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GREENWASHING AS A FORM OF MODERN ECO-MARKETING

Irina Astakhova
Simon Kuznets Kharkiv National University of Economics
9a Nauki Avenue, 61166, Kharkiv, Ukraine, Iryna.Astakhova@m.hneu.edu.ua
https://orcid.org/0000-0003-2165-4719

Tetiana Reznikova
Simon Kuznets Kharkiv National University of Economics
9a Nauki Avenue, 61166, Kharkiv, Ukraine, Tetiana.Reznikova@m.hneu.edu.ua
https://orcid.org/0000-0002-7978-5976

Ekaterina Astakhova
Federal State Budgetary Educational Institution of Higher Education
"Vladivostok State University of Economics and Service"
41 Gogol St., 690014, Vladivostok, Russia, Ekaterina.Astahova@vvsu.ru
https://orcid.org/0000-0003-2198-5569

Abstract
The article analyzes development trends of ecological production traded internationally. It focuses on such forms of eco-marketing as greenwashing and highlights a set of tools that negatively affect the consumer perception of eco-products. It proposes a systematic approach to counter the greenwashing effect at different levels, forming the background for monitoring it and implementing effective countermeasures. Such a scientific approach affects the real environmental commitment of companies, strengthens the social responsibility of business and enhances economic efficiency.

Keywords
target consumers; ecological marketing; greenwashing types and tools; systematic approach; greenwashing countermeasures.

Introduction
The scale of phenomena in the world such as global warming, floods, fires, soil and ocean pollution, melting glaciers, ozone holes, a biodiversity decrease etc., has turned the local environmental problems into a global environmental crisis. This has created a demand for environmentally friendly goods in the society (eco-friendly goods).

A growing environmental movement and a change in a company development vector, on the one hand, leads to an increase in the cost of eco-friendly goods, but on the other hand, makes them cheaper through the use of such ecological marketing forms as greenwashing.

Greenwashing (from English green and whitewash - whitening, or green camouflage) is a form of ecological marketing related to the environmental positioning of enterprises, when they spend significant resources on convincing customers of their eco-friendliness, rather than concentrating on real environmental initiatives.
Greenwashing in transnational companies is becoming a destructive force affecting various industries and social groups. Therefore, its impact on company's outcomes is attracting the attention of scientists, researchers and journalists.
Greenwashing as a form of eco-marketing was studied by such famous scientists as: J. Westerveld, B. Clegg, K.Bruno, R. Wolniak, E. L. Lane, K. Peattie and others. However, each of them is more concerned with its practical aspects. Therefore, the problem of using greenwashing in international companies is still unresolved due to the underdeveloped mechanisms of its prevention.

Currently, the environmental friendliness of goods is becoming an increasingly important factor of improving their competitiveness in national and international markets. And greenwashing leads to the certain negative long-term consequences: it erodes the image of companies and decreases their competitiveness in world

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markets, undermines consumer confidence in eco-friendliness of any goods and ecological brands in general. Together, this shows the relevance of the research study.

Methods

The purpose of the study is to determine and systematize the greenwashing features used internationally, analyze its negative consequences on consumers and the country's economy and formulate directions for counteracting it. In this research, the following methods were used:

- theoretical generalization for determining types and tools of greenwashing,
- statistical processing of information to identify target consumers of eco-goods,
- comparative analysis for comparing the greenwashing countermeasures in developed and developing countries,
- a systematic approach to form a set of measures to counter the negative impact of greenwashing in three directions,
- structural - logical approach to build the logic of the research structure, presented in Fig. 1.

<table>
<tr><td colspan="6">Marketing</td></tr>
<tr><td colspan="6">Ecological marketing</td></tr>
<tr><td colspan="3">Strategies of ecological marketing</td><td colspan="3">Segments of consumers of eco-goods</td></tr>
<tr><td colspan="6">Greenwashing as a tool of ecological marketing</td></tr>
<tr><td colspan="3">Greenwashing types</td><td colspan="3">Greenwashing tools</td></tr>
<tr><td colspan="6">A set of measures to counteract greenwashing</td></tr>
<tr><td colspan="2">Legislative directions to counter greenwashing</td><td colspan="2">Professional directions to counter greenwashing</td><td colspan="2">Public directions to counter greenwashing</td></tr>
</table>

Fig. 1. A structural - logical framework of the greenwashing research. *Source: Source: Own research*

Therefore, the further research is carried out according to the proposed structural - logical scheme, starting from determining the increasing role of ecological marketing in the modern society to consumer targeting, detecting ecological marketing strategies, greenwashing types and tools, then to the developing of ways to counter it.

Results and discussion

In today's world, the production and promotion of eco-goods is a steady development trend both on international and national markets, therefore the importance of ecological marketing is constantly growing globally. Production and marketing urge to meet the ecological needs of consumers more often, thus stimulating the demand for ecological goods and services.

According to the American Marketing Association, ecological or green marketing is the marketing of products that are presumed to be environmentally safe [1]. In other words, it represents the efforts of organizations to produce, promote, package and recycle products in a way that complies with eco-standards. A variety of concepts leads to the understanding that ecological marketing is a holistic and responsible approach that includes identifying, forecasting and finding opportunities to meet the needs of stakeholders without a negative impact on the society and the environment.

Eco-marketing tools facilitated the growth of a new target segment of consumers - people who consume ecological products. In the post-Soviet countries, this market is still in its initial phase. It is characterized by a consumer choice of products that do not threaten health or do not harm the environment during their production, use and disposal.

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There are various consumer groups in international markets and companies use different ecological marketing strategies in order to achieve higher company performance. For example, the Natural Marketing Institute identified five groups of American consumers. They formed relevant ecological marketing strategies for each target consumer [2] to gain a competitive advantage of companies in the markets. The results of such approaches are summarized in Table 1.

Table 1. Consumer Research Results and Ecological Marketing Strategies. *Source: [2-3]*

Consumer characteristics	
Consumer segment name	**Characteristics of consumers in this segment**
LOHAS	Prefer a lifestyle of health and sustainability (LOHAS).
Naturalists	Focused primarily on a healthy lifestyle.
Drifters	Exposed to social trends, such as personal values.
Conventional	Most of them are motivated to save money, rational in choosing a product, practical, buying eco-friendly goods is not a priority for them.
Unconcerned	Indifferent to environmental protection.
Ecological Marketing Strategies for enterprises	
Lean Green	Responsibility to society, the main goal is not to promote own ecological initiative or the environmental properties of products but to reduce costs and increase efficiency due to ecological management.
Shaded Green	Investing in environmentally friendly long-term processes that require significant financial and non-financial resources, improving own products and technologies to guarantee them a competitive advantage.
Extreme Green	Integration of ecological issues into business processes and products, including using of specialized outlets and distribution.

The analysis of the research results indicates that the largest share, namely 26%, is covered by consumers - drifters, LOHAS - consumers make up 23%, naturalists - 20%, unconcerned -17%, conventional - take the smallest share in the structure of consumers - 14%. Therefore, the main attention in the eco-marketing tools is paid to the first three consumer segments.

Nevertheless, some enterprises, attempting to increase sales, attract new customers and enter new markets, only create the illusion of environmental performance. They misuse marketing tools, especially advertising and PR, in order to promote their products as "green", "bio" or "organic" although often they do not meet such characteristics. This is the marketing approach that greenwashing uses. As a certain form of eco-marketing it is used to build the corporate image by misleading consumers about the environmental friendliness of their products. Moreover, greenwashing is the most common for mass consumers who emotionally perceive eco-friendly goods. At the same time, those producers for institutional consumers who use innovative ecological technologies have a greater impact on the public, rather than on consumers. They build their image and enhance their reputation of a strong driver of ecological innovation.

