of the changes in compression strength, depending on the adopted variables X and Y are shown in figure 1.

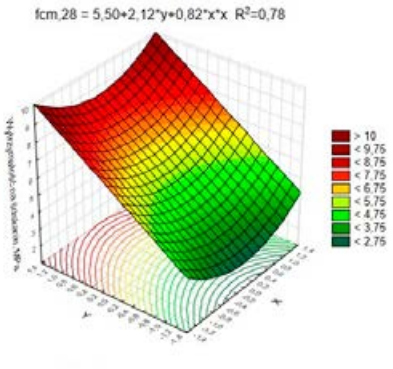


Figure 1. Graphical interpretation of changes in compression strength, depending on the adopted X and Y variables

Two of the predictive factors taken into account in the model had a significant influence on the results of compression strength after 28 days of cement composite maturation: the content of the fraction certificate 0-4 mm (X), 4-8 mm and 8-16 mm (Y). As can be seen from the regression equation, predictor X affects the result by being in a square. Analyzing the above graph one can see a dependence that the increase in the number of fractions 4-8 mm and 8-16 mm Certification causes also an increase in compression strength. When using the maximum content of X and Y factors, the strength increases by more than 60% compared to the strength of cement composite with organic filler only. A 60% increase in strength is also observed when organic filler is replaced by only Y factor in 100%, while X factor is omitted.

Absorbability analysis

The weight gain of samples in the absorption test depends on two variables: X – content of the fine fraction certificate 0-4mm and Y – content of the thick fraction certificate 4-8 and 8-16mm. The combination of variables and average absorbability results was tested on 34 samples and the results of the analysis are presented in table 4.

The average absorbability of the samples ranged from 24.74% to 38.27%. The standard deviation for particular series ranged from 0.33 to 2.87. Among all the samples the lowest level of differentiation was observed for the samples from series 8 containing aggregate Certification of fraction 0-2 mm in the amount of 24.78 kg/m^3, fraction 4-8 mm in the amount of 31.14 kg/m^3,

fraction 8-16 mm in the amount of 32.08 kg/m^3 and fraction sawdust 0-2 mm in the amount of 59.84 kg/m^3, fraction chips 2-10 mm in the amount of 12.89 kg/m^3 and fraction chips 10-20 mm in the amount of 13.28 kg/m^3. This means that the 8-series samples are the best with the least variation in absorbability. In series 1, the results are the most varied.

Table 4. Results of statistical analysis of water absorption tests of cement composites based on artificial aggregate type Certification and organic aggregate

Series No.	Absorbency average [%]	Standard deviation S_x	Variation S_x^2	Coefficient of variation V_x [%]
I	24.74	2.87	79.62	11.62
II	25.09	0.70	69.07	2.80
III	27.43	1.28	24.20	4.67
IV	28.40	1.86	8.84	6.54
V	38.27	1.83	81.22	4.78
VI	27.46	1.34	17.67	4.88
VII	35.26	1.99	86.71	5.63
VIII	24.93	0.33	73.75	1.33
IX	33.70	2.22	58.16	6.57
X	29.23	1.30	1.32	4.45

Source: author's own work.

Table 5. Analysis of linear regression in the study of absorbability of cement composites based on organic and artificial aggregate

N=46	Regression analysis of the dependent variable: Absorbability R = 0.80763105 R^2 = 0.65226791 Amendment R2 = 0.59017290 F(5,28) = 10.504 p					
	b*	Stand. error z b*	b	Stand. error z b	t(40)	p
Free word			32.2461	1.28849	25.0262	0.00000
X	0.21319	0.11164	1.1218	0.58749	1.9096	0.06647
Y	-0.55859	0.11201	-3.0545	0.61254	-4.9866	0.00002
XX	-0.45910	0.12902	-2.8892	0.81198	-3.5582	0.00135
YY	-0.06839	0.12934	-0.4380	0.82850	-0.5287	0.60114
XY	-0.26431	0.11173	-2.0785	0.87864	-2.3656	0.02515

Source: author's own work.

Using linear regression to estimate the effect of the X and Y variables on the water absorption test results of particle concrete samples after 28 days of maturation, the regression model proved to be significant (F = 10.504) and explained about 80% of the dependent variable (R^2 = 0.6523). The results of linear regression analysis are presented in table 5.

The form of the regression equation and the graphic interpretation of the changes in absorbability, depending on the adopted variables X and Y are shown in figure 2.

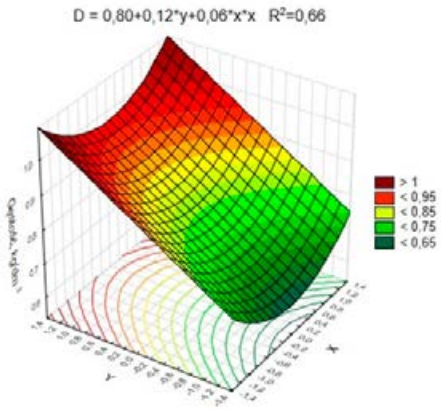


Figure 2. Graphical interpretation of water absorption changes, depending on the adopted variables X and Y

Analyzing the above graph it can be stated that two of the predictive factors influence the water absorption capacity of cement composite. As in previous cases, these predicators are the content of the fraction certificate 0-4 mm (X), 4-8 mm and 8-16 mm (Y). The absorbability decreases with the increase of the Certificate content, which is caused by a much lower absorbability of lightweight aggregate in comparison with organic filler. The highest decrease in absorbability of about 50% was recorded with the use of X and Y factors as a substitute for organic filler in the amount of 100% of its mass.

Volumetric density analysis

The volumetric density test was performed on 34 samples. For each of the series the mean volumetric density was determined and standard deviation, variance and coefficient of variation were calculated. The results of the analysis are presented in table 6.

Table 6. Results of statistical analysis of volumetric density of cement composites based on artificial aggregate type Certification and organic aggregate

Series No.	Average volumetric density result [kg/dm^3]	Standard deviation S_x	Variation S_x^2	Coefficient of variation V_x [kg/dm^3]
I	0.778	0.14	0.03	18.07
II	1.043	0.04	0.08	3.43
III	0.855	0.10	0.00	11.28
IV	0.971	0.15	0.03	15.14
V	0.727	0.03	0.10	3.74
VI	1.025	0.05	0.06	5.06
VII	0.766	0.03	0.04	3.44
VIII	1.053	0.01	0.09	0.90
IX	0.759	0.02	0.06	2.94
X	0.834	0.01	0.01	0.61

Source: author's own work.

The mean volumetric density of samples ranged from 0.727 kg/dm^3 to 1.053 kg/dm^3. The standard deviation for each series ranged from 0.01 to 0.15. Among all the samples the lowest level of differentiation was observed for the samples from the series 10 containing aggregate Certification of fraction 0-2 mm in the amount of 42.31 kg/m^3, fraction 4-8 mm in the amount of 22.02 kg/m^3, fraction 8-16 mm in the amount of 22.68 kg/m^3 and fraction sawdust 0-2 mm in the amount of 42.31 kg/m^3, fraction chips 2-10 mm in the amount of 22.02 kg/m^3 and fraction chips 10-20 mm in the amount of 22.68 kg/m3. This means that the 10-series samples are the best with the least variation in bulk density. In Series 1, the results are the most varied.

Using linear regression to estimate the effect of the X and Y variables on the bulk density of particle concrete samples after 28 days of maturation, the regression model proved to be significant (F = 11.025) and explained about 81% of the dependent variable (R^2 = 0.6632). The results of linear regression analysis are presented in table 7.

The form of the regression equation and the graphical interpretation of changes in bulk density, depending on the adopted variables X and Y are shown in figure 3.

Table 7. Linear regression analysis of volume density testing of cement composites based on organic and artificial aggregate

N=46	Regression analysis of the dependent variable: Volumetric density R= 0.81434985 R^2 = 0.66316568 Amendment R2 = 0.60301669 F(5,28) = 11.025 p					
	b*	Stand. error z b*	b	Stand. error z b	t(40)	p
Free word			0.79999	0.03742	21.3763	0.00000
X	0.12270	0.10987	0.01905	0.01706	1.1167	0.27359
Y	0.76174	0.11024	0.12292	0.01779	6.9093	0.00000
XX	0.31491	0.12699	0.05848	0.02358	2.4798	0.01942
YY	0.22160	0.12729	0.04189	0.02406	1.7408	0.09269
XY	0.02104	0.10996	0.00488	0.02552	0.1914	0.84958

Source: author's own work.

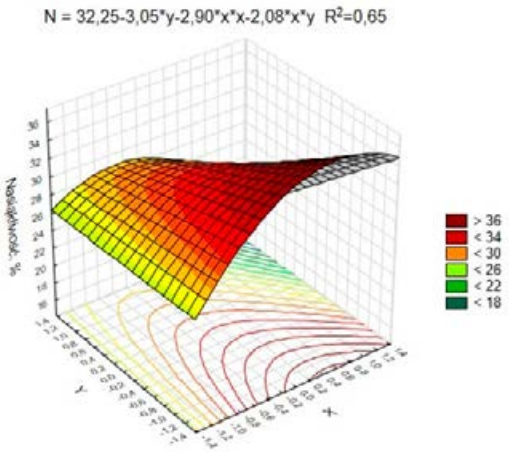


Figure 3. Graphical interpretation of changes in bulk density depending on the adopted variables X and Y

The density results after 28 days of composite maturation were affected by two predictive factors: the content of fraction certificate 0-4 mm (X) and 4-8 mm and 8-16 mm (Y). The highest density of the composite was observed at the maximum content of both 0-4 mm, 4-8 mm and 8-16 mm fractions. This is related to the higher density of the Certificate in comparison with organic aggregates. When organic filler is replaced with 100% fine fraction certificate 0-4 mm and thick fraction 4-16 mm, the density increases by about 20%. The same increase was achieved using only the 4-16mm fraction certificate.

Conclusions

A number of studies conducted allowed us to determine the recipe for obtaining lightweight concrete using waste materials with very good physical and mechanical parameters. The results of basic tests, such as compressive strength, absorbability and density, prove that the products obtained have good physical and mechanical parameters, and in some series – better results than standard lightweight concretes made on the basis of natural aggregates. The use of artificial aggregate made it possible to obtain ecological products with good strength parameters, which proves that the requirements for modern concrete have been met.

Acknowledgements

This research has been supported by Białystok University of Technology within the framework of the project No. ZP/PR/10/64/19.

Literature

Aamr-Daya E. et al. (2008), *Feasibility study of lightweight cement composite containing flax by-product particles: Physico-mechanical properties*, "Cement and Concrete Composites" Vol. 30, Issue 10, p. 957-963, DOI: 10.1016/j.cemconcomp.2008.06.002

Alengaram U.J. (2013), *Utilization of oil palm kernel shell as lightweight aggregate in concrete – A review*, "Construction and Building Materials" Vol. 38, p. 161-172, DOI: 10.1016/j.conbuildmat.2012.08.026

Bardan (2016), *Właściwości i zastosowanie CERTYDU – lekkiego kruszywa sztucznego*, "Kruszywa: produkcja – transport – zastosowanie" No. 1, p. 58-62

Bedi R., Chandra R., Singh S.P. (2013), *Mechanical properties of polymer concrete*, "Journal of Composites", ID 948745, 12 pages, DOI: 10.1155/2013/948745

Demirboğa R. (2007), *Thermal conductivity and compressive strength of concrete incorporation with mineral admixtures*, "Building and Environment" Vol. 42, Issue 7, p. 2467-2471, DOI: 10.1016/j.buildenv.2006.06.010

Du H., Du S., Liu X. (2014), *Durability performances of concrete with nano-silica*, "Construction and Building Materials" Vol. 73, p. 705-712, DOI: 10.1016/j.conbuildmat.2014.10.014

Guo Y. et al. (2014), *Compressive behaviour of concrete structures incorporating recycled concrete aggregates, rubber crumb and reinforced with steel fibre, subjected to elevated temperatures*, "Journal of Cleaner Production" Vol. 72, p. 193-203, DOI: 10.1016/j.jclepro.2014.02.036

Kabay N. (2015), *Properties of concrete with pumice powder and fly ash as cement replacement materials*, "Construction and Building Materials" Vol. 85, p. 1-8, DOI: 10.1016/j.conbuildmat.2015.03.026

Kim K.H. et al. (2003), *An experimental study on thermal conductivity of concrete*, "Cement and Concrete Research" Vol. 33, Issue 3, p. 363-371, DOI: 10.1016/S0008-8846(02)00965-1

Liu M.Y.J. et al. (2013), *Evaluation of thermal conductivity, mechanical and transport properties of lightweight aggregate foamed geopolymer concrete*, "Energy and Buildings" Vol. 72, p. 238-245, DOI: 10.1016/j.enbuild.2013.12.029

Łuczaj K., Urbańska P. (2015), *Certyd – nowe, lekkie, wysokowytrzymałe kruszywo spiekane*, "Materiały budowlane" No. 520, p. 42-45

Oktay H., Yumrutaş R., Akpolat A. (2015), *Mechanical and thermophysical properties of lightweight aggregate concretes*, "Construction and Building Materials" Vol. 96, p. 217-225, DOI: 10.1016/j.conbuildmat.2015.08.015

Olszak P. (2016), *Lekkie kruszywa CERTYD – unikatowym wyrobem budowlanym*, "Kruszywa: produkcja – transport – zastosowanie" No. 4, p. 38-42

Zeyad A.M. et al. (2017), *Pozzolanic reactivity of ultrafine palm oil fuel ash waste on strength and durability performances of high strength concrete*, "Journal of Cleaner Production" Vol. 144, p. 511-522, DOI: 10.1016/j.jclepro.2016.12.121

Zhu Q., Barney C.W., Erk K.A. (2015), *Effect of ionic crosslinking on the swelling and mechanical response of model superabsorbent polymer hydrogels for internally cured concrete*, "Materials and Structures" Vol. 48, Issue 7, p. 2261-2276, DOI: 10.1617/s11527-014-0308-5

GENERAL ENVIRONMENTAL AND SOCIAL PROBLEMS

PROBLEMATYKA OGÓLNOEKOLOGICZNA I SPOŁECZNA

Barbara **KRYK**

ENSURING SUSTAINABLE ENERGY AS A SIGN OF ENVIRONMENTAL RESPONSIBILITY AND SOCIAL JUSTICE IN EUROPEAN UNION MEMBERS

Barbara **Kryk**, Associate Prof. (ORCID 0000-0003-1269-3142) – *Institute of Economy and Finance, Associate Professor of University of Szczecin*

Correspondence address:
The University of Szczecin
Mickiewicza Street 64, 71-101, Szczecin, Poland
e-mail: Barbara.Kryk@usz.edu.pl

ABSTRACT: The article aims to measure and assess the degree of providing sustainable energy in the European Union (EU) countries in the context of social and environmental responsibility and social justice as well as in the context of implementation of the 7th goal of Agenda 2030. Providing people with access to sustainable energy and increasing energy efficiency in all sectors of the economy is necessary to achieve the goals of the concept of sustainable development, the Agenda 2030, the Europe 2020 strategy, and the European energy policy. Ensuring sustainable energy is also a sign of environmental responsibility and social justice. Accurate evaluation of achievements in this area is a relatively new issue, both in economic practice and in modern economics, therefore, there is a need to develop ways for measuring access to sustainable energy other than the usual analysis of time-series of data in individual years, on which current studies are based. Hence, an attempt was made to use two methods belonging to cluster analysis (Ward method and k-means) in order to more effectively assess the degree of sustainable energy provision undertaken by EU countries. This is a novel approach in this area as it directs the article towards the research trend focused on the operationalization of the concept of sustainable development. In the study, available statistical data on 8 indicators for SDG 7, reported by Eurostat and established by the UN, were used, covering the years 2010 and 2016. The study enabled the grouping of EU countries by the degree of provision of sustainable energy and, thus, the determining of their environmental responsibility and social justice in this area. The study shows that past EU achievements in providing sustainable energy are not particularly spectacular; there is no country where they were completely satisfactory, they were quite satisfactory in only 14 countries, averagely satisfactory in 9 countries, and unsatisfactory in 5 countries.