This leads to the lack of consumers' confidence, which is the negative consequence of the greenwashing.

According to the Oxford English Dictionary, greenwashing represents "activities by a company or an organization that are intended to make people think that it is concerned about the environment, even if its real business actually harms the environment" [4].

In addition to advertising and PR, greenwashing uses such marketing communication tools as publishing ecological reports, creating educational environmental programs, organizing and sponsoring relevant events.

Despite the social and ethical focus of these events, greenwashing is a way to mislead consumers and the public, which gives companies positive feedback at the start.

Greenwashing is a relatively new phenomenon for most post-Soviet countries (Belarus, Ukraine, Kazakhstan, Russia and others). The use of such a pseudo ecological form of marketing internationally requires effective mechanisms for monitoring production and promotion of products on national markets as well as imported goods from various countries.

Three types of greenwashing were identified according to the study by the global nonprofit organization BSR [5]. The research of the Canadian company Terra Choice allowed us to determine and systematize the main sins of greenwashing as false and deceptive statements about the environment [6]. As a result, the main characteristics of greenwashing types and tools are represented in Table 2.

Table 2. Main characteristics of greenwashing types and tools. *Source: [5-6]*

Main greenwashing types and their characteristics	
Greenwashing types	**Characteristics of greenwashing types**
Misguided greenwashing	Companies make significant efforts to become environmentally friendly, but they are unable to communicate these efforts effectively, although they often use statements such as "environmentally friendly" in their communications.
Unsubstantiated greenwashing	Companies do commendable work and their production information is based on sound data, but a more detailed study reveals that they act not for the environment, but for their own benefit, spending more resources into communications than actual ecological initiatives.
Greenwashing noise	The companies claim that they are “green” with no sound evidence, and the actual corporate reports do not convince even their clients.
False and deceitful statements, so-called “7 sins of greenwashing”	
Sins of greenwashing	**Characteristics of the greenwashing tool**
Sin of the hidden trade-off	Environmental issues are highlighted at the expense of another possibly more significant issue. For example, the purchase of paper products when refusing plastic is not always ecological, as forests are cut down for these products.
Sin of no proof	Environmental claims or promotional products are not supported by factual evidence or a reliable third party certification.
Sin of vagueness	Environmental claims are so vague and broad that they become meaningless and are usually misunderstood by consumers.
Sin of worshiping false labels	Fake certificates or labels are created to mislead consumers about the environmental testing of production, packaging and etc.
Sin of irrelevance	The absence of certain substances that are already prohibited by law is emphasized or advertised. That is, the information is truthful but unimportant and irrelevant.
Sin of lesser of two evils	Green products that are harmful by their nature are advertised (for example, organic cigarettes).
Sin of fibbing	Environmental claims are not true, knowingly false in the form of statements.

The number of greenwashing cases is constantly growing internationally and already has serious negative consequences: consumer attention to eco-goods is reducing; confidence in the green market is undermined.
It also negatively affects the investor interest in ecological industries, thus decreasing the level of capital investments in this market.

Research of the existing approaches to the production and promotion of eco-goods in various countries [7 - 13] allowed us to determine greenwashing countermeasures in developed, developing and post-Soviet countries in three directions: at the legislative, professional and public level, Table 3.

As follows from the study, many greenwashing countermeasures in the post-Soviet and developing countries are not deeply worked out being at their initial stage, in contrast to the developed countries. This is because of the later interest and willingness of the society to control the production and consumption of eco-products. Most of these countermeasures are at the formative stage. At the same time, legislative and professional directions to counter greenwashing are at a high level. And public institutions here become an increasingly significant protective force against greenwashing. Numerous consumer and journalist associations are developing to reveal greenwashing cases and affecting deceivers.

Developed countries have their own standards for organic products. Many of their companies take active efforts to support a high level of environmental responsibility. They implement ecological management programs, energy-saving projects that reduce the negative impact on the environment, reduce water consumption and waste generation, and increase energy efficiency.

Table 3. Directions of greenwashing countermeasures in developed and developing countries. *Source: Source: Own research*

Efforts to counter greenwashing	
Developed countries	Post-Soviet and developing countries
Legislative directions to counter greenwashing	
Approved legislation governing the requirements for environmental production, turnover and labeling of eco-goods.	The minimum level of legislation on environmental production, turnover and labeling of organic products, which is in the implementation phase.
Institutional structures protecting against greenwashing. Regulated by the Federal Trade Commission (FTC) in the USA.	Lack of specific institutional structures protecting from greenwashing.
Effective mechanisms of implementing the legislation on eco-products.	Mechanisms for the implementation of legislation are under development.
Well-functioning legal system.	Corrupt legal system where environmental issues are not priority yet.
Professional directions to counter greenwashing	
Ecological certification is carried out through: - International Federation of Organic Agricultural Movements (IFOAM); - Codex Alimentarius (lat. Food Code) ISO 14024.	Ecological certification is carried out only by some of the largest manufacturers – exporters.
Active participation in international environmental organizations such as the Global Ecolabelling Network (GEN), the global Go green movement and others.	Cooperation is not systemic. Only major manufacturers of eco-products participate.
Availability of a wide network of certified centers in each EU country.	Availability of foreign certification centers. Thus, there are 15 certification centers in Ukraine: 5 - Germany, 3 - Italy, 2 - Austria, one each from Switzerland, Turkey, the Netherlands, France and Ukraine.
A number of ecological auditing companies in different countries.	Limited number of ecological auditing companies in different countries.
Investment programs into ecological production at the level of EU, countries, regions.	Only major manufacturers of eco-products participate in investment programs.

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Public directions to counter greenwashing	
Classification of companies by the level of eco-friendliness of products, using/not using greenwashing and transparency of this information.	Lack of a systematic approach to the classification of companies producing eco-goods.
Creation of active public associations of consumers against greenwashing with the use of radio, television and Internet.	Individual cases of public consumers' associations against greenwashing with the use of radio, television and Internet.
"Black lists" of companies using greenwashing are consistently forming.	There are no "black lists" of companies using greenwashing.
Educational programs in schools, universities, specialized courses.	Occasional training programs in schools, universities, specialized courses.

The modern measure to counter greenwashing is a labeling system developed by both governments and voluntary associations. Some of eco labels are used all over the world, while others are used in certain countries. They are implemented in a mobile application - Eco Label Guide - developed by the Global Ecolabelling Network. It scans goods and checks them for compliance with different environmental standards. This approach received international status in 2018 [14] and was approved by the United Nations Environment Program (UNEP).

The number and volume of investment programs into ecological production on the international market are growing. However, some manufacturers still use greenwashing in their environmental programs. For example, Philip Morris International Ukraine implements an environmental project to purify water and air, at the same time releasing products that are environmentally harmful and hazardous to the health of individual consumers. Oji Paper Company, Japan, claimed for decades to use 40% recycled content in its products while they used 0% [15]. The car giant Volkswagen claimed the use of technology that emitted less pollutants while later it admitted to cheating emissions tests by fitting vehicles with a "defeat" device that altered the performance to reduce the emissions level. In truth, these engines were emitting up to 40x the allowed limit of nitrogen oxide pollutants [16].

Public directions to counter greenwashing are at an early stage of development in the post-Soviet and developing countries because of the lack of specialists with expertise in greenwashing issues. Therefore, the real situation of the control systems over ecological production and promotion, especially in the mass production in these countries, is still rather weak and requires strengthened efforts in this direction.

The number of publications devoted to the greenwashing problem is increasing worldwide. However, they is a lack of adequate scientific justification in terms of determining its countermeasures.

In this case, the attitude towards greenwashing as a new form of eco-marketing is debatable. Some authors [3, 17], consider it as a new set of methods and strategies of the traditional marketing mix. Others, like K. Bruno, B. Clegg, R. Horiouchi, etc. [5, 18, 19], address greenwashing in terms of two components: ecological commitments, when companies manage the environment through the ecological approach; and environmental outlook, when they assess the joint effect of companies on the environment.

In our opinion, the contradictory nature of greenwashing lies in the fact that in declaring a focus on the environmental outlook and achieving instant economic benefits with the use of marketing tools in the current period, companies ignore long-term environmental commitments. Moreover, this leads to transition from social - ethical marketing to greenwashing as a form of pseudo-ecological marketing.

Most scientists studying the problems of green marketing deal with the classic tools of the marketing mix, using them for eco-marketing [9, 11, 20]. In contrast, we highlighted two groups of consumers during marketing research: institutional and non-institutional, greenwashing risks were identified for each of them.

At present, the ways of reducing greenwashing risks should be explored. There is a need for their evaluation depending on the volume of production and their duration. On this basis, the authors formulated directions to neutralize the negative impact of greenwashing risks on the environment and humans. Thereby, the presented research results can be considered as one of the attempts of a systematic approach for improving the environmental sustainability of consumers.

Impact

The research results develop scientific knowledge, theoretical rethinking of the greenwashing value, proposing a systematic approach to assess the ecological safety of countries and form the appropriate greenwashing countermeasures.

Greenwashing causes the uncertainty that creates both economic, environmental and other risks, as well as the ability to influence the Global Environment Outlook and environmental commitments of companies.

Greenwashing risks of the production, promotion and sale of mass products for institutional consumers are significant but short-term and easier to identify. Companies increase profits to a certain point without spending resources on improving the level of eco-friendliness of the product, while consumers harm their health as well as the environment. Greenwashing countermeasures can reduce such risks through publishing exposing articles, holding PR campaigns, forming the “black list” of deceptive manufacturers, public censure, re-certification, judicial mechanisms, financial penalties, etc. As a result, companies accept lower profits or losses and get a “vaccination” against greenwashing and consumers receive compensation for damage to their health.

Greenwashing risks of the technical and technological re-equipment of companies in order to meet the environmental needs entail a mismatch with the declared level of eco-friendliness for institutional consumers. They are more significant, long-term and difficult to identify. These risks require constant attention in order to manage them at each stage.

For developed, post-Soviet and developing countries, perspective directions to counter greenwashing are:

- conclusion of international agreements between countries, industry enterprises, universities in order to prevent greenwashing effects,
- exchange of experience and technologies into the environment, revealing cases of greenwashing on a regular basis,
- exchange of specialists, scholars, graduates and students actively involved in greenwashing issues,
- introduction of "green" curricula in education, entrepreneurship and business to form their commitment to environmental friendliness and rejection of greenwashing.

Greenwashing counteraction increases the level of environmental responsibility of companies, which affects the environmental perspective of society as a whole.

Conclusions

The modern need of society for ecological goods is constantly growing. Popularization of eco-marketing as an integral part of doing business has allowed unfair manufacturers to use such a pseudo-marketing tool as greenwashing. Its usage undermines the trust of both consumers and investors in responsible ecological production.

Greenwashing risks should be addressed urgently by creating a system to counter its use in developed, developing and post-Soviet countries. This includes a set of measures in three directions: at the legislative, professional and public level. Such a systematic approach will help regulate and control environmental standards in the countries, as a result, consumers will be able to get the desired ecological product and companies would improve their competitiveness and effectiveness in the international markets.

The global economy trends include the continuous growth of:

- technical and technological innovations in the means of production for those institutional consumers who form their image as an environmentalist,
- the need for high-quality eco-goods for individual consumers.

In the future, the temptation to use greenwashing in order to resolve the contradiction between the effectiveness and environmental commitment of companies will increase. Hence, without a well-built

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comprehensive system uniting professionals, countries and the society, it will difficult to place a barrier on greenwashing. This is becoming an important part of saving the environment, especially in post-Soviet and developing countries since their share of eco-friendly industries is not yet sufficient. Therefore, they can use the proposed approach to the monitor situation in order to achieve better results in the protection of the environment, human life and health.

Conflict of interests
There are no conflicts to declare.

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SETTING UP THE STAGE FOR SMART SUSTAINABLE CITY: INTERNATIONAL AND UKRAINIAN CONTEXT. THE ROLE OF SMART SOLUTIONS

Anna Pozdniakova
Research Centre of Industrial Problems of Development of NAS of Ukraine
1a, Inzhenernyy prov., 61166 Kharkiv, Ukraine, anna.pozdnyakova@p2h.com
https://orcid.org/0000-0002-2589-7585

Iryna Velska
The Eastern Partnership Civil Society Facility
23-2505, Grygorenko Ave., 02068, Kiev, Ukraine, iryna.velska@eapcivilsociety.eu

Abstract
The paper analyzes the key steps taken by different cities worldwide and gathered into a clear step-by-step roadmap that can be useful for emerging smart cities. The Roadmap covers three main stages as we see them during the process of development: *preparation*, *formation* and *spreading* stages. We reveal how this is incorporated in the Ukrainian context.
Our analysis of smart city solutions from all over the world (based on the BeeSmartCity database) showed that the tech component on its own is not enough to overcome urban challenges within different domains (environment, economy, government etc.), as we see each of the solutions has a human component involved in a form of knowledge generation and sharing, different forms of co-creation and partnership etc. Thus, ICTs are a required but not a sufficient element of building successful citizen-friendly and resilient cities.

Keywords
Smart Sustainable city, ICT, sustainability, digitalization, Smart Solution, co-creation.

Introduction
Many international institutions (World Bank, UN etc.) consider information and communication technologies (ICT) as one of the possible tools that can help a society to overcome the urban challenges of the 21st century, in particular: environmental degradation, the growing demand for limited resources, migration, the ageing of the population in some countries and the related growing demand for smart health solutions.

Research from the McKinsey Global Institute (MGI) in 2018 showed that the application of data and technologies in decision-making processes has allowed smart cities to reduce the crime rate by 30–40 %, decrease water consumption by 20–30 % and accelerate emergency response time by 20–35 % [1].

Smart cities represent a deep and multidisciplinary model, which aims to unite and use the synergy of the physical, digital, and human components. They are becoming a trend of the 21stcentury among business and political stakeholders, as more cities claim their smartness and sustainability.

In recent years, the concept has evolved from the purely technology-led approach (Smart City 1.0) towards an inclusive and sustainable human-centered framework (Smart City 3.0) that aims to solve urban problems, and not just test new tech solutions.

The Smart City Concept is quite widespread topic among the academic sector as many prominent urbanists and economists study the topic, such as: B. Cohen, R. Giffinger, P. Lombardi, H. Schaffers, M. Rosenthal, and others. In addition, many international institutions are joining the academic sector in research and analysis, including IESE, ITU, OECD, and UN-Habitat along with such private sector representatives as Arcadis, Ericsson, and Huawei. In addition, there are many international platforms that aim to gather best practices and solutions to share the positive experiences among cities and communities, such as Bee Smart City, the European Innovation Partnership on Smart Cities and Communities (EIP-SCC), Idea bank of the Eastern Partnership Civil Society Facility etc.