KEY WORDS: sustainable development; sustainable energy; environmental responsibility; social justice; European Union

Introduction

Providing people with access to inexpensive, clean, sustainable, and modern energy at an affordable price, which is the objective of Agenda 2030 (SDG 7), is one of the most important goals of the sustainable development concept as it determines the achievement of several other goals set within it as well as fulfilling the overriding goals of the concept, i.e. prosperity and justice (both inter and intra generation). To improve monitoring of its implementation, the UN has set indicators to determine the level of sustainable development in terms of availability of energy as well as of the development itself. This is something of a novelty in terms of enforcing the implementation of the goals set in Agenda 2030 (Kryk, 2019b, pp. 22-36). Further, the designated indicators are the basis for searching/application of more advanced methods for monitoring the performance of tasks by individual countries/groups of countries than ordinary statistical analysis, which until now has been the norm in this respect. Therefore, an attempt was made to utilize the Ward method and k-means to achieve the goal of the article, which is the measurement and assessment of the degree of providing sustainable energy in European Union (EU) countries in the context of implementation of the 7th goal of Agenda 2030 as well as environmental responsibility and social justice. The use of econometric methods to measure the provision of sustainable energy also meets the expectations of modern economics, as it contributes not only to widening the spectrum of analyzed issues and methods of operationalization of sustainable development but also to increasing the level of precision of calculations and conclusions. Therefore, we may say that the article supplements the recognized research gap. Articles on the need to use advanced econometric methods to operationalize sustainable development have also been written, inter alia, by Radovanovic, Ivanivic, Teodorovic (2011), Mardani and others (2017), Kumar and others (2017), (Kryk, 2019a).

The research body consists of EU member states, and the subject – the degree of providing sustainable energy, analyzed based on Eurostat data on 8 core indicators for SDG 7 of Agenda 2030, which is the point of reference in the article. The beginning of the research period is 2010, at which time discussions and actions were initiated to increase the availability of sustainable energy for societies. The end of the research period (2016) is determined by available data. The research description was preceded by a synthetic presentation of the essence of sustainable development in conjunction with the EU's commitment to achieving the 7th goal of Agenda 2030 and the concept of sustainable energy. The conducted research made it possible to assess the achievements of EU countries and group them according to the degree of ensuring sustainable energy as well as to formulate conclusions regarding

the implementation of SDG 7 together with environmental responsibility and social justice.

An overview of the literature

The beginnings of the concept of sustainable development date back to the 1970s and are associated with the reports of the Club of Rome, which revealed the ecological crisis and numerous environmental barriers to economic growth and socio-economic development, thereby making people aware that their activities could become the cause of the destruction of life on Earth. Attempts to find *the antidote* to the ecological problems of the world in the form of post-industrial concepts of economic growth and development gave rise to the belief that there is no other way of socio-economic development – both worldwide and in individual countries – than sustainable development (Kryk, 2003). The concept of sustainable development is very wide, covering many areas of human activities, and its essence is meeting the needs of the current generation without reducing the chances of future generations to meet them (this definition is included in the report of the Global Commission on Environment and Development "Our Common Future" (1987). Currently, it is one of the most important concepts of economic development.

The concept of sustainable development is winning more and more followers and, most importantly, is implemented in many countries, especially those with a well-developed market economy. The basis of the concept of sustainable development is focused on people as entities affecting the environment, our planet as an area (object) of people's impact, and method of action, i.e. partnership, as only integrated actions will allow us to achieve the goal of this concept; prosperity and peace in the world. These five elements have the following significance in the concept of sustainable development:

- People – we are determined to eliminate poverty and hunger in all their forms and dimensions and to provide all people with the opportunity to use their potential with dignity in a healthy environment and in accordance with the principle of equality.
- Our planet – we want to protect the Earth from deteriorating environmental conditions by sustainable consumption and production, sustainable management of natural resources, and by taking urgent action against climate change and supporting the needs of present and future generations. Climate change is affecting public health, food and water security, migration, and preserving peace and global security. Investing in sustainable development will help counteract climate change by reducing emissions and building disaster resilience. Actions taken on climate change will drive sustainable development and vice versa.

- Prosperity – we want to ensure a decent and satisfying life for all the people, and ensure that economic, social, and technological development is in harmony with nature.
- World peace – we are building peaceful and inclusive societies, free from fear and violence. There is no sustainable development without peace, and there is no peace without sustainable development.
- Partnership as a method of implementing the concept means that we will mobilize the resources needed to implement this concept by revitalizing the global partnership for sustainable development in a spirit of enhanced global solidarity, a partnership focused in particular on the needs of the poorest and the most vulnerable groups, and in the cooperation of all countries, parties and people around the world (United Nations, 2015; Latoszek, 2016, pp. 25-26).

In contemporary socio-economic conditions, M. Prasopchoke's approach should be considered as particularly important in the process of disseminating the concept of sustainable development, which tries to make the ruling classes aware that economic growth cannot consist only in the growth of GDP, production, employment or income, but must at least maintain the current level of social, relational, and natural capital, which will ensure intergenerational/social justice (and development in the future). Therefore, the assumptions for sustainable growth should be considered appropriate from a macroeconomic point of view (Buszko, 2012, p. 177).

F. Piontek understands sustainable development in a similar way, according to whom it is "a lasting improvement in the quality of life of contemporary and future generations by shaping the right proportions between three types of capital: economic, human and natural" (Piontek, 2000, pp. 117-189). Usually, the abbreviation 3xP is mentioned, derived from the first letters of the English words: *planet, people,* and at then, *profit*. This order suggests an emphasis primarily on preserving the Earth's resources, not threatening the environment, and profit comes only at the very end.

Peggy F. Barlett and Geoffrey W. Chase – as in the Bruntland report – argue that sustainable development is about meeting the current needs of society in such a way that the next generations will also be able to meet their own needs (Niesenbaum, 2005, pp. 775-777). In the concept of sustainable development – as H. Komiyama and K. Takeuchi say (2006, pp. 1-6) – strong emphasis has been placed not only on the elimination of barriers for growth, poverty, implementation of innovative solutions, and increase of intangible assets but also on environmental protection and the possibility of renewing resources, which is of particular importance in the new global conditions. Thus, sustainable development is activity that favors the natural environ-

ment, does not take place at the expense of the next generation, and is set in the globalization reality.

An interesting global initiative of the second decade of the 21st century is the UN Resolution *Transforming our world: the 2030 Agenda for Sustainable Development* (2015), which is a global program for sustainable development which sets a universal, global framework for action to eradicate poverty and achieve sustainable development by 2030. The agenda includes a set of 17 ambitious goals and 169 goal-related and complementary tasks. One of the goals is to guarantee universal access to cheap, reliable, modern, and sustainable energy (SDG 7) by 2030 by:

- ensuring universal access to affordable, reliable, and modern energy services,
- significant increase in the share of renewable energy in the overall energy mix,
- doubling the global energy efficiency improvement rate,
- development of infrastructure and modernization of technologies for providing modern and sustainable energy services in all developing countries, in particular in the least developed countries, small island developing countries, inland developing countries, in accordance with their respective support programs,
- strengthening international cooperation to facilitate access to clean energy and technology, including renewable energy, greater energy efficiency, and advanced, clean fossil fuel technologies, and supporting investment in energy infrastructure and clean energy technologies.

Actions aimed at ensuring access to sustainable energy are important from the point of view of both social justice (giving people the chance of access to the achievements of civilization, development, and prosperity) and environmental protection (affecting not only the environment condition but also intra- and intergenerational justice). Hence, undertaking these actions and effects not only reflect the degree of implementation of SDG 7 but also are a sign of environmental responsibility and social justice.

The concept of sustainable energy must first be explained as there are few attempts to define it broadly in the literature (Prandecki, 2014a). It is primarily associated with the application of renewable energy sources (Pawłowski, 2011, p. 242), which is an over-simplification. Most often, authors paraphrase the previously quoted definition of sustainable development from Bruntlad, describing sustainable energy as "energy consumption and supply that meets our needs without compromising our children's ability to meet their needs" (Patterson, 2009; Lemaire, 2010; Tester et al., 2005). They, therefore, emphasize the issue of sustainability of energy availability. In turn, LG Action points out that sustainable energy is associated not only with

the issue of sustainability but also with the authorization for use of energy sources causing slight damage to the environment and human health (2012). This extension of the definition is vital because there are no energy sources that would be completely harmless to the environment. For some authors, the above-mentioned definition has become the basis for equating sustainable energy with a sustainable energy system. This was taken up by Prandecki (2014b), who defines such a system as a conversion of primary energy into electrical and heat energy and its delivery to the final recipient in a way that meets the needs of current and future generations, taking into account the economic, social, and environmental aspects of human development. According to the author of this article, equating a sustainable energy system with sustainable energy also does not exhaust the entire spectrum of issues that can be included in its definition as well as its reduction only to renewable energy sources. This can be demonstrated, for example, by the variety of subjects forming acts from the EU package "*Clean Energy for all Europeans*" (2016), which also fails to show a clear definition of sustainable energy. Therefore, it would be worthwhile, at least for future reference, to formulate its complete definition to ensure uniformity of understanding and comparability of data and information provided on this issue.

The European Union is known for its high commitment and experience in the implementation of sustainable development, which is anchored in the highest-ranking documents, including: Treaty on European Union (2012), strategy for sustainable development (COM (2009) 400 final), "Europe 2020" strategy (COM 2010) and others. EU has also played an important role in shaping Agenda 2030, which is fully in line with the European vision and is a global action program for global sustainable development based on the objectives of this concept. The EU was one of the leading forces that led to the adoption of Agenda 2030. It is fully committed to its implementation and determined to act as a precursor in the implementation of this program and the objectives of sustainable development in cooperation with the Member States in accordance with the principle of subsidiarity. That is why the EU adopted in 2016 the action program for sustainable development entitled *Next steps for a sustainable European future European action for sustainability* (COM 739 final 2016). It is implemented in two ways. The first direction of works is to completely integrate the goals of sustainable development within European policy with the priorities of the European Commission. The second direction is to develop a long-term vision and the main points of the sectoral policy after 2020 as part of the preparation for the long-term implementation of the sustainable development goals. With regard to this work, a long-term vision was created to establish a prosperous, modern, competitive and climate-neutral EU economy by 2050 (COM 773 final 2018). This vision paves

the way for a structural change in the European economy, stimulating sustainable growth and job creation. On the other hand, with regard to the first direction, the identification has shown that under the current EU policies, all 17 sustainable development objectives are being implemented. Moreover, they are included in all 10 of the Commission's priorities for 2015-2019. These are: (1) employment, economic growth and investments; (2) the single digital market; (3) energy union and climate; (4) internal market: (5) a deepened and fairer economic and monetary union; (6) a balanced and progressive trade policy to exploit the opportunities of globalization; (7) justice and fundamental rights; (8) migration; (9) stronger position in the international arena; (10) democratic changes. An important role in the process of implementing a number of sustainable development goals is played by the "Europe 2020" strategy and its assumptions regarding sustainable energy and climate to be implemented by 2020: increase of energy efficiency by 20%, increase of up to 20% share of energy from renewable sources in total energy consumption, reduction of greenhouse gas emissions to 20% compared to 1990. In the document *Towards a Sustainable Europe by 2030* (COM 22 final 2019), this strategy was pointed out as a way for achieving, among others, Goal 7 of the Agenda 2030. Namely:

- "The process of **separating economic growth** from energy inputs and related **greenhouse gas emissions**. In 1990–2017, greenhouse gas emissions fell by 22%, while GDP increased by 58%. Since 2000, the energy productivity and the intensity of greenhouse gas emissions have been improving almost uninterruptedly in the EU.
- The EU seeks to achieve its target value for energy efficiency, set at 20% by 2020. In 2005–2016, primary energy consumption in the EU decreased by 9.9%, and final energy consumption by 7.1%.
- The EU is on track to achieve the 2020 target of a 20% share of renewable energy in final energy consumption. In the last decade, the use of renewable energy has grown steadily in the EU – from 9% to 17% of gross final energy consumption (in 2005-2016). The main driver of this growth was the predictable EU regulatory framework, more efficient technologies, falling costs of renewable energy technologies and more market-oriented support.
- The EU continues to meet its demand for energy mainly by importing fuels from non-EU countries. The EU dependence on import is 53.6% and has practically remained unchanged between 2006 and 2016, while energy production has decreased by 14% during this period. In the same period, there was a constant decrease in primary energy consumption – by about 10%.

- The EU has made progress in increasing access to affordable energy. In recent years, the percentage of households that can not afford to heat the house to the right temperature has decreased. In 2017, 8.1% of the EU population complained about the lack of access to affordable energy – which is less by 2.8 percentage points than in 2007."

The trends presented, based on data analysis in the form of time-series, suggest that changes in the provision of sustainable energy by EU countries are satisfactory (Kryk, 2019a). Whereas, the research performed using the Ward method and k-means shows less satisfactory results, which are presented later in the article.

Research methods

Observation of the implementation of tasks that were aimed at achieving the goals of sustainable development set out in the Agenda 2030, including ensuring access to sustainable energy, is based on the most common tool available, being indicators. According to T. Borys (2005), an indicator refers to a certain state of a phenomenon. The most important feature of each indicator is the comparability of its values, which allows the positioning of a given object (e.g. country), compared with others. Sustainable development indicators are tools that are intended for monitoring implemented changes, providing information on the level of implementation of tasks in the field of sustainability and the current state of the environment. The use of the indicator as a medium has become quite popular due to its multidimensionality, accessibility, readability, unambiguity, and comparability. Indicators assigned to specific orders (economic, environmental, social) or sustainable development goals create the possibility of constructing economic models, forecasting, and monitoring/assessing the implementation of changes. Determination of indicators for the implementation of the 7th goal of Agenda 2030 by the UN has created the possibility of using multidimensional exploration techniques to measure its implementation (e.g. Hellwig, 1968; Shen, Tzeng, 2018), GDM (Jajuga et al., 2003; Walesiak, 1993), consisting predominantly of cluster analysis. Hence, this article uses two such cluster analysis methods (the Ward method and k-means) to determine the degree of providing sustainable energy by EU countries, their environmental responsibility, and social justice.

The term "cluster analysis" was coined by R. Tryon (1939) and then further developed by R. Cattell (1944, pp. 169-184) and the use of cluster methods has increased significantly over the past 30 years (Gore, 2000). The purpose of cluster analysis – also known as data clustering or non-model classification – is to combine the examined elements into similar groups in such a

way that the degree of association of objects belonging to the same group is as large as possible and as small as possible with objects from other groups (Statistica PL, 1997; Kisielińska, Stańko, 2009, p. 68). In the non-model classification, there is no information on the belonging of objects to classes, classification is based on the distances between the objects. Cluster methods can be used to group different objects based on their values in the data set and to discover data structures, but without providing an explanation or interpretation of the reason behind their existence. All dependencies are found only on the basis of input variables. Cluster analysis is a set of different algorithms that assign objects to clusters according to well-defined similarity rules. It is important that, unlike a number of other statistical procedures, cluster analysis is most often used when the hypothesis is not prioritized in terms of data structure, but rather is in the exploratory phase of the research. Among various methods used to analyze clusters, the two most common ones have been selected that will enable the article's goal to be achieved.

The first method used is the Ward method, which is classified among the hierarchical, agglomerative methods. It uses the rule of minimizing variance (Migut, 2009). The methods employed in this group do not require any previous assumption as to the resulting number of clusters – at the end of the analysis, the chart (dendrogram) can be cut off at the proper height and then interpreted (Lotko, Lotko, 2015, p. 5) – this has been done in this study.

Table 1. Set of variables

Variable mark	Type of variable	Variable name
x_1	D	Primary energy consumption [million tons of oil equivalent – TOE]
x_2	D	Final energy consumption [million tons of oil equivalent – TOE]
X_3	D	Final energy consumption in households *per capita* [kg of oil equivalent]
X_4	S	Energy productivity [Euro per kilogram of oil equivalent – KGOE]
X_5	S	Share of renewable energy in gross final energy consumption by sector [%]
X_6	D	Energy dependence by-product [% of imports in total energy consumption]
x_7	D	Population unable to keep home adequately warm by poverty status [% of the population]
x_8	D	Greenhouse gas emissions intensity of energy consumption

D – destimulant, S – stimulant

Source: author's own work based on Eurostat.

The second grouping method – the k-means method – belongs to the group of non-hierarchical methods. They are fast in terms of calculation times but require the input of the assumed number of clusters at the beginning, which may affect the results of grouping (Salamaga, 2010).

In this article, the Ward method was used to identify the number of clusters (number of groups of EU countries), and the k-means method was then used to group cases and interpret the results based on the average value of each variable in each cluster.

To measure the achievement of the 7th goal of the UN Agenda 2030, 8 indicators have been established. These were adopted in this article as variables against which 28 EU countries were examined (table 1).

Before grouping, the variable destimulants were converted into stimulants and normalized using the zero unitarization method according to the following formula (Kukuła, 1999, p. 13):

$$x'_{ij} = \frac{\max\limits_i x_{ij} - x_{ij}}{\max\limits_i x_{ij} - \min\limits_i x_{ij}}, \tag{1}$$

where:
x'_{ij} – value of converted variable,
x_{ij} – diagnostic variable value for the country,
j – variable number.