In her article, Angelidou M. [3] analyses the types of Smart City Strategies and unites them into groups. She specifically studies the smart city strategies of 15 cities [24] worldwide in detail, confirming that most of them emphasize the role of ICTs failing to involve other important tools (co-creation and bottom-up approach).

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In our research, we aimed to outline the main components of the *default* Smart City Strategy and suggest the possible options within each component, i.e. objectives, principles, tools, models, stakeholders etc. Following the components, we created a step-by-step roadmap for any city aiming to become smart and sustainable. Apart from that, we presented the Ukrainian context and cities experience in building their digital agenda, solutions and platform that already work successfully.

Since smart applications are one of the widespread helping tools used to achieve the objectives of Smart Sustainable cities, many researchers (Angelidou M., Psaltoglou A., Komninos N.) and business companies (McKinsey Global Institute) aim to provide a qualitative and quantitative impact analysis of the latest.

Methods

In our research, we apply the methods of comparative analysis and generalization along with the methods of theoretical and systematic analysis of literature (both international and local smart solution libraries, smart city platforms, smart city strategies and plans, etc.).

The increased number of stakeholders led to an escalation of the amount of the generated Smart Solutions. To analyze the role of smart solutions in making our cities more citizen-centric and convenient, we selected a worldwide BeeSmartCity library of solutions. Reviewing 600+ smart solutions, we have outlined and summarized the issues they aim to address and enabling factors involved within different domains (economy, environment, people, government).

Results and discussion

Since 2014, more and more cities are engaging in the process of Smart city development. This includes both the development of a new strategy for a city, and introducing certain organizational and technical changes. The latest include, in particular:

- data opening (open data portals in Singapore, London, Chicago, Stockholm etc.),
- encouraging Civic Tech direction (Amsterdam Startup Residence, New York's NYCx Challenges, Civic Innovation Challenge London),
- support and encouragement of innovations,
- citizens digital readiness (providing access to ICTs, developing digital literacy and promoting digital engagement, improving digital safety),
- support for spreading digital solutions and working on common standards for digital services.

Cities typically start with a separate Smart City strategy, which is later integrated into the general city development strategy. This makes the model of the smart sustainable city just a tool to achieve a greater target.

There are also cities that still do not have formally accepted Smart City strategies like Amsterdam [2]. In the meantime, other countries might also accept nationwide strategies to ensure common standards between different cities and promote experience exchange on the national level. (The Netherlands, Singapore). Fig. 1. provides an overview of possible types of strategies along with their particular pros and cons.

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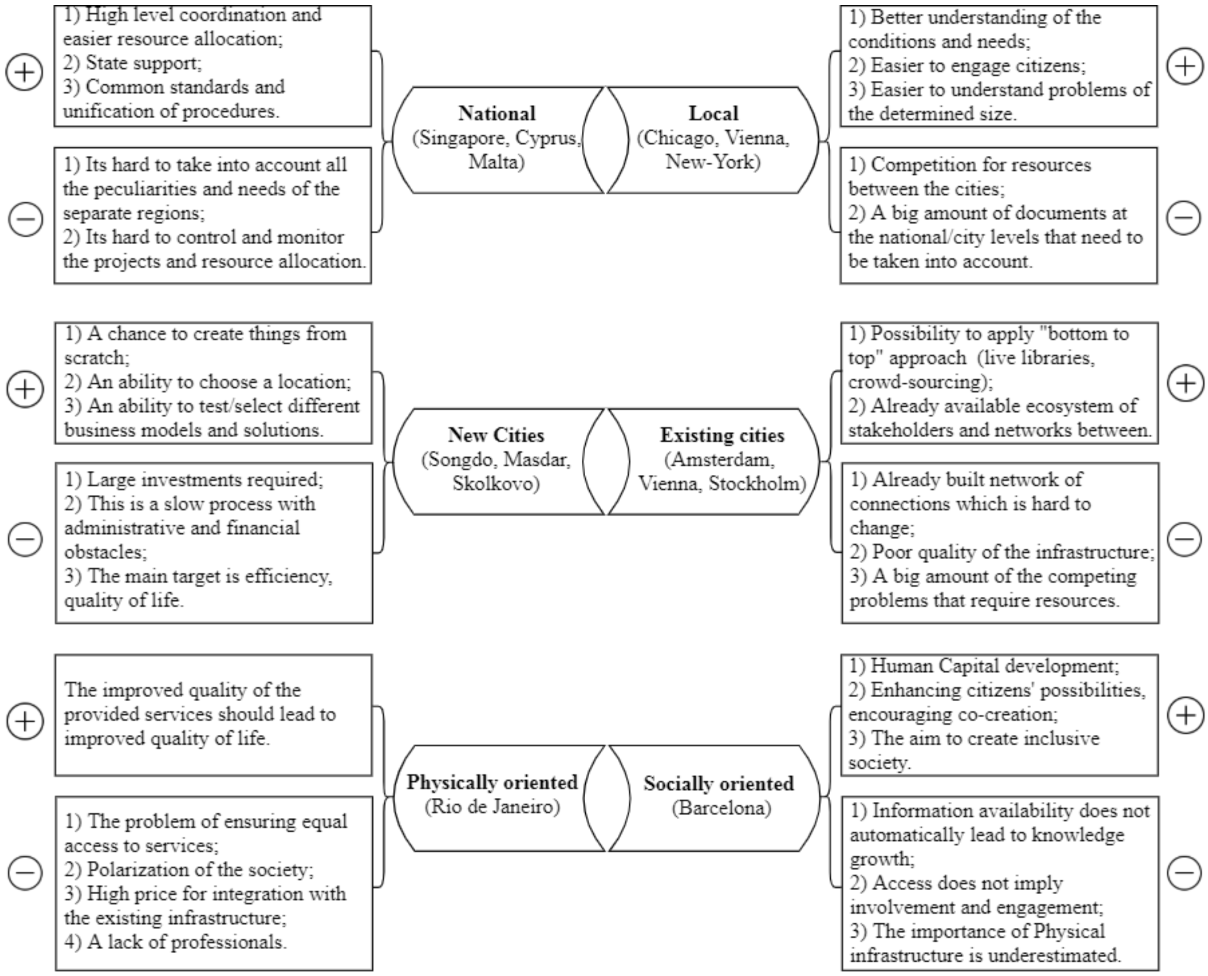

Fig. 1. Types of Smart City Strategies. *Source: [3]*

Local strategies are the most widespread since they allow local community needs to be addressed, and more flexible for new business models and solutions to be identified to engage citizens more actively. At the same time, national strategies are more widespread in small size homogeneous countries with minor economic diversification.

It is more time-consuming and expensive to create cities from scratch then to improve the existing cities. Apart from this, cities created from scratch have much higher risks of failure (they may be too expensive to live in, too complex to be used by people etc.).
So cities more often choose projects, which aim to regenerate their degraded territories to make them more convenient and comfortable for the users. Some cities place an emphasis on improving their physical infrastructure, investing in transport systems, energy, public utility services etc. Such cities hope that an enhanced range of the provided services will automatically result in a better quality of life. However, there are many questions regarding equal access to new services and problems of integration between the old and new infrastructure. Alongside there are cities that make a greater impact on the social component like Barcelona, investing more in knowledge growth, skills development, human capital and creativity, which, in its turn, will develop all other areas of life.