Then, the stimulants were normalized and deprived of the identifier, using the formula:

$$x'_{ij} = \frac{x_{ij} - \max\limits_i x_{ij}}{\max\limits_i x_{ij} - \min\limits_i x_{ij}}. \tag{2}$$

Variables standardized by this method take values from the range [0,1]. For each diagnostic variable, the least favorable state is valued by the number zero (being min x_{ij} for stimulant and max x_{ij} for destimulant). However, the condition considered to be the most favorable (max x_{ij} for stimulant and min x_{ij} for destimulant) is estimated by the largest number in the range of variation of normed variables, i.e. unity.

Using the above methods, European Union countries were grouped in terms of the degree of providing sustainable energy, and thus the implementation of the principle of environmental responsibility and social justice in connection with the SDG 7 of Agenda 2030. The beginning of the research period is 2010 when the United Nations report "The Global Partnership for Development: Time to Deliver" (2011) informed of the difficulties in supply-

ing energy to a significant part of the Earth's population. This information was the basis for the formulation of the 2011 UN opinion on the need to increase efforts to ensure wider public access to energy and the 7th goal in the New Agenda, which is the subject of the article. The end of the research period (2016) is determined by available data.

Results of the research

Calculations and charts in this section were derived using Statistica version 13.1. The dendrogram prepared using the Ward method (figure 1) presents the clusters of EU Member States in the field of ensuring sustainable energy obtained in the next steps in 2010.

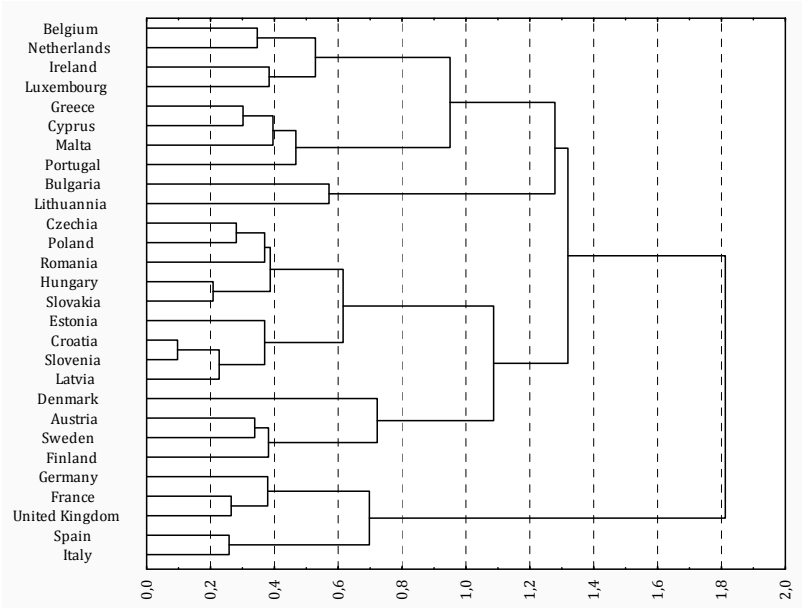


Figure 1. Dendrogram of clusters of EU countries in the field of ensuring sustainable energy determined by the Ward method (2010)
Source: author's own work.

Analysis of figure 1 shows that with a cut-off of 0.8, we obtain a clear and logical division into 6 groups. In this condition:

- 1st group: Italy, Spain, United Kingdom, France, Germany,
- 2nd group: Finland, Sweden, Austria, Denmark,
- 3rd group: Latvia, Slovenia, Croatia, Estonia, Slovakia, Hungary, Romania, Poland, Czechia,

- 4th group: Lithuania, Bulgaria,
- 5th group: Portugal, Malta, Cyprus, Greece,
- 6th group: Luxembourg, Ireland, Netherlands, Belgium.

The division into six groups was adopted in the grouping using the k-means method as the initial value of the number of clusters. The results of grouping EU countries by this method are shown in table 2 and figure 2.

Table 2. Clusters of EU countries in the field of ensuring sustainable energy determined by the k-means method in 2010 and 2016

2010		2016	
Cluster elements	**Distance from the center of cluster**	**Cluster elements**	**Distance from the center of cluster**
Cluster 1		Cluster 1	
Belgium	0.184814	Belgium	0.171062
Spain	0.122939	Czechia	0.088108
Italy	0.220052	Estonia	0.189681
Netherlands	0.233038	Croatia	0.089577
Austria	0.198091	Latvia	0.146819
Portugal	0.351651	Hungary	0.091497
Cluster 2		Netherlands	0.160064
Bulgaria	0	Poland	0.133063
Cluster 3		Romania	0.142325
Ireland	0.269652	Slovenia	0.054797
Greece	0.059351	Slovakia	0.127734
Cyprus	0.094806	Cluster 2	
Lithuania	0.560238	Bulgaria	0.203475
Luxembourg	0.377806	Greece	0.126121
Malta	0.297849	Cyprus	0.140249
Slovakia	0.210114	Lithuania	0.114690
Cluster 4		Portugal	0.142030
Denmark	0	Cluster 3	
Cluster 5		Ireland	0.124702
Germany	0.095808	Luxembourg	0.186237
France	0.027457	Malta	0.224063
United Kingdom	0.090601	Cluster 4	

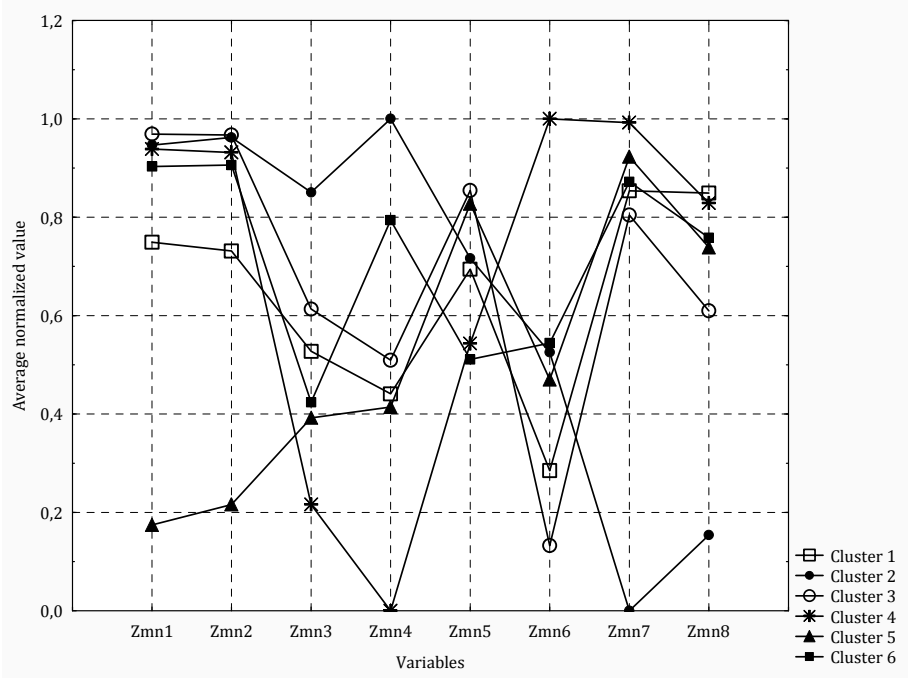
2010		2016	
Cluster elements	Distance from the center of cluster	Cluster elements	Distance from the center of cluster
Cluster 6		Denmark	0.173219
Czechia	0.155702	Austria	0.116986
Estonia	0.154563	Finland	0.125825
Croatia	0.031004	Sweden	0.117216
Latvia	0.074931	Cluster 5	
Hungary	0.141034	Germany	0.205567
Poland	0.213809	Spain	0.171354
Romania	0.169403	France	0.091844
Slovenia	0.037186	Italy	0.128973
Finland	0.256169	United Kingdom	0.107218
Sweden	0.406447		

Source: author's own work.

When analyzing figure 2, the following conclusions can be drawn:

- Cluster 1 had the highest value of the 8th variable compared to other clusters, which means that countries belonging to this cluster were characterized by a low intensity of greenhouse gas emissions in energy consumption (when interpreting the results, remember to replace destimulants with stimulants). The values of variables 1, 2, and 6 took the penultimate place compared to other clusters, i.e. the countries from this cluster had relatively high values respectively in terms of primary energy consumption, final energy consumption, and were highly dependent on energy imports, not a favorable perspective for providing sustainable energy. The values of the other variables 3, 4, 5, and 7 were average.
- Clusters 2 and 3 are among the best clusters. Bulgaria belonging to cluster 2 is a country with a high value of variable 2, 3, and 4, i.e. low final energy consumption and final energy consumption in household per capita, and high energy productivity, respectively. The value of variable 1 was also quite high, which means low primary energy consumption in the country forming the group. However, in this group/country there was the lowest value of variable 7 amongst all clusters, meaning that its country had the worst indicator of adequate heat for the population because of poverty. The values of the other variables were average. However, it should be taken into account that Bulgaria, which forms Cluster 2 was one of the poorest EU members, hence the low values of certain indica-

tors, favorable from the point of view of ensuring sustainable energy was not always the result of deliberate actions in this respect, but rather of existing conditions.



Key: Zmn=x – variable

Figure 2. Average values of quantitative variables measuring the provision of sustainable energy by clusters determined by the k-means method (2010)

Source: author's own work.

- Cluster 3 is the cluster in which the values of variables 1, 2, and 5 were the highest compared to other clusters. Thus, the countries in this group were characterized by low primary and final energy consumption and a high share of energy from renewable sources in gross final energy consumption by sector. The value of variable 3 was quite high, which indicates a high consumption of final energy in households per capita. The value of variable 4 (energy productivity) was average. On the other hand, variables 6, 7, and 8 took last or penultimate place, i.e. countries in this cluster were characterized, respectively, by high dependence on energy imports, poor situation in terms of adequate heating of houses by the population due to poverty, and high intensity of greenhouse gas emissions in energy consumption.

- Cluster 4 included the country with the highest values of the last three variables (6, 7, 8) compared to other clusters (it was the best in this area). Thus, it was characterized respectively as having low dependence on energy imports, a small percentage of the population unable to properly heat the house due to poverty, and low intensity of greenhouse gas emissions in energy consumption. Other variables had an average value, except for variable 4 (energy productivity), which had the lowest value among all clusters. It is interesting to note that in the case of the country examined (Denmark), it was not associated with low energy productivity but rather with a minor increase. Denmark had the highest energy productivity in the EU during the period examined. Generally, Cluster 4, together with Cluster 6, was average in terms of the implementation of sustainable energy variables.
- Cluster 5 is one of the weakest clusters. The values of variables 1 and 2 were the lowest. In this cluster, only variables 5 and 7 were at a fairly high, but not the highest level, that is, countries from this group were characterized by a relatively large share of the renewable energy sector in gross final energy consumption by sector and a relatively low indicator of the population unable to heat the house properly due to poverty. The values of the other variables were poor or average.
- In Cluster 6, variables 4 and 6 achieved quite positive values so, the countries in this group were characterized by relatively good energy productivity and are not overly dependent on energy imports. The values of other variables were average (1, 2, 3, 7, 8) or poor (variable 5 – a low share of energy from renewable sources in gross final energy consumption by sector) compared to other clusters.

This implies that, in 2010, the countries of Clusters 2 and 3, namely Bulgaria, Ireland, Greece, Cyprus, Lithuania, Luxembourg, Malta, and Slovakia had the most favorable situation in terms of ensuring sustainable energy. In these countries, most variables had the highest values in the examined range. In the countries from cluster 5, i.e. Germany, France, Great Britain, most of the variables were poor or average, and only two variables were quite high. Countries from other clusters (1, 4, 6) were average in terms of the implementation of sustainable energy variables. The results obtained will be compared with the results of the analysis in 2016 so as to assess the degree of providing sustainable energy in EU countries.

The dendrogram prepared using the Ward method (figure 3) presents the clusters of EU Member States in the field of ensuring sustainable energy obtained in the next steps in 2016.

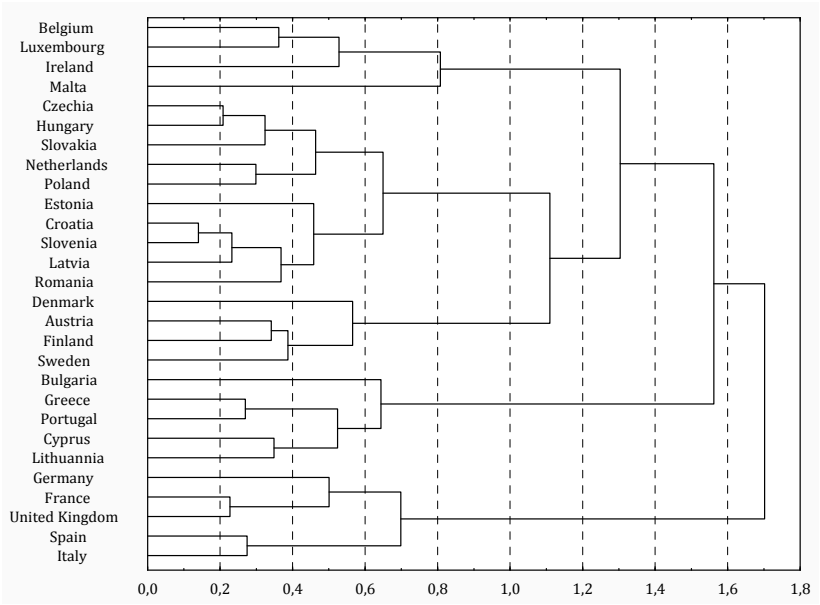


Figure 3. Dendrogram of clusters of EU countries in the field of ensuring sustainable energy determined by the Ward method (2016)

Source: author's own work.

Analysis of figure 3 shows that when there is a cut-off at a height of 1.5-2, a clear and logical division into 5 groups takes place, where:

- 1st group: Italy, Spain, United Kingdom, France, Germany,
- 2nd group: Lithuania, Cyprus, Portugal, Greece, Bulgaria,
- 3rd group: Sweden, Finland, Austria, Denmark,
- 4th group: Romania, Latvia, Slovenia, Croatia, Estonia, Poland, Netherlands, Slovakia, Hungary, Czech Republic,
- 5th group: Malta, Ireland, Luxembourg, Belgium.

The remaining divisions are less characteristic, therefore, division into five groups was adopted in the grouping using the k-means method as the initial value of the number of clusters. The results of grouping EU countries by this method are shown in table 2 and figure 4.

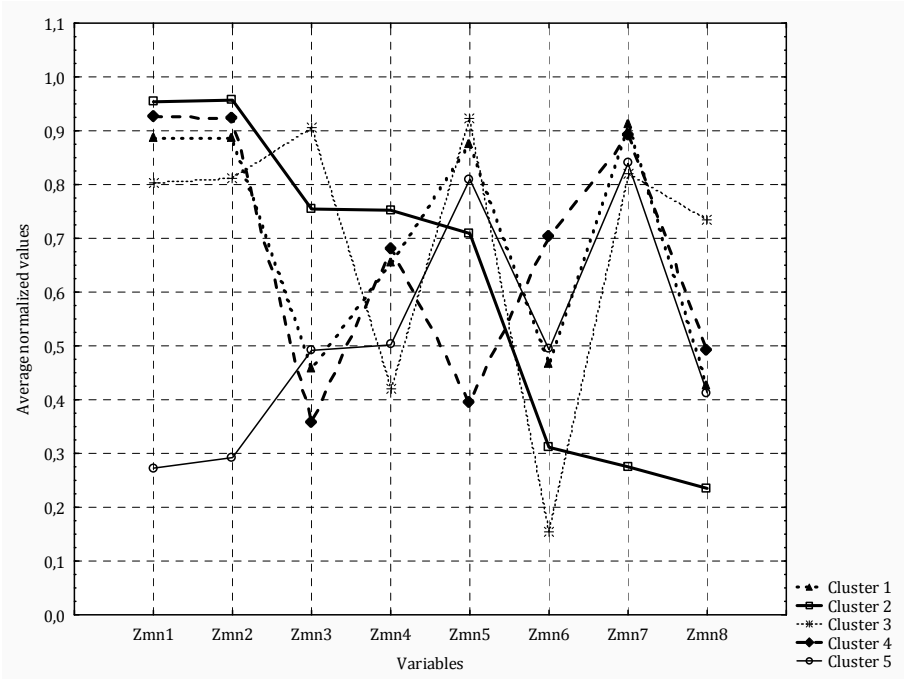


Figure 4. Average values of quantitative variables measuring the provision of sustainable energy by clusters determined by the k-means method (2016)

Source: author's own work.

When analyzing figure 4, the following conclusions can be drawn:

- Cluster 1 was ranked second after Cluster 3, among the best grouping in this research in terms of providing sustainable energy. Variables 4 and 6 had the highest values in this cluster. This means that the countries grouped in it were characterized by high energy production and not very high dependence on energy imports. The values of the other variables were quite high (variable 1, 2, 7) or average (variable 3, 5, 8), which placed the cluster mostly in third place among other clusters.
- Cluster 2 had the highest value for variable 3, compared to other clusters. Thus, the countries in this group were characterized by low final energy consumption in households per capita. The values of variables 1, 2, 4 were quite high, which placed this cluster second in relation to other clusters in this respect. For variables 1 and 2, this meant low primary energy consumption and final energy consumption, respectively, and for variable 4, high energy production. The values of variables 5 and 6 were average. In contrast, the values of variables 7 and 8 were the lowest compared to other clusters, i.e. countries from this group were characterized

by a high rate of the population unable to properly heat their house due to poverty and high intensity of greenhouse gas emissions in energy consumption.

- Cluster 3, as already mentioned, was the best in this study in the context of providing sustainable energy. The values of its three variables 1, 2, and 5 were the highest compared to other clusters, i.e. the countries in this cluster were characterized by low primary energy consumption, low final energy consumption, and a low share of renewable energy in gross final energy consumption by sector. The values of variables 3, 7, 8 were quite high, placing this cluster second among the others. These values meant, respectively, relatively high final energy consumption in households per capita, small changes in the index of the population unable to properly heat the house due to poverty, and high intensity of greenhouse gas emissions in energy consumption. Only the average values of variables 4 and 6 reached the lowest level in the study, which meant a high dependence on energy imports and low energy efficiency. It should be noted, however, that three countries from this cluster (Ireland, Luxembourg, Malta) were characterized by high energy efficiency both in 2010 and 2016, and the remaining countries in the group featured low energy efficiency, hence the average value of a given variable was low.
- In cluster 4, the values of variables 6, 7, and 8 were the highest in the research, i.e. the countries belonging to it were characterized by low dependence on energy imports, low rate of population unable to properly heat the house due to poverty, and lower intensity of greenhouse gas emissions in energy consumption compared to countries outside this cluster, which is very good in terms of providing sustainable energy. Further, the values of variables 3 and 5 were the lowest compared to other clusters, i.e. the countries in this cluster were characterized by high final energy consumption in households per capita and a large share of energy from renewable sources in gross final energy consumption by sector. The values of the other variables were average.
- Cluster 5 showed the worst result in the research. In this cluster, two variables (1, 2) out of eight featured the lowest values, therefore, the countries in this group were characterized by high primary energy consumption and final energy use. Other variables featured average values.

The analysis shows that in 2016, countries from clusters 1 and 3, i.e. Ireland, Luxembourg, Malta, Denmark, Austria, Finland, and Sweden had the most favorable situation in terms of providing sustainable energy. In these countries, most variables had either the highest values or quite high in the examined range. The countries from cluster 5, i.e. Germany, Spain, France,

Italy, and the United Kingdom featured the poorest result, where most of the variables had average or poor values, and only one variable (5) was at a fairly high level. Countries from other clusters (2, 4) were average in terms of the implementation of sustainable energy variables.

Conclusions

Comparing the situation in 2010 with the achievements of EU Member States in providing sustainable energy in 2016, it may be said that:

- In 2016, the first cluster was made up of 11 countries, including 9 from the so-called former Eastern Bloc (Czech Republic, Estonia, Croatia, Latvia, Hungary, Poland, Romania, Slovenia, Slovakia), which were in a group along with two countries with a more developed economy and better indicators regarding the provision of sustainable energy (Belgium and the Netherlands). This fact alone is indicative of the positive changes that have taken place in these post-socialist countries in the researched field. In 2016, these countries were characterized by much better levels of the examined variables than in 2010. They maintained a high level of variables 4 and 6 and achieved higher values of other variables. Variables 1, 2, and 7 (respectively: primary energy consumption, final energy consumption, people unable to heat the house properly due to poverty) increased from average to quite high, and variables 3, 5, and 8 (final energy consumption in households per capita, share of renewable energy sector in gross final energy consumption by sector, intensity of greenhouse gas emissions in energy consumption) from poor to average. As a result, there has evidently been progress in providing sustainable energy that has put these countries in a group with Belgium and the Netherlands. These last two countries had good levels of all variables in 2010 and improved them further, which had a positive effect on the average values of individual variables in the cluster, hence, the results of cluster 1 in providing sustainable energy can be assessed as quite satisfactory because five out of eight variables reached quite high values (1, 2, 4, 6, 7) and the other three variables (3, 5, 8) were average. On a four-point rating scale (unsatisfactory, medium satisfactory, fairly satisfactory, and satisfactory), this is a good result.
- In 2016, cluster 2 covered 5 countries being Bulgaria, Greece, Cyprus, Lithuania, and Portugal. It is interesting that while Greece, Cyprus, and Lithuania were already in one cluster in 2010, the other two countries then joined them. Bulgaria was previously included in a one-element cluster, and its entry was associated with an improvement in the values of

the variables researched (five out of eight, i.e. variables 4, 5, 6, 7, 8), which reduced the distance from the center of the cluster (from 0 to 0,2). In contrast, Portugal, despite the improvement in the values of the researched variables (seven out of eight indicators improved, only the intensity of greenhouse gas emissions in energy consumption deteriorated) (Kryk, 2019a; Eurostat, 2018), moved away from the center of the cluster due to the increase in the number of countries with similar achievements in the field of ensuring sustainable energy (Greece, Cyprus, and Bulgaria).

Compared to 2010, virtually all countries from cluster 2 showed relatively good achievements with respect to four of the variables (primary and final energy consumption, final energy consumption per household per capita, and energy productivity), average results were seen in the share of energy from renewable sources in gross final energy consumption by sector and dependence on energy imports. The group had lower achievements in two cases; the population unable to heat the house properly due to poverty and the intensity of greenhouse gas emissions in energy consumption.

Taking into account that four out of the eight average variable values were quite high and high, two were average, and two were low, the achievements of a given cluster can be assessed as moderately satisfactory.

- Cluster 3 consists of countries with a similar economic situation (Ireland, Luxembourg, and Malta), which were in the same group in both researched years; however, within six years, these countries moved away from the center of the cluster, as indicated by the reduced values of distance from the center (table 2). This was related to both a larger number of member countries in which the values of certain variables improved as well as to the poor performance of given countries in relation to variable 6 (still high dependence on energy imports) and variable 3 (final energy consumption in households per capita is still high despite its lowering). Quite good results were achieved in the case of variable 4 (energy productivity in these countries became one of the highest in the EU), variable 2 (final energy consumption is also relatively lower compared to countries from other clusters) and good results in the case of variable 5 (significantly increasing the share of energy from renewable sources in gross final energy consumption by sector). Variable 1 (primary energy consumption) decreased slightly. Despite this, its level was relatively lower compared to other countries, which is still a positive achievement. The changes that took place in the values of variable 7 (the indicator on population unable to heat the house properly due to poverty) and variable 8 (the intensity of greenhouse gas emissions in energy consumption – still high) were not large, but they improved the standing of these countries in rela-

tion to the other clusters. The change of variable 7 was moderately satisfactory, and for variable 8 it was unsatisfactory.

Taking into account that four out of eight average variable values were quite high and high, two were average but vital, and two were low, the achievements of a given cluster can be assessed as quite satisfactory overall.

- In 2016, four countries with a similar economic situation were included in cluster 4 (Denmark, Austria, Finland, and Sweden), which in 2010 belonged to different groups. Over the six years to 2016, the distance from the center of the cluster of these countries increased, which was associated with a greater number of member countries in which the values of certain variables have improved as well as with moderately satisfactory changes in variables 1 (primary energy consumption), 2 (final energy consumption), 3 (final energy consumption in households per capita), 4 (energy productivity), and 6 (dependence on energy imports). It should be noted, however, that the level of these variables in cluster 4 countries was better than in other Member States, therefore, it will be increasingly difficult for them to achieve spectacular results in this respect. The researched countries obtained the best achievements in the case of variable 5, as they were characterized by the largest share of energy from renewable sources in gross final energy consumption by sectors (in each country of the cluster, this indicator increased) and variable 8 (in all cluster countries the intensity of greenhouse gas emissions in energy consumption decreased to a greater extent than in other EU countries). In the case of variable 7, there is the issue of the success of the group, which is characterized by the lowest values of the population unable to properly heat the house due to poverty (resulting in first place among other groups in Fig. 4) compared to other groups. However, within the group, this indicator only decreased in Austria, while in the other three countries it increased, which is why achievements in this area can be described as moderately satisfactory.

In light of the above achievement, cluster 4 (taking into account the relatively favorable level of five variables out of eight and the level of changes compared to other clusters) can be described as moderately satisfactory in terms of providing sustainable energy.

- In 2016, cluster 5 was made up of five countries which, in 2010, were placed in different clusters. During the period researched, the distance from the center of the cluster of four of them slightly decreased (Germany, Spain, France, and the United Kingdom), which indicates positive, albeit slight, changes in the provision of sustainable energy. However, the distance from the center of the cluster for one country – Italy, increased, which was associated with more minor achievements relative to the

achievements of other countries. It should be noted, however, that positive changes occurred in Italy in seven of the eight variables researched, the negative change being only in the case of variable 7 (the population is not able to warm the house properly due to poverty). Generally, during the six years in the countries belonging to this cluster, fifth in achievement relative to variables 1, 2, 3, 6, 7, and 8 was unsatisfactory, in relation to variable 4 (energy productivity) – moderately satisfactory, while variable 5 (share of energy from renewable sources in gross final energy consumption by sector) – quite satisfactory. In the context of the above, the assessment of the overall achievements of this cluster is unsatisfactory.

To sum up, the research shows that:

- Achievements in providing sustainable energy were quite satisfactory in two clusters (1, 3) covering 14 countries, moderately satisfactory in clusters 2 and 4, covering 9 countries, and unsatisfactory in cluster 5, covering 5 countries. The evaluation of achievements confirms a diverse approach and the possibilities for EU countries not only in relation to a given issue but also for environmental responsibility and social justice.
- The EU's six-year achievements in providing sustainable energy are not overly spectacular, as suggested by the time series analysis (Kryk, 2019b). This proves the need to modify/take actions that will intensify the effects in this respect.

In general, EU Member States are characterized by an average degree of sustainable energy provision and thus the results are insufficient in terms of achieving the 7th goal of Agenda 2030, and thereby environmental responsibility and social justice. Despite some progress being made in the area examined, existing initiatives have not been able to ensure full implementation of the UN 2030 action program. Therefore, there was a need for more efficient implementation and further targeted action in all areas. In the context of the above, the EU has taken new initiatives to facilitate the achievement of the 7th goal of Agenda (COM 22 final, 2019), which are implemented and should bring better results than before. One of the most important initiatives is the already mentioned package "Clean Energy for All Europeans". In May 2019, the EU completed the final legislative acts of this package, thus reaching an important stage towards the completion of the Energy Union. The package includes documents on energy efficiency, renewable energy sources, new energy and climate laws, consumer rights, energy security, electricity market efficiency, and cooperation between the EU and Member States to achieve the ambitious energy and climate goals (Clean Energy Package, 2019). The suggested regulations are aimed at creating a secure, sustainable, and affordable energy system that will materialize and bring results when EU Member

States cooperate in a spirit of solidarity. Achieving satisfactory results requires Member States to quickly implement new regulations and intensify efforts, especially in areas requiring it. The involvement of countries will also be a sign of their environmental responsibility and social justice.

Acknowledgements

The project is financed within the framework of the program of the Minister of Science and Higher Education under the name "Regional Excellence Initiative" in the years 2019-2022, project number 001/RID/2018/19, the amount of financing PLN 10,684,000.00.

Literature

Borys T. (ed.) (2005), *Wskaźniki zrównoważonego rozwoju*, Wydawnictwo Ekonomia i Środowisko, Warszawa – Białystok, pp. 68-78

Buszko A. (2012), *Nowy sposób myślenia o ładzie ekonomicznym*, Difin, Warszawa, p. 177

Cattell R. (1944), *A note on correlation clusters and cluster search methods*, "Psychometrica" No. 9, pp. 169-184

European Commission (2016), *Clean Energy for all Europeans*, COM 860 final, Brussels

European Commission (2019), Package Clean Energy for all Europeans, Luxembourg, https://op.europa.eu/en/publication-detail/-/publication/b4e46873-7528-11e9-9f05-aa75ed71a1/language-en?WT.mc_id = Searchresult & WT.ria_c = null & WT.ria_f = 3608 & WT.ria_ev = search, [02-11-2019]

European Commission (2018), *A Clean Planet for all European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy*, COM 773 final, Brussels

European Commission (2016) *Next steps for a sustainable European future European action for sustainability*, COM (2016) 739 final, Brussels

European Commission (2019), *Towards a Sustainable Europe by 2030*, COM 22 final, ANNEXES 1 to 3, Brussels

Eurostat (2018), *Sustainable development in the European Union*, Monitoring Report On Progress Towards The SDGs In An Eu Context. Luxembourg, Publications Office of the European Union, p. 132

Gore P. (2000), *Cluster Analysis*, in: H. Tinsley, S. Brown (eds.), *Handbook of Applied Multivariate Statistics and Mathematical Modeling,* Academic Press, San Diego

Hellwig Z. (1968), *Application of the Taxonomic Method to the Countries Typology According to their Level of Development and the Structure of Resources and Qualified Staff* (in Polish), "Statistical Review" No. 15(4), pp. 307-326

Jajuga K., Walesiak M., Bak A. (2003), *On The General Distance Measure*, others *Exploratory Data Analysis in Empirical Research*, in: M. Schwaiger, O. Opitz (eds.), Springer, Berlin Heidelberg, pp. 104-109

Kisielińska J., Stańko S. (2009). *Multidimensional data analysis in agricultural economics*, "Annals of Agricultural Sciences" No. 96(2), pp. 63-76

Komiyama H., Takeuchi K. (2006), *Science: building a new discipline*, "Sustainability Science", No. 1, p. 1-6, DOI 10.1007/s11625-006-0007-4

Kryk B. (2019a*), Measuring the provision of access to sustainable energy in the EU as a new task of modern economics in line with Agenda 2030,* in: K. Nermend, M. Łatuszyńska (eds.), *Experimental and Quantitative Methods in Contemporary Economics*, Book Subtitle: Computational Methods in Experimental Economics (CMEE) 2019 Conference, Series Title: Springer Proceedings Business and Economics, pp. 323-334

Kryk B. (2019b), *Providing sustainable energy in Poland in comparison to the European Union in light of the seventh goal of the 2030 agenda*, "Ekonomia i Środowisko" No. 1(68), pp. 22-36

Kryk B. (2003), *Rachunek sozoekonomiczny działalności gospodarczej na przykładzie energetyki zawodowej regionu szczecińskiego*, Uniwersytet Szczeciński, Szczecin

Kukuła K. (1999), *Metoda unitaryzacji zerowanej na tle wybranych metod normowania cech diagnostycznych*, "Acta Scientifica Academiae Ostroviensis" No. 4, pp. 5-31

Kumar A. et al. (2017), *A review of multi criteria decision making (MCDM) towards sustainable renewable energy development*, "Renewable and Sustainable Energy Reviews" No. 69, pp. 596-609, DOI:10.1016/j.rser.2016.11.191

Latoszek E. (2016), *Koncepcja zrównoważonego rozwoju w teorii i praktyce ONZ*, in: E. Latoszek, M. Proczek, M. Krukowska (eds.), *Zrównoważony rozwój a globalne dobra publiczne w teorii i praktyce organizacji międzynarodowych,* Dom Wydawniczy Elipsa, Warszawa, pp. 25-26

Lemaire X. (2010), *Glossary of Terms in Sustainable Energy Regulation*, "Renewable Energy and Efficiency Partnership"

LG Action (2012), *Project definition of sustainable energy*, LG Action, http://www.lg-action.eu/index.php?id [30-09-2019]

Lotko A., Lotko M. (2015), *Zastosowanie analizy skupień do oceny zagrożeń zawodowych pracowników wiedzy i ich postaw wobec charakteru pracy*, "Eksploatacja i Niezawodność" No. 17(1), pp. 1-23

Mardani A. et al. (2017), *A review of multi-criteria decision-making applications to solve energy management problems: Two decades from 1995 to 2015*, "Renewable and Sustainable Energy Reviews" No. 71, p. 216-256, DOI 10.1016/j.rser.2016.12.053