There are strategies that are focused on economic sectors, suggesting solutions for a particular sector such as energy, agriculture, industry etc., and strategies that focus on the geographical localization of clusters. Most cities want to involve all the stakeholders into a strategy development process, including citizens starting from public discussions to reach a common vision and set particular targets.

As for the further model of organization and governance, typically cities establish a department for Smart cities within the municipality structure to connect all stakeholders, create a special position for Information and Digitalization Officer or/and establish a common public-private platform for communication (Vienna Smart City, London Smart city).

Financial models differ depending on the possible sources available for smart city projects. In general, we can outline the following:

- public financing, which implies the use of local or national tax revenues,
- private-public partnership, which involves the private sector to do the job and paid either from the budget or from future users' fees,
- crowdfunding,
- grants. [4].

While European cities typically rely on the local, national or EU budget, private investments are more popular in North America [5].

A project's size and associated risks influence the decision regarding the financial model, i.e. while crowdfunding, private sector philanthropy or special grant programs will be enough for small projects, middle size projects require venture capital and national funds, and big projects can involve national funds. Subsidies and state grants are a popular financial source, since many countries have nationwide *challenges* that allow cities compete for grants for particular projects, for example: Smart Cities Challenge India, Smart City Challenge Canada etc.

However, the private-public partnership remains one of the most widespread solutions. Crowdfunding is the rarest form to date, since municipalities do not have a clear understanding of how to use it.

The targets most cities set in their strategies can be roughly united into three groups:
economic (the desire to improve the quality and efficiency of services provided; further investments attracting, improving overall economic activity);

- social (ensuring inclusiveness, transparency of government bodies, increasing trust and citizens engagement),
- sustainable environment [5].

Among others, national strategies also include the following objectives:

- scaling up initiatives with good prospects,
- cooperation encouraging investments from the government and private sector,
- a more competitive position on the international market with the products and services that were successfully tested and applied within the country.

Our study of several smart city strategies allowed us to outline the following principles, which may contribute to the successful building of smart city concept:

- cooperation and coordination of efforts between the private, public, academic sectors and civil society,
- concept should be citizen-centered,
- data should be available and accessible,
- efficient resource management,
- the need for common standards during the development and implementation of smart city solutions;
- providing the opportunities and encouraging experience exchange on national and international levels,
- the importance of digital leadership and digital literacy.

Along with the strategy development, the most advanced cities are currently also setting up a separate platform for smart city projects and solutions (e.g. Amsterdam Smart City, Vienna Smart City etc.).

The platform represents a space for discussion and communication between authority representatives, citizens, business and the academic sector. It allows for sharing news, providing feedback, discussing monitoring results and KPIs updates [2, 6].

There are also nationwide platforms for synchronization and experience exchange between cities (Smart City Sweden, Smart City Embassy in the Netherlands). Apart from this, cities also tend to unite going beyond just national boundaries [7, 8], like the following examples:

- The European Innovation Partnership on Smart Cities and Communities (EIP-SCC), a major EU-supported market-changing institution that brings together cities, industries, SMEs, investors, researchers [9],
- ASEAN Smart Cities Network (ASCN), a collaborative platform where cities from the ten ASEAN Member States (AMS) work towards the common goal of smart and sustainable urban development [10],
- Open and Agile Smart Cities, an international smart city network creating and shaping the global smart city data and services market of tomorrow [11],
- The Fab city, a global project to develop locally productive and globally connected self-sufficient cities. This a decentralized and open format project [12],
- The "United for Smart Sustainable Cities" (U4SSC), a UN initiative coordinated by ITU, UNECE and UN-Habitat to achieve Sustainable Development Goal 11 [13].

According to the Future Cities Catapult analysis, these are believed to be the most widespread tools to establish and support Smart Sustainable Cities [5]:

- the use of ICTs, open data and analytics,
- networks and platforms,
- citizens engagement for generating innovative and crowdsourcing solutions,
- improving the basic infrastructure.

We have decided to investigate how those tools are used in real-life implemented solutions and what issues are aimed to be solved via provided technical solutions.
For this research, we have selected one of the largest worldwide databases for smart city solutions, BeeSmartCity. The network connects around 1,000 cities and already contains more than 600 solutions. BeeSmartCity also publishes its own Smart city ranking based on the number of Smart city solutions shared on the platform. At present Amsterdam, Moscow and Lublin are the top three cities in the ranking [14]. Below we have provided a breakdown of solutions by categories: smart economy, smart mobility, smart environment, smart governance, smart living, smart people (Fig. 2).

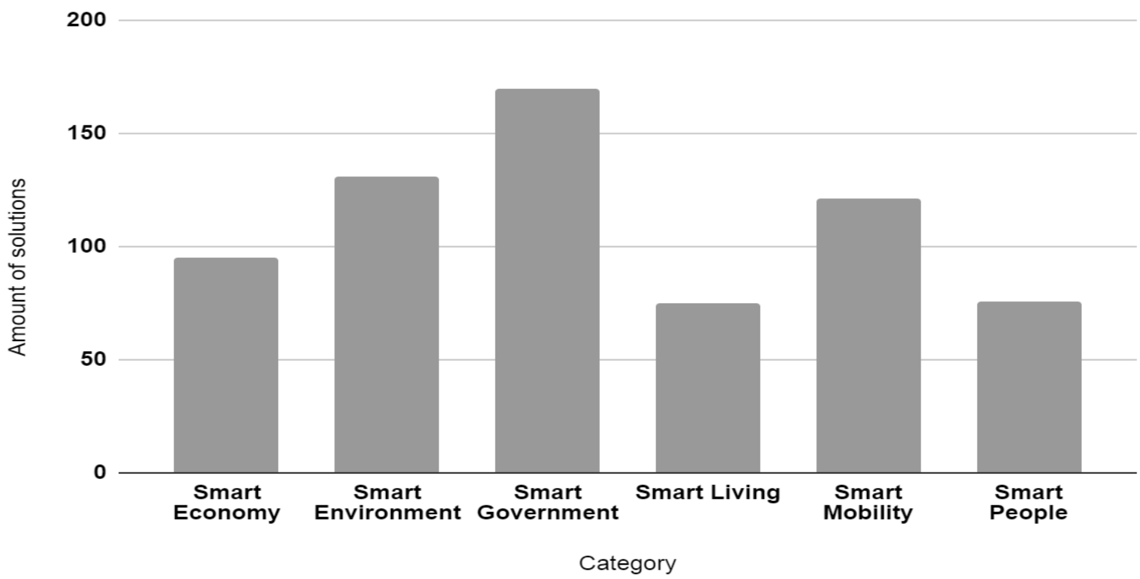

Fig. 2 Distribution of Smart Solutions from BeeSmartCity by areas of application. *Source: Source: Own research based on [14]*

Most solutions presented on the platform belong to the Smart Governance category. Geographically, most solutions come from Europe (418), with North America being second (181). It is necessary, however, to keep data subjectivity in mind, as not all cities are active on the BeeSmartCity platform.

We have reviewed each of the solutions to identify:

- what issue the solution aims to solve,
- what smart solutions are available,
- what the innovative enablers of these solutions are (technology, process, approach).

The findings are summarized in the Fig. 3.

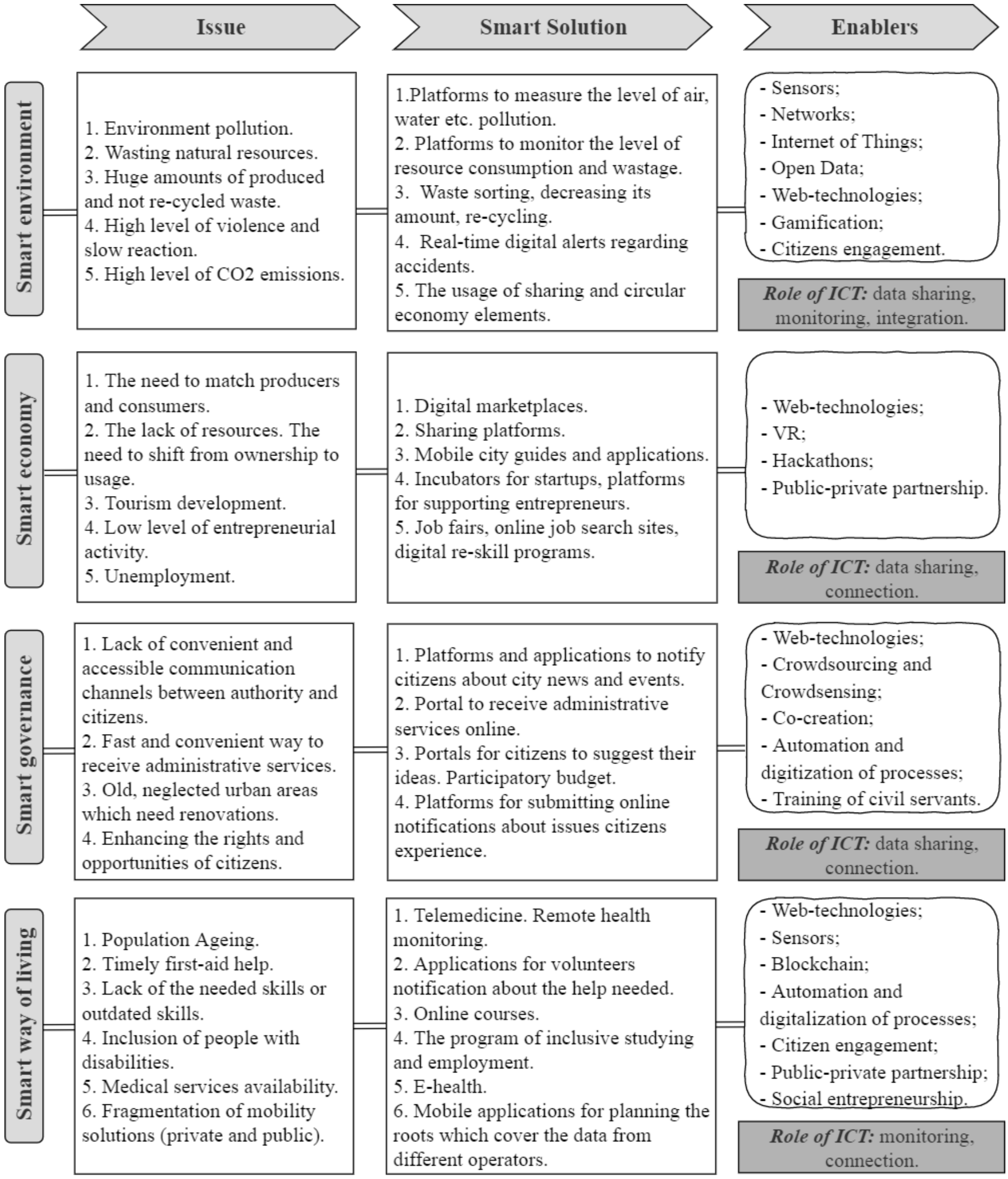

Fig. 3. The results of the analysis Issue - Solution - Enablers based on BeeSmartCity. *Source: Source: Own research based on [14]*

The conducted analysis reveals that even though ICTs serve as one of the most widespread enablers for Smart Solutions, problem solving would be impossible without the human component involved in a form of knowledge generation and sharing, different forms of co-creation etc. Moreover, none of these solutions is needed unless the city has a proper physical infrastructure maintained in first order.

It's important to stress the crucial role *digital sustainability* plays in smart solutions development. With '*digital sustainability'* we understand the development of solutions, which can be efficiently used during a long period of time. The end result should ensure user-friendly usage, easy future updates and integration with other solutions.
This is possible under the following conditions:

- establishing common standards for tech solutions,
- modular approach in development,
- ensuring a constant flow of information within and beyond the system,
- taking security into account; e) using inclusiveness by design.

Smart city concept is gaining in popularity in Ukrainian cities along with the worldwide trend due to a number of facts: active decentralization processes, growing number of IT specialists and active IT industry development, progressive society ready and craving for changes. The country plans to join the EU strategy for Smart Specialization, aiming each region to select its strongest and most promising industries.

We already have successful examples of smart solutions implemented, e.g. smart lighting project in Kropyvnytskyi, intellectual systems for mobility, e-gov solutions in a number of Ukrainian cities etc.

Moreover, we have cities that are working on developing the Smart City concept both in theory and in practice (Kyiv, Lviv, Kharkiv, Dnipro etc.). Most of them already have either a strategy for digital transformation (Lviv, Vinnytsia) or Smart city strategy (Kyiv, Dnipro Region). However, when compared to the European examples, current versions of strategies lack the needed level of details, KPIs, constant monitoring and progress sharing.

In 2016, the Hi-Tech Office Ukraine civil society organization was established. It unites the high tech companies that aim to create favorable conditions for innovative business and digital economy development in Ukraine. This organization contributes to the development of the "Digital Agenda of Ukraine 2020". The document discusses the main principles of digitalization, trends and challenges, along with the particular developments in different areas [15].

In 2019, the Ministry of Digital Transformation was established on the national level. It aims to create a "country in a smartphone" and is responsible for the state policy in the area of digitalization. The Ministry has the following targets to be achieved by 2024: a) to provide 100% of public services online; b) 95% of transport infrastructure, cities, social objects should have an access to the fast internet; c) to involve 6 million Ukrainian citizens into the program of digital skills development; d) to increase the volume of IT sector in GDP up to 10% [16].

The Ministry is currently working on the application called "Diya" ("Action"), which will cover the main services provided by the state to citizens and will allow direct communication between citizens and state, and actually envisages the "State in the smartphone" approach. The first step is a digital driver's license, which has been already launched in a test mode [16].

Unfortunately, to date only nine cities of Ukraine have joint the international Open Data Charter, despite the fact that accessible data is a key factor for the development of smart solutions that contributes to the improvement of citizens' life [17].

Cities can use their local budget funds, the public-private financial mechanism, EU grants and money of the State Regional Development Fund (SRDF). However, right now, only 30% of the projects submitted for state funding belong to municipalities, and their quality leaves much to be desired [18].

We have only one city, which has developed and accepted the Smart City strategy (Kyiv Smart City in 2017). However, a number of cities have already established Reform Offices (Kharkiv, Dnipro) and instituted the corresponding positions for Officer of Digital Transformation (Kharkiv), and conduct forums for experience and

knowledge exchange (Kharkiv Smart City forum, Kyiv Smart City Forum, Lviv 451 Forum).
Hackathons and challenges for urban problems gain popularity both at the national and local levels.