Migut G. (2009), *Zastosowanie technik analizy skupień i drzew decyzyjnych do segmentacji rynku*, StatSoft, Kraków

Niesenbaum R.A. (2005), *A Review of: "Barlett, Peggy F. and Geoffrey W. Chase, eds. Sustainability on Campus: Stories for Strategy and Change"*, "Society & Natural Resources" Vol. 18, Issue 8, p. 775-777, DOI org/10.1080/08941920591005025

Our Common Future (1987), Report of the World Commission on Environment and Development, Oxford University Press, Oxford

Patterson W. (2009), *Keeping the Lights On. Towards Sustainable Electricity*, Earthscan, London, p. 14

Pawłowski A. (2011), Uw*arunkowania bezpieczeństwa energetycznego Polski a rozwój zrównoważony*, in: D. Kiełczewski (ed.), *Implementacyjne aspekty wdrażania zrównoważonego rozwoju*, Wydawnictwo Wyższej Szkoły Ekonomicznej w Białymstoku, Białystok, p. 242

Piontek F. (2000), *Człowiek i jego środowisko w strategii wzrostu gospodarczego i w zrównoważonym (trwałym) rozwoju*, "Problemy Ekologii" No. 5, pp. 177-189

Prandecki K. (2014a), *Theoretical Aspects of Sustainable Energy*, "Energy and Environmental Engineering" No. 2(4), pp. 83-90, http://www.hrpub.org, DOI: 10.13189/eee.2014.020401

Prandecki K. (2014b), *Teoretyczne podstawy zrównoważonej energetyki*, "Studia Ekonomiczne" No. 166, Katowice, pp. 238-248

Radovanovic M., Ivanivic O.M., Teodorovic N. (2011), *The review of the achieved degree of sustainable development in South-Eastern Europe-The use of linear regression method*, "Renewable and Sustainable Energy Reviews" No. 15(1), pp. 766-772, DOI 10.1016/j.rser.2010.07.064

Salamaga M. (2010), *Mierniki podobieństwa grupowania obiektów*, "Wiadomości Statystyczne" No. 6(589), pp. 1-11

Shen K.-Y., Tzeng G.-H. (2018), *Advances in Multiple Criteria Decision Making for Sustainability: Modeling and Applications*, "Sustainability" No. 1, p. 1600, DOI:10.3390/su10051600

Statistica PL, *Volume III: Statystyki II* (1997), StatSoft, Kraków

United Nations (2011), *The Global Partnership for Development: Time to Deliver* (MDG Gap Task Force Report)

United Nations (2015), *Transforming our World: The 2030 Agenda for Sustainable Development*, Resolution A/RES/70/1, sustainabledevelopment.un.org [30-09-2019]

Tester J.W. et al. (2005), *Sustainable Energy, Choosing Among Options*, The MIT Press, London, p. XIX

Tryon R. (1939), *Cluster Analysis*, McGraw Hill, New York

Walesiak M. (1993), *Multivariate Statistical Analysis in Marketing Research* (in Polish), "Wrocław University of Economics, Research Papers" No. 654

Yusif HUSEYNOV

RESILIENCE OF THE REPUBLIC OF AZERBAIJAN AND IMPLEMENTATION OF THE "STATE PROGRAM ON THE SOCIAL AND ECONOMIC DEVELOPMENT OF REGIONS – 2019-2023"

Yusif **Huseynov**, PhD (ORCID 0000-0003-4846-8975) – *Academy of Public Administration under the President of the Republic of Azerbaijan*

Correspondence address:
Route de Collex 162, 1239 API, Switzerland
e-mail: y_huseynov@mfa.gov.az

ABSTRACT: Over the past two decades, the Republic of Azerbaijan has adopted three national strategy programs in order to accelerate the social and economic development of the country's regions. The primary objectives of these national strategies have been ecological safety and responsible use of natural resources, sustainable and balanced development as well as social welfare. In contrast to the previous programs implemented by the state, the new strategy includes the United Nations' principles of sustainable development goals that were formulated in "Transforming our world: the 2030 Agenda for Sustainable Development". However, recommendations given in the Paris Agreement and in the Sendai Framework for Disaster Risk Reduction are also very important for the adoption of any national strategies. Therefore, this article analyzes the environmental and socio-economic activities that are integral to the newly adopted state program on Disaster Risk Reduction strategies and suggests further measures that could be taken improve the effectiveness of its implementation.

KEY WORDS: Azerbaijan, SDGs, Sendai Framework, Resilience, Disaster Risk Reduction

Introduction

The long-term economic development strategy that the government of the Republic of Azerbaijan is pursuing aims to ensure that the regions of the country develop in a resilient and sustainable way. The strategic outlook includes the creation of an atmosphere that favors the formation of a globally competitive economy. The components of such a system should be grounded in principles of sustainable development, social welfare of the highest standards and ecological safety systems that encourage the efficient use of natural resources as well as reliable environmental protection. Azerbaijan's national strategies regarding the socio-economic development of its regions are significant in the implementation of this latest state program and the process of transitioning to an innovative stage of social and economic development. The previous national strategies covering the periods of 2004-2008, 2009-2013 and 2014-2018 were implemented with great success and led to radically positive changes in both urban and regional areas of the country (Sardarov, 2018). The success of these previous national strategies has provided opportunities for Azerbaijan to increase the capacity of its infrastructure while improving the quality of public services and the welfare of its citizens in addition to facilitating a prosperous business and investment climate (Imrani and Musayeva, 2016).

The National Strategy on Socio-Economic Development of the Regions of the Republic of Azerbaijan 2019-2023 (NSA) was developed as a means of further enhancing achievements in the field of social and economic development of the country, particularly in regional and rural areas (Ministry of Economy, 2019). Its development was also designed to ensure the implementation of a Strategic Road Map that reliably anticipates risks and fortifies resilience to potential threats. The NSA will aid government departments and organizations in improving the regulatory framework relating to the country's development, which includes legislation as well as various institutional and economic mechanisms. Examples of instruments of influence are the stimulation of investment and innovation activities, the strengthening and integration of economic activities, the facilitation of access to financial resources, the extension of the range and quality of social services whilst ensuring their accessibility to low income families, the advancement of social programs that protect vulnerable people, the use of natural resources in a more efficient manner and the perfection of techniques used to control ecological issues (Dergunova and Smagulova, 2018).

As a consequence of the Azerbaijani government utilizing these instruments, there are expectations of achieving a range of positive outcomes. These include enhancement of the capabilities of economic agents, compre-

hensive and efficient use of natural resources, development of innovative goods and services as well as the creation and facilitation of the conditions necessary for sustainably developing a prosperous green economy (Ahmadov and Khalilov, 2019). Optimization of a green economy can be realized through the introduction of technological advances that ensure that non-oil sectors are developed in a sustainable way. This will serve to improve the likelihood of balanced regional development and increase the number of permanent green jobs thus creating opportunities for wealth generation and improved well-being for local communities.

The Review of the social and economic outcomes of previously implemented policies designed to increase resilience and socio-economic development in Azerbaijan.

By adopting and implementing national programs for socio-economic development, Azerbaijan has significantly improved factors that ensure that long-term sustainable progress targets are reached. The country has undergone a radical transformation since the 2004 roadmap was successfully implemented. From this time onwards, Azerbaijan has adopted three national programs aimed at increasing the country's levels of development and resilience to potential threats. The initial program was known as "Socio-Economic Development of the Republic of Azerbaijan" and was implemented in the 2004-2008 period (Ministry of Economy, 2004). Its primary objective was the creation of sustainable development strategies for industries in the non-oil sector by advancing social infrastructure and services as well as providing better living standards to locals by increasing opportunities for employment. The second program, "Socio-Economic Development of the Republic of Azerbaijan," was launched in 2009 and operated until 2013 (Ministry of Economy, 2009). Its aim was to further accelerate the advances of the non-oil sector and diversify the economy in a way that leads to sustainable and balanced regional development as well as long-term social and economic resilience. As a result of this program being successfully implemented, markers of resilient sustainable development significantly improved, which manifested as increases in various progress indicators. The success of these two policies fostered the implementation of the third program, "Socio-Economic Development of the Republic of Azerbaijan" that was introduced in the 2014-2018 period (Ministry of Economy, 2014). The key innovations in this program were the further acceleration of policy reforms and the construction of stronger all-encompassing development strategies. In order to provide a general idea of the level of success that this third program has produced, ref-

erence can be made to the total number of facilities that were opened across the various districts and population centers in Azerbaijan. This number was over 1,800 in the 2014-2018 periods, which represents a 40% increase since the 2004-2013 periods (Isabalayeva, 2018).

The progress that has been made within these programs has significantly supported the efforts towards long-term sustainable socio-economic development of both national and regional economies and the communities they support. These advances have resulted in the overall GDP growing 3.3 times larger while the non-energy sector grew 2.8 times larger. Since 2014, currency reserves have risen 24 times, reaching roughly 45 billion USD in 2019 (Agasalim, 2019). A great deal of progress has been made within the framework of regional development programs towards ensuring the long-term sustainability of industries in the non-energy sector. Particular emphasis has been placed upon creating an ideal environment for the expansion of newly emerging high-tech innovative industries (Alakbarov, 2019). The transportation sector infrastructure is one example of an area that has undergone significant advancement in recent years as a result of large-scale investments into the sustainability of the sector. Noteworthy projects include extensive renovations made to vehicle fleets, bridge-building as well as the construction of new highways and repairs to damaged roads. The activities of the three important strategic projects have effectively produced positive results in terms of economic development as demonstrated by three-fold growth levels (Gahramanova, 2019).

There have been many indicators of progress in the field of regional and global infrastructure development. These advances have improved Azerbaijan's opportunity to participate in major transit projects, such as the stepping up of the Europe-Caucasus-Asia transport corridor in addition to the successful continuation of the construction of highways on the North-South and East-West transport corridors (Habibova and Zeynalova, 2018). Furthermore, the volume of freight cargo that can be transported through the Azerbaijani territory is anticipated to increase significantly with the opening of the Baku-Tbilisi-Kars railway. This project will drastically improve the potential of Azerbaijan's transit capacity. Another indicator of progress was the Baku International Sea Trade Port Complex that was completed in 2018. Situated on the junction of the North-South and East-West transport corridors, the port has enabled greater potential transit capabilities and serves as a strategic transport hub for the processing of incoming and outgoing shipped goods. Throughout the last twenty years, Azerbaijan has seen the construction of 6 new airports. The country has also undergone extensive construction and repairs on around 14,000 km of key road infrastructure as well as 436 bridges and tunnels (Kizi, 2018).

A key component of these programs has been ensuring the long-term health and resilience of the natural environment that supports the well-being of local communities who depend on natural resources for their livelihood and survival. Numerous efforts have been made to maintain ecological harmony, adjust to the predicted effects of changing climate, ensure clean air and water for local people and encourage further protection of the natural environment. Many programs have focused on increasing the implementation of green activities throughout the past 15 years. In this period, over 133,000 hectares of land were used for carrying out tree farming and forestation measures. Furthermore, adverse environmental impacts were reduced and natural resources were preserved because of the construction of domestic waste sorting and combustion facilities. The implementation of plans that restore and develop social and economic infrastructure in the regions is providing local communities with ongoing services. This has been achieved by creating electrical, natural gas and water supply networks that are resilient and reliable. Likewise, health and education facilities have received large-scale public funding into their continued development (Aliyev, 2019).

In reflecting on the previous projects that have been successfully implemented in the Republic of Azerbaijan, the country's commitment to long-term resilience is very clear. Examples include the 28 power plant stations that have been built in suburban regions of Azerbaijan as well as the installation and repair of 45,000 km of electricity cables in order to ensure improved quality and resilience of the electricity coverage of populated areas (Nasibov, 2018). Similar efforts have been made to improve the country's energy infrastructure. During the last 15 years, 56,000 km of gas pipelines have been constructed or underdone significant reconstruction (Huseynov, 2018). Consequently, 94% of people living in suburban areas are currently being supplied with sufficient amounts of natural gas (Agasalim, 2019). It is also important to mention that the gasification of small, medium and large communities in suburban areas prevents the use of timber for energy, which leads to effective reforestation in certain regions. Another area of progress within this period has been the work carried out on the country's water supply network. Azerbaijan has sought to guarantee the supply of water to local communities through the construction of new water reservoirs as well as new sewage and water lines. Access to water resources has been specifically increased through the construction of 224 water reservoirs, 6,000 km of sewage canals and 11,000 km of water channels. Furthermore, the supply of safe drinking water has seen an increase from 9% to 44% (Aliyev, 2018). Particular attention has been given to improving irrigation in rural areas and using land and water resources more rationally. This focus has led to the construction and rehabilitation of 4,000 km of irrigation channels (Ahmadov and Khalilov, 2019).

Methods and Objectives of the 2019-2023 National Strategy

The primary purpose of the 2019-2023 State Program is the positive transformation of Azerbaijan's environment so that its regions are able to benefit from both the sustainability and resilience that development provides. Other important aims of this new state program are the building of a robust economy that is founded on sustainable development targets, effective social welfare systems, efficient allocation of natural resources as well as the protection of local ecosystems and the environment. Further objectives of the new program are listed as follows (Ministry of Economy, 2019):

1. Continuing to increase activities involving innovation and investment.
2. Introducing advanced technology and technical equipment.
3. Diversifying and growing towards a more competitive and effective economy.
4. Policies of self-sufficient environmentally friendly production of vital food supplies.
5. Improving employment opportunities and the total number of employers in the regions.
6. Reducing poverty, raising living standards and strengthening community well-being.
7. Improving accessibility to quality social services like education and healthcare.
8. Providing alternative sources of energy.
9. Improving transportation and road infrastructure within suburban areas.
10. Developing management and supply strategies for water resources.
11. Refining legislation and other systems in financial institutions.
12. Rehabilitating and accelerating the role of private and public aid in the regions.
13. Using modern technologies to expand existing infrastructure.
14. Increasing the level of scientific research and innovation.
15. Acquiring public and private support of activities based on research and innovation.
16. Developing rigorous and effective insurance systems.
17. Using natural resources efficiently and protecting the environment.

Successfully implementing the objectives above requires financial support. Being a state program, it is to be financed through the Republic of Azerbaijan's state budget in addition to extra-budgetary funds as well as both foreign and domestic investments (Ministry of Economy, 2019). The table below provides a rough outline of the action plans for the State Program 2019-2023 concerning Environmental Social and Economic Activities and the executive bodies governing each activity.

Results of the 2019-2023 National Strategy

Table 1. Activities in the field of Ecology and Natural Resources

Activities	Period	Executive bodies
Improvement of the hydrometeorological networks	2019-2023	The Ministry of Environment and Natural Resources
Greening policy and forestation: - 157 hectares of new forestation belt with drip irrigation system along Alat-Astara city highway, - 45 hectares of new forestation with drip irrigation system in Shirvan National Park, - 35 hectares of new forestation with drip irrigation system along the highway between Baku and Guba cities.	2019-2023	Ministry of Ecology and Natural Resources, local branches of executive bodies
Locating and evaluating underground freshwater deposits	2019-2023	The Ministry of Environment and Natural Resources
Establishing complex environmental monitoring laboratories	2019-2023	Ministry of Ecology and Natural Resources, State Agency for Control of Antimonopoly and Consumer Market
Conducting geological exploration	2019-2023	The Ministry of Environment and Natural Resources
Organization of environmental awareness for the population	2019-2023	Ministry of Ecology and Natural Resources, Ministry of Education, local branches of executive bodies and municipalities
Improvement of solid waste management	2019-2023	Ministry of Ecology and Natural Resources, Ministry of Education, local branches of executive bodies
Improvement of the ecological preservation and rehabilitation of the lakes in Absheron Peninsula, continuation of the works in Boyukshor Lake ("Great Salt Lake")	2019-2023	Ministry of Economy, Ministry of Ecology and Natural Resources

Source: author's own work.

Table 2. Activities in the field of Transportation Facilities Development

Activities	Period	Executive bodies
Further progress in constructing railway infrastructure projects: - East-West railway route: lanes, power supply and communication systems, - North-South railway route: lanes, power supply and communication systems, - Construction of the Laki-Gabala railway route.	2019-2023	"Azerbaijan Railways" CJSC, Ministry of Economy
Further progress in constructing road infrastructure projects: - Construction of a new highway on the state border of Azerbaijan and the Russian Federation (132-192 km), - Expansion of the highway on the state border of Azerbaijan and Georgia (Ganja City to Georgian border), - Highway reconstruction on the state border of Azerbaijan and the Islamic Republic of Iran (81 km of Balasuvar (AZE) highway).	2019-2023	State Agency for Roads, Ministry of Economy

Source: author's own work.