NGO SocialBoost plays an important role in the process being an umbrella for startups, civic tech experts and government representatives who unite to address urban challenges and conduct annual hackathons. The organization developed the system of participatory budgets for municipalities, which is currently used in 32 cities and by 800 thousand citizens [19].

Another interesting initiative is the Dosvit project, which allows cities and united territorial communities to create modern, investor-friendly websites and add additional modules to them, like participatory budgeting, open budget, survey for citizens etc. [20].

In 2018, a project "E-services for amalgamated hromadas" was launched; representing a library of digital services used in different cities and amalgamated hromadas all over Ukraine. Right now, the system has around 300 solutions within different areas of life [21].

Also starting from 2018 the most popular services used by citizens of Ukraine have been united within one platform: e-dem.tools. It includes such services as e-petitions, participatory budgets, open city budget, and online consultations with citizens [22].

Though Ukrainian cities have done a lot in recent years to build smart and citizen-friendly cities, there is stillroom for improvement. Right now, we lack a holistic approach both on local and national levels regarding standards, ICT infrastructure, processes etc. Due to the fragmentary approach of each city, we risk to end up with a fully disintegrated national digital system [23]. In addition, the components of sustainability and smartness do not meet each other yet to serve as a tool and target accordingly.

We have created a roadmap for developing a Smart City Concept based on the performed analysis.

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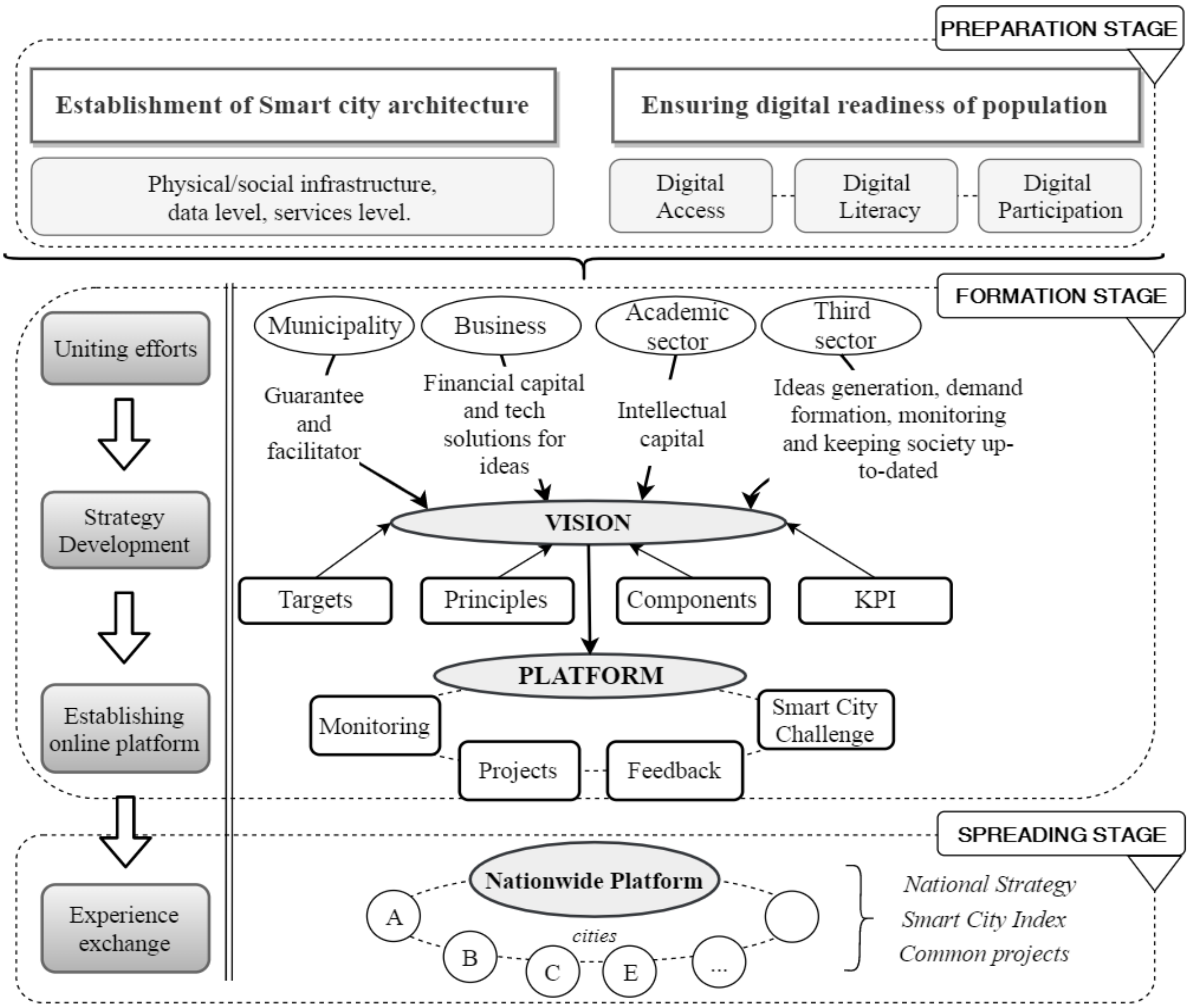

Fig. 4. Roadmap to develop Smart City Concept. *Source: Source: Own research*

We believe the process should have three stages.
During t*he preparation stage,* a city needs to ensure that its citizens are ready for a new model of cooperation having both the needed digital skills and the possibility to apply them. At this stage, the required infrastructure needs to be prepared. This should cover both material and social components. A significant number of skilled professionals should be ready to work in a new environment and ensure its flawlessness. Communication and feedback are very important at this stage.

During *the formation stage*, cities aim to encourage cooperation based on a quadruple helix model involving all the stakeholders in search of a common vision of the city. The possible tools to be used are online surveys, round tables, voting etc.

At this stage, the responsible body should be established, like a reform office, department or new position within the municipality.

In result, the city should create a permanent platform and ensure that the community is involved in the process. Active citizens should engage in the process of co-creation through hackathons and competitions.

The spreading stage happens when cities have already set the vectors of development within their boundaries and have something to share with the world. A good idea would be to establish a national platform for experience exchange and "success stories" sharing. We believe at this stage, cities can start working on the National strategy and Smart City Index to compare and analyze the results of their work.

Impact

The provided step-by-step Roadmap for Smart city concept development based on the successful international experience will be useful for city development experts and municipalities that currently work on the agenda for their cities. We hope it contributes to a more integrated and efficient approach as well as to sustainability and proactivity of the newly developed strategies. This is especially relevant for Ukrainian cities, most of which are currently joining the movement of smart cities but do not have a well-structured approach and vision yet.

The analysis of the world library of smart solutions will help to identify the most relevant urban issues for each particular city and possible products that can be launched on the local level to address them. The listed enabling factors should help to understand the efforts and cooperation models required for each particular case. While business sector, which aims to take part in smart city projects (development, support etc.), can identify the closest domains to work in, develop a strategy and offer its services.

Overall, the research aims to transform the way our cities deal with urban challenges in the 21st century, making the process more agile and efficient, encouraging new models of partnership and providing the theoretical foundation along with the practical recommendations.