Table 3. Activities in the field of Energy

Activities	Period	Executive bodies
Further progress in constructing electric power projects: - Construction of small hydropower plants, - Reconstructing high voltage transmission lines and stations, - Construction of renewable energy power stations, - Assistance to rural areas via the production of biofuels and bioenergy from agricultural waste, - Use of renewable energy sources in irrigation systems and household heating systems, - Completion and Maintenance of the "Southern Gas Corridor".	2019-2023	Ministry of Energy, Ministry of Economy, "Azerenergy" OJSC, Ministry of Agriculture, "Melioration and Water Management" OJSC, "Azeristiliktechizat", SOCAR

Source: author's own work.

International practices guiding National Strategy Policy

Azerbaijan is developing its national strategy using important theoretical and methodological approaches from already existing international practices in the fields of sustainable economic, social and environmental development (Huseynov, 2019). Although each country possesses unique characteristics and implements custom sustainability strategies according to their developmental needs, it is significantly beneficial to share mutual ethics and international attitudes on the most effective actions in the area of environmental protection. Issues of key concern include human-caused impacts upon natural resources resulting in the depletion of minerals, land, water and forests. Other concerns include the expansion of environmentally harmful industrial

production activities and the escalation of uncontrolled land use and exploitation. The interchange of ideas and experiences in order to incorporate global practices into programs aimed at national development has become the contemporary paradigm for international collaboration and strategic policy-making. In contrast to previous standards, this new style of cooperation at an international level solves problems more efficiently by bringing together the policies and knowledge of neighboring countries and innovating existing approaches to promote both economic competitiveness and resilience in accordance with the ideals of the growing green movement (Albrito, 2018).

International cooperation and regional integration were established by Azerbaijan in its previous programs of local and regional development. These programs have stimulated significant projects while developing the region's economic and social infrastructure in order to meet international standards. In an effort to increase the general well-being of communities, Baku has permitted the active involvement of local governments. This includes the involvement of rural communities and self-governance bodies in the planning and implementation of regional development programs. Azerbaijan's next stage of resilient advancement was significantly assisted by international principles throughout the process of drafting the country's 2019-2023 regional development programs. Unlike development programs of the past, the new program includes the United Nations' principles of sustainable development (Ministry of Economy, 2019). These principles are known internationally as "Transforming our world: the 2030 Agenda for Sustainable Development" and serve as the foundation for agreements of cooperation that have been made with Azerbaijan's international partners (UN, 2018). The leading global and regional theoretical approaches and practical methods in the area of innovative solutions have become a vital component of the country's national program for the 2019-2023 period. The merging of this knowledge into the program will help to facilitate efficient and effective management of the social and economic development of Azerbaijan's urban and rural areas.

Measures that could be added to the National Strategy 2019-2023

In the modern world, Disaster Risk Reduction (DRR) is a fundamental part of any effective sustainable development strategy (Kelman, 2015). In spite of a global awareness and understanding of the growing risks of natural disasters and an international commitment to disaster risk reduction, many countries have not yet completely taken into account the full gravity of their exposure to global risks in their development planning and manage-

ment styles. Natural disasters and catastrophic events are often viewed as one-off isolated incidences rather than a part of a greater looming threat. Usually the bulk of financial aid and media attention in the aftermath is focused on repairing property damage and dealing with humanitarian consequences of the disasters instead of addressing the causes of disasters.

Recognizing emerging risks and spreading awareness of imminent challenges is essential to implementing an effective approach towards sustainable development and resilience. In order to build long-term resilience to potential threats in this rapidly evolving world, it is necessary for countries to adopt appropriate development programs and strategic models (Albrito, 2018). In particular, it is essential that countries make progress in implementation of two key UN documents, namely the Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals (UNDRR, 2015). Both of these documents were designed to specifically target equitable, resilient and sustainable progress. Azerbaijan's 2019-2023 State Program addresses three primary interlinkages between resilient development and disaster risks. These are 1) the integration of DRR strategies into decision-making processes and policy development, 2) the alignment of every future state program and project with the SDGs and Sendai Framework targets, and 3) the integration of governing bodies and state institutions into a strategic action plan.

It has been emphasized that the adoption of the 2019-2023 State Program by the Republic of Azerbaijan is very likely to promote further socio-economic development of the nation over the next 5-year period. Nevertheless, successful reduction of environmental, economic and social risks and their potential consequences needs proper disaster risk management and resilient disaster risk governance. This strategy in combination with the integration of DRR into the state program would help prepare Azerbaijan for the possible negative effects of climate change in addition to supporting the country's sustainable advancement. As such, there is a necessity for the Republic of Azerbaijan's state program to make reference to three central documents: the SDGs, the Sendai Framework and the Paris Agreement (Kinley, 2017). Regarding potential natural disasters, Azerbaijan is surrounded by sea, rivers and mountains. The country is subject to many disasters each year, including floods and landslides. A few high magnitude earthquakes have been recorded over the last two decades. Additionally, Azerbaijan is now likely to face man-made disasters and industrial accidents because of the economy's heavy industrialization. Therefore, it is critical for Azerbaijan to continue its active absorption of the 2030 Sendai Framework into its 2019-2023 State Program in order to support the state's capacity for risk reduction and disaster preparedness. So, in contrast to prior state programs that have

been implemented since 2004, the programs for 2019-2023 should seek to guarantee a methodical style of identifying and assessing possible disaster risks while minimizing the potential socio-economic consequences to Azerbaijan and its intended future projects.

Conclusions

The "State Program on the Social and Economic Development of Regions 2019-2023" is a highly anticipated national strategy for Azerbaijan in the continuation of progress on socio-economic areas over the next period of time. In particular, projects focusing on sustainable ecological systems, preservation of natural resources, development of transportation and energy facilities are playing a significant role in the country's long-term sustainable development. The integration of DRR along with the 2030 Agenda for Sustainable Development targets into all institutions of government would be likely enhance these activities and facilitate the strengthening of resilience of future planned projects. Adapting to climate change and integrating strategies aimed at reducing the risk of disasters will be essential to successfully implementing the state program of 2019-2023.

In accordance with the recommendations derived from research, adjusting to the effects of climate change and adopting a proper DRR strategy will aid in Azerbaijan's emergence into a new and more prosperous period of increased resilience and development. The implementation of comprehensive protocol for management of risk and greater civil protection will ensure an improved level of environmental safety during the future socio-economic development of Azerbaijan. In the context of implementing the state program, the rural and regional areas could become the focus of attention especially within the framework of an agenda for resilient development. Furthermore, the social and economic development of Azerbaijan as well as the broader South Caucasus region will be further accelerated by using the existing potential of the country more efficiently. This acceleration will occur with the adoption and integration of international practices into the state program. The successful implementation of the "State Program on the Social and Economic Development of Regions – 2019-2023" will consequently result in the resilient continuation of Azerbaijan's sustainable development in the long-term future. This success will likely include other positive outcomes related to the dynamic strategies of resilient socio-economic development in the Republic of Azerbaijan.

Literature

Agasalim A. (2019), *Sustainable Economic Development and Azerbaijan*, Economic and Social Development: Book of Proceedings, p. 7-15

Ahmadov E., Khalilov T. (2019), *Azerbaijan from Inclusive and Innovative Governance to Green Economy*, Economic and Social Development: Book of Proceedings, p. 988-1001

Alakbarov U. (2019), *Innovative Technologies of Public Administration Driving World Leadership of the Republic of Azerbaijan in Sustainable Inclusive Development*, Public Administration: Theory and Practice

Albrito P. (2018), *Local level implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030*, International Journal of "Disaster Risk Reduction" No. 31, p. 1307-1308, DOI: 10.1016/j.ijdrr.2017.12.005

Aliyev S. (2018), *Evaluation of the controlled hydrological-meliorative state in the irrigated soils of the Shirvan plain in Azerbaijan*, "Bulletin of Science and Practice," No. 4(4), p. 102-108, DOI: 10.5281/zenodo.1218269

Aliyev Z. (2019), *From Millennium Development Goals to Millennium Development Goals: An Assessment of the Relationship between Economic Development and Education*, "Science and Innovative Technologies" No. 8, p. 52-75, DOI: 10.5782/2616-4418.8.2019.52

Dergunova Y., Smagulova N. (2018), *The impact of state programs on the country's competitiveness rating*, "Bulletin of Science and Practice" No. 4(3), p. 211-216. DOI:10.5281/zenodo.1198718

Gahramanova S. (2019), *The Role of the Corporate Social Responsibility in Sustainable Development of Small and Medium Enterprises in Azerbaijan*, Economic and Social Development: Book of Proceedings, p. 1254-1260

Habibova Z., Zeynalova E. (2018), *Human potential of communities and social entrepreneurship as a factor of sustainable innovative development in Azerbaijan*, "The Business & Management Review" No. 9(4), p. 52-55

Huseynov Y. (2018), *Geopolitics of the diplomacy of the European energy security: Role of Azerbaijan, Beau Bassin*, Mauritius: LAP Lambert Academic Publishing, ISBN: 978-613-9-82494-6

Huseynov Y. (2019), *Sustainable Development with Disaster Risk Reduction: Preparation of Azerbaijan*, "The European Journal of Humanities and Social Sciences", p. 108-111, DOI: 10.29013/EJHSS-19-3-108-111

Imrani Z.T., Musayeva M.R. (2016), *Socio-Economic Aspects of the Concept of Sustainable Development In Azerbaijan Republic*, "Ûg Rossii: Èkologiâ, Razvitie" No. 11(2), p. 42-49, DOI: 10.18470/1992-1098-2016-2-42-49

Isabalayeva I. (2018), *Brief: UN ready to assist Azerbaijan in achieving SDGs*, TCA Regional News, p. TCA Regional News, Jul 2, https://www.azernews.az/nation/134237.html [23-08-2019]

Kelman I. (2015), *Climate Change and the Sendai Framework for Disaster Risk Reduction. International Journal of Disaster Risk Science*, "International Journal of Disaster Risk Science" No. 6(2), p. 117-127, DOI: 10.1007/s13753-015-0046-5

Kinley R. (2017), *Climate change after Paris: From turning point to transformation*, "Climate Policy" No. 17(1), p. 9-15, DOI: 10.1080/14693062.2016.1191009

Kizi S. (2018), *The Review On Strategic Roadmaps Of National Economy And Basic Segments Azerbaijan's Economy*, "Turan: Stratejik Arastirmalar Merkezi" No. 10(37), p. 296-299

Ministry of Economy (2004), *State Program on the Social and Economic Development of Regions – 2004*-2008, Baku, http://unpan1.un.org/intradoc/groups/public/documents/untc/unpan016803.pdf [23-08-2019]

Ministry of Economy (2009), *State Program on the Social and Economic Development of Regions – 2009-2013*, Baku, https://www.economy.gov.az/en/article/state-program/21450 [23-08-2019]

Ministry of Economy (2014), *State Program on the Social and Economic Development of Regions – 2014-2018*, Baku, https://www.economy.gov.az/en/article/state-programs/22376 [23-08-2019]

Ministry of Economy (2019), *State Program on the Social and Economic Development of Regions – 2019-2023*, Baku, https://economy.gov.az//uploads/fm/files/DP/Regionlar%C4%B1n%20iqtisadi%20inki%C5%9Faf%C4%B1.pdf [23-08-2019]

Nasibov V. (2018), *Sustainability and Efficiency of Azerbaijan Energy Performance and the Potentials of their Improvement*, IFAC Papers Online, No. 51(30), p. 575-579, DOI: 10.1016/j.ifacol.2018.11.214

Sardarov T. (2018), *Social Infrastructure Regulating in an Emerging Economy*, "Academy of Strategic Management Journal" No. 17(3), p. 1-12

UN. Department of Economic Social Affairs (2018), *The Sustainable Development Goals report 2018,* https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf [23-08-2019]

UNDRR (United Nations International Strategy for Disaster Reduction) (2015), *Sendai framework for disaster risk reduction 2015-2030*, Geneva, https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf [23-08-2019]

Agnieszka SOBOL

CIRCULAR ECONOMY IN SUSTAINABLE DEVELOPMENT OF CITIES

Agnieszka **Sobol,** Assistant Prof. (ORCID: 0000-0002-4363-8923) – *Katowice University of Economics*

Correspondence address:
Faculty of Economics, Department of Spatial and Environmental Economics
1 Maja Street 50, 40-287, Katowice
e-mail: agnieszka.sobol14@gmail.com

ABSTRACT: The closed-loop economy, its opportunities and challenges, are of high interest to a growing number of organizations, especially industrial ones. However, an important role has to be played by the cities that spatially link different types of activities. Besides, local authorities have the potential to initiate and coordinate cooperation by connecting the activities of residents with the municipal economy and many industries. The purpose of this paper is to enhance awareness of the process of transforming the cities for circularity. It aims to provide some guidelines to the complexity of the process presenting the mixture of economic, management, environmental and social instruments. The main research methods were case studies analysis followed by literature and document review. The article explores the good practices of building an urban circular economy. It presents theoretical and application conclusions and recommendations. Special attention has been paid to the current activities in the Polish cities.

KEY WORDS: circular economy, local development, sustainable development, cities

Introduction

Cities play a crucial role in climate adaptation and mitigation. They are expected to be at the forefront of the battle with climate change. Urban areas account for a generation of more than 70% of global greenhouse gas (GHG) emissions worldwide. Climate adaptation needs a huge infrastructural transformation. Estimates show that the current needs of cities in meeting their infrastructural targets are 4.3 trillion $ per year and an additional amount of 1.1 trillion $ is required to ensure a low carbon future (CCFLA Report, 2015).

Nevertheless, new infrastructure and money are not enough. City leaders need to rethink and implement new urban models to minimize the use of energy, water and land in urban areas. Mental change is essential. Discussion on the green transformation derives from the need of a change of the general paradigm shift in economics. For decades numerous organizations and academics have been building the ground for a wider debate, from the Club of Rome reports, school of ecological economics and its steady-state economics (Daly, 1977) to prosperity without growth (Jackson, 2009) and Ostrom's research of the commons (Ostrom, 1990).

The current and urgent challenge is a system of circularity in resource flows. The circular economy introduces so called cradle to cradle philosophy. It incorporates resource utilization and efficiency, water efficiency and energy efficiency. The idea seems to be presented as a panacea for all the ecological problems of the Earth. The direction is good, but thinking of a circular economy as a technical solution for all the environmental problems is an utopia. The key challenge is reducing the consumption of resources. What is more, circularity model needs to incorporate aspects of health and social responsibility.

Urban transformation to a circular economy is under a policy of the global leading organizations. The United Nations and the European Union both have undertaken steps to make it real. In the UN policy, the Sustainable Development Goals adopted by the member states in 2015, include many aims related to circularity (https://www.un.org/sustainabledevelopment/sustainable-development-goals/). Moving to a circular economy is a crucial direction allowing societies to meet the goals of the Paris Agreement on Climate Action. Circular transformation can contribute to achieving the 2030 EU target to reduce greenhouse gas emissions by 40% i.e. 62 Mt of CO2 eq per year (Meyer, 2011). Circular economy is part of UE policy to deliver the resource efficiency agenda established under the Europe 2020 Strategy for smart, sustainable and inclusive growth (European Commission, 2010). The European Union has endorsed the concept of a circular economy through recycling and waste management legislation and associated laws and regulations (European

Commission, 2014). The UE has also implemented the Ecodesign Working Plan to foster material reuse and resource efficiency (European Commission, 2016). In order to boost markets to circularity, some voluntary tools have been supplemented, such as the EU Ecolabel or Green Public Procurement criteria (European Commission, 2019).

Circular transformation is on its way. In 2016, four million people were employed in sectors related to the circular economy such as repair, reuse or recycling. Circular activities generated almost €147 billion of revenue and €17.5 billion worth of investments (https://www.un.org/development/desa/en/news/sustainable/good-practice-circular-economy.html). More intensive use of resources could also represent an overall savings potential of €630 billion per year for the European industry (Greenovate, 2012). The complex material cost-saving opportunities for the EU industry from circular economy approaches can boost EU GDP by up to 3.9% (Ellen MacArthur Foundation, 2012). It is estimated that resource efficiency improvements all along the value chains could reduce material inputs needs by 17%-24% by 2030 (Meyer, 2011). At the same time, a potential for a change is huge, as only 9% of materials are reused globally (Circle Economy, 2019).

The paper presents good practices in the field of urban circular economy and gives the key insights from the Polish experiences. The research is based on mixed methods. Case studies analysis was followed by a literature and documents review. The analysis was supplemented by interviews in the examined cities. Finally, based on synthetic overlook it provides a list of recommendations on how to support the process of circular economy in cities.

The idea of circular economy

The term circular economy has been coined to many environmental problems of the planet. A circular economy is about a systemic change. It requires a selection of priority areas where innovation is most needed to achieve deep decarbonization (fossil fuels) and effective adaptation. It supports to face the challenges of overconsumption. The initiative combines an approach of consuming less with an approach of consuming differently i.e. ecologically friendly. The orientation towards closed-loops in an urban economy is also associated with economic goals. It results from the optimization of the management process and the search for solutions improving the financial outcome.

Energy self-sufficiency is very often the driving force behind the transformation towards a circular economy. The prerequisites for independence

from energy suppliers are related to safety and economic criteria as a result of rising energy prices.

An urban circular economy is often limited to waste management. This is a particularly important sector of a municipal economy in this area. The circular economy model often uses the so called 3-R strategy (Reduction, Reuse, Recycling). This means returning the waste stream and processing it. The transformation of waste management to secondary raw material management is one of the cores in a circular economy. The complexity of the system also assumes a need for responsible and economical management of resources and their multiple use processes of exchange and new applications. This strategy therefore, includes direction to sustainable or green procurement, sustainable production and consumption or sharing economy.

The transition from a linear system to circularity requires a reformulation of a sequence of processes, which until now are commonly carried out in the following way: extraction-processing-using-disposing. This results in complex negative externalities, including pollution and waste. However, these by-products of consumption and production process do not have to be a ballast. They can become valuable secondary raw materials. Closing the cycles and introducing cradle to cradle concept requires a systemic approach to the functioning of socio-economic processes.

Many challenges for a transition to circularity have been identified. There are some which cut across many fields and seems to be crucial. These are a lack of political support, joined-up regulatory framework and common standards, data and institutional capacity (Williams, 2019).

A circular economy in cities – international practices

More and more cities in Europe face the challenge of creating a circular economy. Some cities already have advanced experience in this field. These include Glasgow, Barcelona, Brussels, Gothenburg, Ljubljana, Paris, Peterborough, Amsterdam, London, Helsinki, Cremona. These cities introduce many innovative solutions combining biological, technical, economic aspects as well as in the field of education and social impact. A lot of attention is paid to the promotion of knowledge about urban circular economy and indicating the role of the local community in this process.

One of the leaders of good practice in Europe is the municipal company Snaga from Ljubljana with over a hundred years of experience in waste management (http://www.snaga.si/en). The company is an example of a systemic approach to resource management in practice. Individually and in cooperation with the partners from the network is involved in the develop-

ment of a closed-loop system in Ljubljana and its surroundings and implementation of a "zero waste" strategy. A strong emphasis in the company's activities is put on the education of the inhabitants and their involvement in conducted activities.

In Amsterdam, great achievements in co-creating the urban circular system are due to the original use of the game's formula for involving citizens (Games for cities: circular Amsterdam). Local authorities and municipal companies indicate that the basis for successes is cooperation and the use of innovative tools of social impact. Through various games in the field of recycling, water-saving, energy conservation and the use of organic waste many partners are involved, in particular, the local community.

The game formula is also used by Recyclebank organization which has been developing since 2004. Recyclebank is a kind of social venture where recycling and reuse of valuable secondary raw materials are developed through social media and networking. A network of actors from different sectors combines activities for sustainable development. The activities are primarily focused on residents. The axis of the strategy of social impact is related to information and education policy. Raising ecological awareness is supported by a system of social impact by rewarding positive behaviors. Engagement with Recyclebank is rewarded with points from partners that can be exchanged for dedicated prizes, services or shopping discounts. The number of points is determined by RFID (Radio Frequency Identification) sensors installed on the recycling containers. Since its creation, Recyclebank has grown rapidly and now operates in several hundred cities, involving more than 3 million households (https://www.recyclebank.com/). Recyclebank is an example of a business model integrated with social and environmental goals.

A circular economy in cities – practices in Poland

In Poland, a process of building a circular economy is still at a low level. The outstanding project includes the pilot program by the Ministry of Entrepreneurship and Technology, Ministry of Environment and National Fund for Environmental Protection and Water Management implemented in Wieluń, in the Łódź voivodeship[1]. In this commune of 23,000 inhabitants, as the first since July 2018 is implementing a governmental project testing various solutions that fit into a local circular economy. These solutions in a systemic way

[1] The program implemented within inter-ministerial team for innovation entitled "Road map of the circular economy for Poland". Apart from Wieluń, the municipalities of Krasnobród, Łukowica, Sokoły and Tuczno took part in a pilotage. Their task is to develop good practices in urban circular economy. A program budget is PLN 40 million.

link eco-innovative infrastructure with technological instruments, as well as economic and social impact. The program implemented in Wieluń placed great emphasis on environmental education. It is also pointed out that the pro-social character is important for the final success.

The most important infrastructural task is the construction of a composting plant in the vanity of the waste segregation line in Ruda and the waste sorting line. The recycling of secondary raw materials in the production process is mainly based on their selective collection at source. In the urban space, underground containers have been located, from which waste is directed to further segregation at the RIPOK area (Regional Plant for Processing of Municipal Waste). The costs of selective collection are financed by the fees paid by the plastic recycler operating in Wielun. The inhabitants, who are the main actors in the process are supported by appropriate infrastructure and motivated by instruments of social impact. They have at their disposal an EcoTech System IT platform, mobile application and vending machines for the return of recyclable materials. There are 30 Reverse-Vending Machine (RVM) in the city that accept cans, plastic and glass. Similarly to the Recyclebank model described above, participation in the selective collection of recyclable materials is scored. The collected points are settled, e.g. in fees for water and sewage, but not only. Moreover, the EcoTech platform is connected to a system of discounts offered by the city and the partners – for the swimming pool, cinema or shopping in local shops. System EcoTech records the disposal of waste into the vending machine. In return, it assigns points to the particular resident on the electronic card and mobile application.

As part of a circular economy system in Wieluń, the city has signed a contract for the collection of so called alternative fuel (Refuse Derived Fuel – RDF) with a cement plant located 200 km away from Wieluń. It is also planned that water from sewage treatment plant will drive a small hydropower plant. The sewage sludge will be used as an input for the biogas plant. The commune also wants to collect rainfall from the urban area in a small retention reservoir. The energy efficiency will be improved by LED street lightning in a whole municipality, as well as in schools and municipal institutions. Besides, 8 out of 10 city busses will be replaced with electric ones. A rental of electric bicycles ordered from the local manufacturer is also planned. The energy driving these vehicles will be produced in the city. Part of an investment program is a geothermal borehole and under favorable conditions a geothermal heat and power plant. What is more, a biomass heat and power plant and a photovoltaic farm are planned on an area of above 1,5 ha (installation of photovoltaic panels above a parking lot for the entire industrial zone). Each parking lot will have a charging station for electric cars. According to forecasts, by 2022 Wieluń will be energetically self-sufficient and all the energy consumed

by the municipality will be from renewable sources (http://samorzad.pap.pl/depesze/dobre_praktyki/177833/Gmina-z-GOZ--Burmistrz-Wielunia-w-5-lat-wdrozymy-gospodarke-o-obiegu-zamkniety).

The example of the city of Tychy in the Silesian voivodeship is also worth disseminating. Unlike Wieluń, Tychy has a bottom-up, self-government initiative to build an urban circular economy. The Tyski model is based on a synergy of industries such as: waste management, water supply and sewage disposal, transport and energy. The main cooperation partners are Master Waste and Energy, Regional Center for Water and Sewage Management (Regionalne Centrum Gospodarki Wodno-Ściekowej S.A. w Tychach – RCGW), The City of Tychy Transportation Company (Przedsiębiorstwo Komunikacji Miejskiej w Tychach – PKM). The cooperation consists of a systemic connection of the production processes, in which by-products or even ballast of activity for some become valuable resources for the others. Cooperation within the circular economy implemented in Tychy is called SymbioTychy energy area. It is worth noting that environmental education is an important element of the Tychy circular economy model.

The Master company specializes primarily in the collection, transportation and management of municipal waste as well as selective waste collection. It also develops activities in the field of renewable energy, production of alternative RDF fuels, as well as the production of high-quality compost for soil improvements. Master serves 190 thousand inhabitants and manages the waste stream from eight stakeholder municipalities including: Tychy, Imielin, Chełm Śląski, Lędziny, Bieruń, Bojszowy, Wyry and Kobiór. The main indicators of the Master waste management process include: recovered secondary raw materials sent for reuse and recycling 11000 Mg/ year (12%); production of alternative fuel 8000 Mg/ year (9%); production of compost 4000 Mg/ year (5%); reduction of biodegradable waste used for biogas production (about 25%). At the beginning of 2018, the Company launched a compost under the market name KOMPO-MASTER. Processing organic material into fertilizer and compost production means returning valuable organics in the form of humus to the soil. The compost produced by Master improves the physical and chemical properties of the soil. It can be used in agricultural and energy crops. It can also be used to reclaim degraded agricultural land, as well as to set slopes and roadside embankments.

Another partner, RCGW, owns more than 400 km of sewage and sanitary network, 34 pumping stations and operates the Tychy-Urbanowice sewage treatment plant. It is the first passive sewage treatment plant in Poland and the leader in terms of energy balance among water and sewage companies in Europe. The begging of co-fermentation in RCGW date back to 2009. This year the dosing of waste whey and waste from a nearby dairy plant started.

The energy self-sufficiency of the sewage treatment plant in Tychy is 120-150%[2]. The caloric value of biogas obtained is 16,7 – 23 MJ/m3 and the caloric value of pure methane is 35,7 MJ/m^3. In 2015-2016 RCGW was the leader of the OMEGA research and development project under the GEKON initiative entitled "Development of the system solution for energy recovery from sewage sludge with the use of gasification process". The result of the project is the production of so-called biocarbon, which average energy value is 12 MJ/kg of dry sludge. RCGW is also the investor and operator of the Tychy Water Park, which is fully supplied with electricity and heat from a self-sufficient energy system of the sewage treatment plant.

The third leader of the Tychy consortium is PKM, which is the owner of the largest fleet of CNG (Compressed Natural Gas) bus in Poland (75 buses). PKM is one of the leaders in the city transportation industry in the field of environmental transformation. The methane used to drive the bus fleet of the Company is obtained from partners i.e. Master and RCGW. In their plants, the production process gives biogas in the amount of 1,6 mln m^3 (methane content 56,6%) and 6 mln m^3 (62%), respectively. The share of alternative fuels in PKM is 55% (demand – 2,9 mln CNG Nm^3). The target for 2021 is 100% (demand – 4700000 CNG Nm^3). PKM Tychy reduces the negative impact also by reducing noise level (reduction of around 40%) and exhaust emissions generated by the bus fleet. The achieved emission reductions are as follows: CO – 82%, NMHC – 100%, NO_X – 52%, PM – 70%, CO_2 – 20%.

Way to circular transition – conclusions

In terms of circular transition, cities are a problem and a solution at the same time. Adaptation and transformation in production and consumption patterns are part of the international discourse in sustainable development. There is an emerging recognition of the importance of cities within the sustainability debate. Improvements in resource efficiency performance are within reach and can bring major economic benefits.

Sustainable urban development and linked urban circular economy are part of systemic thinking. This implies a complex change, and innovation, in technologies, organization and societies. It emphasizes interdisciplinary dependence of social, economic and environmental components and processes. A circular economy requires changes throughout different value chains, from product design to new production and consumption.

[2] The average value according to IGWP in 2016 was 40,86% for large enterprises and 47,71% for medium enterprises.

Building a circular economy implies a definition of the economics' foundations in its basic assumptions. These range from economic development, environmental policy instruments to combating energy poverty or the promotion of civic education and sustainable consumption. Confronting consumption and life styles with production solutions is increasingly important in terms of the sustainable development of cities. It requires aligning the consumer behavior with cultural context and promotion of urban eco-friendly policy.

Among the key interdependent directions of transformation towards urban circular economy, the following actions should be included:

- Optimizing the use of raw materials in the biological and technical cycle – Solutions include composting, CO_2 sequestration in the ground, fermentation and transformation of waste into compost and other products (search for innovative applications). There are great opportunities to reduce the amount of landfilled waste and reuse – about 30% of the total mass of municipal waste is organic, so called bio. They can be used to improve soil properties and biogas production. It is postulated to increase the use of biogas in a household, transport, agriculture production, e.g. food waste to food (greenhouses).
- Social education – The level of civic awareness, including ecological awareness translates into a real involvement of residents in the process of co-creating of city circular system. It is necessary to strengthen communication and information with particular reference to local conditions and the role of residents. It is important to clarify the direct interrelations between various local processes and the importance of individual users of urban services. Educational activities should be implemented systematically, using many forms and instruments depending on the target group. Social impact tools and positive incentives included in sustainable development strategy bring real changes beneficial to the society, economy and environment. A special role is played by locally oriented social campaigns i.e. involving schools, educational institutions and locally targeted raising awareness of social benefits from a circular economy.
- Impact on social processes – Increase of bio-waste collection from households and gastronomy and simultaneous improvement of monitoring and enforcement of environmental regulations. Increased pressure and control, e.g. a system of photographing and not collecting unsorted waste. Introduction of incentive programs and a deposit system. It is postulated to implement a deposit system that increases the share of material recycling (in Lithuania, the collection rate increased from 7 to 33%).
- Economic impact – Introduction of mechanisms for extended producers responsibility (EPR). The European Union calls for at least 50% of waste

management costs to be transferred to packaging waste producers. Establishing guidance on the possibilities offered by the new public procurement directives in the field of Green Public Procurement (GPP), and a recommendation on monitoring Member States' performance in achieving the indicative 50% GPP target (European Commission, 2008).

Conclusions

Environmental impacts arising from the scale of overpopulation and overconsumption are important reasons for new solutions, especially in urban areas. The pace of economic development, an increase in the level of wealth and consumption and a growing number of people requires rationalization of social and economic processes. The limits are the potential of natural resources and the absorptive capacity of the Earth ecosystems (Ripple et al., 2017).

Poland is looking for its own way of implementing a circular economy. Current urban policy misconstrues the relationships between resource flow and production and the long-term consumption in the cities. While waste management is not all about a circular economy, the amount of waste in urban areas makes the subject very urgent. A circular economy model means a high increase in the reuse of secondary raw materials in urban areas.

In Poland, an insufficient share of selectively collected waste at source was recognized as the basic problem of waste management. As a result, there is little progress in recycling. This situation is a loss both in economic and environmental terms.

The presented examples suggest that cities can make strong efforts to limit the consumption and environmental pressure of the cities. The example of Wieluń shows that it is an early testing phase based on the adaptation of mechanisms from other countries. New infrastructure and technological solutions are undoubtedly necessary for the success of the entire system. However, in Poland particular emphasis should be placed on educational activities and instruments of social impact. Residents become agents of change, and the role of authorities, institutions and business is to provide mechanisms of transition from linear to a circular economy. Their understanding of the idea of the system and motivation supported by economic incentives is crucial for the process of building the urban circular economy in Poland.

Literature

CCFLA (2015), *State of city climate finance. Report 2015*, Cities Climate Finance Leadership Alliance, New York

Circle Economy (2019), *The circularity gap report. An analysis of the circular state of the global economy*, https://www.circularity-gap.world/ [30-11-2019]

Club of Rome, https://www.clubofrome.org/ [10-06-2019]

Daly H. (1977), *Steady-State Economics*, Island Press, Washington, DC

European Commission (2008), *Public procurement for a better environment*, Communication From The Commission COM(2008) 400, https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0400:FIN:EN:PDF [12-06-2019]

European Commission (2010), *Europe 2020 A Strategy for smart, sustainable and inclusive growth*, Communication From The Commission COM (2010) 2020, https://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf [12-06-2019]

European Commission (2014), *Towards a circular economy: A zero waste programme for Europe*, Communication From The Commission COM/2014/0398, https://ec.europa.eu/environment/circular-economy/pdf/circular-economy-communication.pdf [12-06-2019]

European Commission (2016), *Ecodesign Working Plan 2016-2019*, Communication from the Commission, https://ec.europa.eu/energy/sites/ener/files/documents/com_2016_773.en_.pdf [30-11-2019]

European Commission (2019), *Report from the Commission to the European Parliament, the Council, The European Economic and Social Committee and the Committee of the Regions on the implementation of the Circular Economy Action Plan*, Brussels, COM(2019) 190 4.3.2019, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019DC0190&from=EN [30-11-2019]

Ellen MacArthur Foundation (2012), *Towards the Circular Economy: Economic and business rationale for an accelerated transition*

Greenovate (2012), *Guide to resource efficiency in manufacturing: experiences from improving resource efficiency in manufacturing companies*, INNOVA, European Commission Enterprise and Industry, https://www.greenovate-europe.eu/sites/default/files/publications/REMake_Greenovate%21Europe%20-%20Guide%20to%20resource%20efficient%20manufacturing%20%282012%29.pdf [20-07-2019]

Jackson P. (2009), *Prosperity without growth: economics for a finite planet*, Earthscan, London

Meyer B. et al. (2011), *Macroeconomic modelling of sustainable development and the links between the economy and the environment*, Study for the European Commission (DG Environment), http://ec.europa.eu/environment/enveco/studies_modelling/pdf/report_macroeconomic.pdf [12-06-2019]

Ostrom E. (1990), *Governing the Commons: The evolution of institutions of collective action*, Cambridge University Press

Ripple W.J. et al. (2017), *World Scientists' Warning to Humanity: A Second Notice*, "BioScience" No. 67(12), https://doi.org/10.1093/biosci/bix125

Williams J. (2019), *Circular Cities: Challenges to Implementing Looping Actions,* "Sustainability" No. 11(2):423, https://doi.org/10.3390/su11020423

https://www.un.org/sustainabledevelopment/sustainable-development-goals/ [20-06-2019]

https://www.un.org/development/desa/en/news/sustainable/good-practice-circular-economy.html [20-06-2019]

http://www.snaga.si/en [22-07-2019]

https://www.recyclebank.com/ [22-07-2019]

http://samorzad.pap.pl/depesze/dobre_praktyki/177833/Gmina-z-GOZ--Burmistrz-Wielunia-w-5-lat-wdrozymy-gospodarke-o-obiegu-zamknietym [23-07-2019]

DISCUSSION AND REVIEWS

RECENZJE OMÓWIENIA, PRZEGLĄDY

Eugeniusz KOŚMICKI

The review of the book WEIHENSTEPHAN TRIAL GARDEN IN BAVARIA

Bernd Hertle mit Fotografien von Christa Brand, Sichtungsgarten Weihenstephan, Trial Garden Weihenstephan, 96 pages, 70 colour photographs, Stuttgart (Hohenheim) 2015, Verlag Eugen Ulmer, ISSN 978-3-8001-8298-5, www.ulmer.de

In *Weihenstephan* there was originally a monastery with a garden, which is now part of the town of Freising (near Munich). The gardens of Weihenstephan are now an integral part of the Weihenstephan-Triesdorf University of Applied Sciences. They are located on the hillside of Mount Weihenstephan and refer to at least several hundred years of horticultural tradition in Bavaria. The Weihenstephan Trial Garden itself was created in 1947, although the Oberdieckgarten in the vicinity of the Weihenstephan Trial Garden was created as early as the 1920s. It was founded by Professor Richard Hansen. The very idea of a "trial garden" comes from the most famous German gardener and gardening philosopher Karl Foerster. Richard Hansen himself worked for Karl Foerster in Bornim-Potsdam as a gardener (1935-1936). The garden now has more than 5 hectares and was managed until 1978 by R. Hansen, then by prof. Peter Kiermeiers (1978-2006) and since 2006 by prof. Bernd Hertle. Planting in the garden is based on ecological and aesthetic assumptions. They give a good insight into the use of woody plants, perennials and bulbs, as well as one- and two-year-old plants.

 https://doi.org/10.34659/2019/4/57

The Weihenstephan Trial Garden is located at an altitude of 470 m above sea level, with an average temperature of 8.1°C and average rainfall of up to 792 mm. The coldest average winter temperatures are -20°C to -23°C. Therefore, it is not possible to cultivate plants not resistant to frost in the show garden (the zone of frost resistance for the garden is 4a).

In Germany and Europe, there is a great deal of interest in Trial Garden Weihenstephan. This is why the director of the show garden, prof. Bernd Hertle, developed the text of "Weihenstephan trial garden". The text of this study is available in German and English. Christa Brand took 70 colourful and excellent photographs. A book by B. Hertle and Ch. Brand received the German Horticultural Book Award in 2015 in the category "Best illustrated volume" (third place). The following components can be distinguished in the book: "Introduction" (pp. 4-11); "Wonderful flower beds" (pp. 12-43); "Planting of plants located in the southern areas" (pp. 44-59); "Rock Garden". (p.60-61); "Happy connection – perennials and woodlots" (pp. 62-83); "Moist bed and water". (pp. 84-87); "Plant Shows and Plant Collections" (pp. 88-96).

The "Introduction" presents the history and development of Trial Garden Weihenstephan, the premises of the plant stand and the division of the garden into individual parts: "Flower beds at water reservoirs"; "Pastel flower bed"; "Purple flower bed"; "Siberian iris bed"; "Woodlots and edges of trees"; "Purple-yellow-purple plantings"; "Water garden"; "Geranium hillside"; "Kniphofia hillside"; "Red flower bed"; "Open edges of trees"; "Peony bed"; "Iris germanica flower bed"; "Miscanthus and summer flora"; "Cinquefoil hillside"; "Heath"; "The flower bed of the German Union of Perennial Gardeners"; "Yellow plots"; "Daylily bed"; "Astilbe planting"; "Oak plots"; "Bright flower bed"; "Spring road and hosta"; "Hazel plots"; "Wild fruit trees arboretum".

The Trial Garden is a good opportunity for growing flowerbed perennials. They are located around the main roads in the garden. These are both "pure" bedding plantings of certain perennials and "Mixed Borders", where European smoke tree (*Cotinus coggygria*) European smoke tree, 'Royal Purple', hibiscuses, and roses in many varieties can be found alongside perennials and annual plants. The planting of 'Miscanthus and summer flora' is very characteristic. Their basis here is Chinese Miscanthus in various varieties (*Miscanthus sinensis*), which form the framework for many annual plants, including Patagonian vervain (*Verbena bonariensis*), Mexican aster (*Cosmos bipinnatus*), cleome (*Cleoma spinosa*), snapdragon and zinnia. The latter bloom mainly in summer, like giant hyssop (*Agastache* 'Blue Fortune') or blue globe-thistle (*Echinops bannaticus* 'Taplow Blue'). "The 'red flower bed' includes the Indian shot (*Canna indica* 'Schwabenstolz') and the large-leaved castor bean (*Ricinus communis* 'Carmenata Rot'). "The 'scaffolding' of such beds forms a shrub (*Physocorpus opulifolius* 'Diabola' and varieties of Chinese Miscanthus). It is filled with zinnias, dahlias and annual grasses (*Pennisetum villosum*). The 'Purple bed' is very colourful. Here we distinguish European smoketree with purple leaves (*Cotinus coggyria* 'Royal Purple'), beautiful roses, of 'Veilchenblau' and 'Mozart' varieties) as well as perennials: penstemons, geraniums (*Geranium x magnificum*) and alumblooms (*Heuchera* 'Molly Bush').

There are also pastel flower beds in the Trial Garden. It consists of hops (*Humulus lupulus* 'Aureus'), mallows (*Alcea rugosa*), daylilies (*Hemerocallis* 'Atlas'), asphodels, called ' ox-eye daisy ' (e.g. *Leucanthemum* 'Gruppenstolz'). In spring, however, lilac tulips ('Westpoint', 'White Triumphator') and spurges (*'Euphorbia polychroma'*) bloom.

The "Flower Bed of the German Union of Perennial Gardeners" deserves attention in the trial Garden. It was founded in Weihenstephan on the occasion of the 60th anniversary of the Union. In the spring there bloom spurges, late-blooming tulips, as well as a decorative apple tree (*Malus toringo var. sargentii*). In autumn, asters (*A. novae-angliae* 'Violetta'), goldenrod (*Solidago rugosa* 'Fireworks') and beautiful species of grasses bloom. The 'Yellow Plot' area, on the other hand, is used for growing bedding perennials, which mainly originate in North America. In summer, warm yellow colours of sneezeweeds, goldenrod and rudbeckias dominate. "Bright Flower Bed' has mainly plants with white flowers: goats' beard (*Aruncus* 'Horatio'), white flowering sage (*Salvia nemorosa* 'Adrian'), maiden silver grass (*Miscanthus sinensis* 'Variegatus') and a long-lived tulip from the Viridiflora 'Spring Green' group. Dwarf asters and numerous grasses (mainly maiden silver grass and *Panicum virgatum* millet) bloom in autumn.

The next part of the book deals with plantings located on the southern parts of the discussed garden. These plantings include mainly botanical perennials (so-called wild perennials). The following parts of the show garden are discussed here: The "heath"; "The Red-Hot Pokers' hillside"; "The hillside of cinquefoils". The heath is overgrown with numerous grasses (*Pennisetum orientale; Nasella tenuissima*), high sedums (e.g. *Sedum* 'Matrona'), decorative high garlic, peonies (*Paeonia x smouthii*) and naturally many species and varieties of red-hot pokers. The exotic appearance has "The hillside of cinquefoils", where, in addition to cinquefoils, mulleins, eryngiums, yuccas, many other interesting kinds of grass are grown. The richness of colours is characterized by the flowerbeds of peony, iris germanica and daylily. The terraced rock garden was established as early as the 1950s. In the rock garden, most of the plants bloom in spring and early summer. It is worth mentioning here aubrietas, alyssums, candytufts, cloves, and gentians (*Aubrieta, Aurinia saxatilis, Dianthus gratianopolitanus, Iberis, Aethionema, Gentiana*). In addition, many bulbous or dwarf woody plants are cultivated.

The happy relationships between perennials and woody plants were then presented, as it was called. This concerns the development of vegetation in hazel and oak plots, as well as astilbe, spring pasqueflower and hosta planting. Many bulbous plants grow in these areas and form whole flower carpets in the spring period, e.g. Grecian windflower, striped squill, other squills, Dalmatian crocus (*Crocus tommasinianus*), daffodils, fritillaries, and alpine violets. The astilbe bedding is characterised by a wealth of astilbe colours, as wolfsbanes. In the hazelnut plots, there is a beautiful development of rodgersia and barrenwort, as well as ferns. Trees and shrubs are also very important in the trial garden. In the case of many of them, colourful leaves appear in autumn (so-called late October mood).

The next part of the "Weihenstephan Trial Garden" is devoted to damp beds and water. You can indicate here: The "Siberian iris bed"; "around water reservoirs" and vegetation in the water reservoirs themselves. The Siberian blanket disc mainly contains

species from humid meadows. The Siberian iris occurs with the globeflower (*Trollius chinensis* 'Golden Queen') and the white variety of the Greek valerian (*Polemonium caeruleum* 'Album'). The most characteristic varieties of the Siberian iris are Caesar's Brother' and 'Weisser Orient'. Many plants grow on the banks of numerous garden water reservoirs, as well as in the water reservoirs themselves (rushes, sedges, numerous combs, spatterdock *Nuphar advena*, fringed water lily *Nyphoides peltata*, water pineapple *Stratiotes aloides*). According to scientific research, the planting of plants in the trial garden is often changed in order to carry out appropriate botanical and horticultural experiments.

The book by Bernd Hertle "Weihenstephan Trial Garden" by Bernd Hertle and Christy Brand shows how well the trial garden works in Germany. The individual parts of the garden are well analysed. It would be worth disseminating this well-written and richly illustrated book in Poland as a valuable help for specialists (especially in botanical gardens), as well as a very important book for all interested readers.

Eugeniusz Kośmicki, Prof.

Information for Authors – Submission Guidelines

Authors are invited to submit Academic Papers on theoretical and empirical aspects of Sustainable Development and Environmental Management as well as on Environmental Economics and Natural Resources. Papers submitted for review should be in the form of Articles, Research Reports, Discussions or Reviews of Books, information on Academic Conferences, Symposia or Seminars.

Submissions should have up to 25.000 characters excluding abstract, footnotes, and reference list, with a clearly defined structure (Introduction, Chapters, Sub-chapters, Ending/Conclusions). Please strictly observe the number of characters. Each additional 1.000 characters of the text is charged (25 PLN or 6 EUR net).

Articles should be sent by e-mail to: czasopismo@fe.org.pl, in compliance with the official form published on the website of the journal (www.ekonomiaisrodowisko.pl). A model form can be found in TEMPLATE. The references cited have to be in alphabetical order, unnumbered. Plans, drawings and schemas (black & white only) should be prepared using Microsoft Word with all elements grouped in a single element group. Graphic elements (e.g. JPG) and schemas (e.g. in Excel) should be submitted additionally as separate files.

Papers will be submitted to Peer Review and only original (previously unpublished) papers will be accepted. Papers not complying with Editorial Recommendations will be returned to the Author for correction.

The article, after taking into account the comments of our reviewers, is treated as final text. Possible corrections resulting from the editorial composition can only be made on pdf files sent for our approval. Any corrections should concern only the errors resulting from the work on the text during the composition (e.g. changes in subscript/upload indices, drawing errors and other technical errors).

Please proofread your texts before sending them to us, as only the papers without any grammatical and spelling errors will be accepted. The Author have to sign the STATEMENT, that the article has been checked by the native speaker or professional translator. Please use correct scientific English. The Editorial Office may publish abridged versions of papers or change titles.

Authors of a submitted manuscript must sign a CONTRACT, confirm that the paper has not been published previously and transfer the propriety copyrights concerning the work to the Publisher.

Author's Fees: PLN 1200 plus VAT (PLN 1476) or 350 EUR.

The fee is charged after accepting the paper for publication.

Editorial Office Contact Details:

FUNDACJA EKONOMISTÓW ŚRODOWISKA I ZASOBÓW NATURALNYCH

Journal "Ekonomia i Środowisko"

Correspondence address:
FUNDACJA EKONOMISTOW SRODOWISKA I ZASOBOW NATURALNYCH
Sienkiewicza 22, 15-436 Białystok, POLAND
e-mail: czasopismo@fe.org.pl

Dr Hanna **Adamska**, Poland
Dr Bahman Jabbarian **Amiri**, Iran
Prof. Felix **Arion**, Romania
Prof. Piotr **Banaszuk**, Poland
Prof. Arnold **Bernaciak**, Poland
Prof. Eng. Elżbieta **Broniewicz**, Poland
Prof. Eng. Mirosław **Broniewicz**, Poland
Prof. Małgorzata **Burchard-Dziubińska**, Poland
Dr Eng. Robert **Czubaszek**, Poland
Dr Eng. Jacek **Dawidowicz**, Poland
Prof. Eng. Wojciech **Dąbrowski**, Poland
Dr Dominik **Drzazga**, Poland
Prof. Marcin **Feltynowski**, Poland
Prof. Iwona **Foryś**, Poland
Prof. Tomáš **Gajdošík**, Slovakia
Dr Elżbieta **Gołąbeska**, Poland
Prof. Kazimierz **Górka**, Poland
Prof. Karsten **Grunewald**, Germany
Prof. Andrzej **Hopfer**, Poland
Prof. Ryszard **Janikowski**, Poland
Prof. Józef **Jasiczak**, Poland
Dr Ewa **Jastrzębska**, Poland
Prof. Sławomir **Kalinowski**, Poland
Prof. Eng. Dorota **Krawczyk**, Poland
Prof. Yoram **Krozer**, Netherlands
Prof. Barbara **Kryk**, Poland
Prof. Joanna **Kulczycka**, Poland
Dr Paulina **Legutko-Kobus**, Poland
Prof. Jurij **Lopatynskij**, Ukraine
Prof. Piotr **Małecki**, Poland
Prof. Bulent **Mertoglu**, Turkey
Prof. Ionel-Mugurel **Jitea**, Romania
Prof. Rafał **Miłaszewski**, Poland
Prof. Maciej J. **Nowak**, Poland
Prof. Aleksandra **Nowakowska**, Poland
Dr Eng. Karolina **Ogrodnik**, Poland
Dr Monika **Paradowska**, Poland
Prof. Barbara **Pawłowska**, Poland
Prof. Dariusz **Pieńkowski**, Poland
Prof. Łukasz **Popławski**, Poland
Dr Bogumiła **Powichrowska**, Poland
Prof. Ryszard **Piasecki**, Poland
Prof. Wojciech **Piontek**, Poland
Prof. Eng. Bazyli **Poskrobko**
Prof. Zbigniew **Przygodzki**, Poland
Prof. Joanna **Rodziewicz**, Poland
Dr Agnieszka **Rzeńca**, Poland
Prof. Eng. Mirosław **Skorbiłowicz**, Poland
Prof. Antonis **Skouloudis**, Greece
Prof. Olga **Sobko**, Ukraine
Prof. Mariusz **Sokołowicz**, Poland
Prof. Maciej **Stolarski**, Poland
Prof. Eng. Izabela **Tałałaj**, Poland
Prof. Tetiana **Vitenko**, Ukraine
Prof. Anetta **Zielińska**, Poland