Based on the research completed we believe these are the enabling factors that need to be taken into account by city development experts:

- Funding. It is important to think of possible tax exemptions for companies that work on smart city projects. Though this is not a widespread practice worldwide, many experts mention the need for it. Another point is to use the mechanism of crowdfunding more actively, involving citizens to the process of co-creation,
- Standardization. We believe it's important to develop common standards and best practices in the area of smart city projects, which will include software architecture requirements, data management standards etc.,
- Calls for ideas to engage stakeholders in urban problems solving. This implies data collection and its analysis, the involvement of citizens in the process of planning and consultation, active communication and feedback,
- Networking of cities for best practices exchange and good experience scaling,
- Open Data. Municipalities need to ensure data availability and access to it, the data should be provided in a format convenient for the users and developers, to be used,
- Human Capital Development, which is crucial to encourage the involvement of creative society and co-creation. Municipalities should pay attention to and ensure citizens' readiness for new technologies. STEM and multidisciplinary education are key directions,
- Technologies and IoT, which allow connecting all devices and a constant data exchange between them and the outside,
- Encouragement and support of living labs and science parks for generation, development and testing of new smart solutions and ideas,
- Partnership and cooperation between various stakeholders, both online and offline,
- Cyber Security, which implies the ability of the society to use the internet and other digital channels freely and safely, without risks to their privacy and free of cybercrimes. Specific recommendations would include: avoiding automation only control and always having a possibility of human control, and re-launching the system manually; establishing a position of a digital security officer, taking measures for digital hygiene among citizens etc.

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Obviously, there is no one-size-fits-all solution on how to make your city smart and sustainable but we have outlined above the enabling factors, which can be used in different combinations to achieve the goals in particular city sets.

Conclusions

Based on the research completed the following conclusions on smart city development can be drawn:

- Most cities choose the projects from a certain domain aiming to regenerate particular territories or to improve particular processes, making them more convenient for users. Since “a city built from scratch” model is typically associated with more risks and higher costs,
- There are several financial models available for smart city projects depending on their size and stakeholders involved but till the date public-private partnership stays the most widespread form, while the role of crowdfunding is underestimated,
- Most cities establish a separate department or position within the municipality responsible for the digitalization and development of a smart city framework, which helps to make the process more organized and efficient,
- Once a common vision, targets and principles are identified, cities should establish a platform that unites all stakeholders and is used to share the progress and KPIs, present the projects and provide the feedback,
- There is a tendency for a broader experience exchange on the national and international levels, which leads to city networking and close cooperation on particular projects. Typically, the model involves Lighthouse and Follower cities. Thus, cities should not work on smart concept development in isolation.
- Ukrainian cities have just recently started their journey, that is why their current approach is quite chaotic and disintegrated. Though many factors (e.g. decentralization, number of civic innovators and IT specialists etc.) along with the already undertaken steps (e.g. establishment of the Ministry of Digital Transformation and several local Reform offices, popularization of hackathons and smart city challenges, forums for experience sharing etc.) show the perspective of positive changes that should lead to a more coordinated, involving and holistic approach in developing the framework.

In addition, our study of smart city solutions from all over the world confirmed that tech component on its own is not enough to overcome urban challenges of the 21st century. As we see, each of the solutions has a human component involved in the form of knowledge generation and sharing, different forms of co-creation and partnership, etc.

Moreover, none of these solutions is helpful unless a city has a proper physical infrastructure maintained firstly and digital literacy of the population ensured. Therefore, cities should focus on users’ needs and ensure the solutions that they offer are suitable and convenient for citizens.

Conflict of interest

There are no conflicts to declare.

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ANALYTICAL PROVISION FOR MANAGING INNOVATION ACTIVITIES WITHIN THE COMPANY CONSIDERING THE INTERESTS OF STAKEHOLDERS

Oksana V. Portna
V.N. Karazin Kharkiv National University
Myronosytska St, 61002 Kharkiv, Ukraine, portna@karazin.ua
https://orcid.org/0000-0002-8803-4605

Natalia Yu. Iershova
National Technical University "Kharkiv Polytechnical Institute"
Kirpichov St, 61000. Kharkiv, Ukraine, iershova@kpi.kharkov.ua
https://orcid.org/0000-0003-3544-3816

Dina A. Tereshchenko
Kharkiv National University of Civil Engineering and Architecture
57/4 Nesterova St., 61031, Kharkiv, Ukraine, tereshchenko.dina@kstuca.kharkov.ua
https://orcid.org/0000-0003-0633-0097

Tetyana Yu. Chaika
National Technical University "Kharkiv Polytechnical Institute"
Kirpichov St, 61000, Kharkiv, Ukraine, chayka@kpi.kharkov.ua
https://orcid.org/0000-0002-7622-3193

George Dubynskyi
Embassy of Ukraine to the USA
3350 M Street, NW Washington DC, 20007, USA, georgii.dubynskyi@mfa.gov.ua
https://orcid.org/0000-0002-7860-2437

Abstract
The article covers the problem of analytical provision for managing innovation activities within a company, taking into account the interests of stakeholders — this is connected with the possibility of ensuring the competitiveness, assessment of innovation activities and choice of innovation strategy. The purpose of the study is to identify the conditions and trends of innovation activities within companies as well as to develop a methodological approach to the evaluation of their innovation activities on the basis of accounting and analytical data considering the interests of stakeholders. The study of the current state and general trends of innovation activities at enterprises was conducted in a logical sequence as follows: 1) the number of innovatively active enterprises, 2) the share of industrial enterprises among the innovatively active enterprises, 3) the estimation of the amount of financing and the level of expenditures on innovations and 4) strategic priority directions of innovation activities that allowed to identify and analyze barriers to the development of an effective innovation policy. This provided an opportunity to develop the structure of analytical provision for the system of managing innovation activities within a company as a logical chain of strategic results for achieving economic success. However, a number of limitations and risks were identified. The assessment of the impact of innovation on the economic, environmental and social efficiency of a manufacturing production process is argued to be based on systematic and structured accounting and analytical information and reflected in non-financial reporting (in particular, the G4 Sustainability Reporting). In view of this, we consider it advisable to supplement the sustainability reporting with the indicators that characterize the effectiveness of innovation management. The results of the study are relevant and useful for large and medium-sized enterprises in the context of ensuring the implementation of an innovation model of development as well as for conducting applied research in the field of business strategies to ensure sustainable company development.

Keywords
innovation; activities; management; stakeholders; analytical provision.

Introduction

Increasing the role of scientific and technological progress and knowledge, informatization, convergence of national economies, increased competition in markets as well as intensification of social and cultural ties are important trends in the development of society worldwide. An innovative model of developing the economy is widely recognized and in particular has been reflected in the European Union's Europe 2020 strategy [*1*], which is based on flagship initiatives to deliver rational, sustainable and inclusive growth. Fundamental transformations in business and manufacturing processes, service delivery, organizational methods and other non-technological innovations are equally important. The innovation-orientated companies are certain to enter new markets, change the model of doing business, apply original methods to reduce expenses, find new opportunities and resources, and as experts say [*2*], apply new products and tools in the market of innovative technologies such as electronic money, cryptocurrency, etc. The changes taking place cause the development of goal-setting systems, tasks of current and strategic development, their detailing, integration and transformation in different fields and directions of individual activities.

The international scientific community is currently focused on studying a wide range of aspects of company innovation activities and new ways of enhancing innovation management efficiency, implementing innovations in different areas of company functioning and applying different approaches, methods and indicators to the analysis of innovation activities. We agree [*3*] that innovation has a strong positive impact on social development, and innovation increases the quality of life.

According to experts, new technologies have already influenced almost every aspect of human life. Today, in the face of significant changes, innovation is becoming one of key elements of stability and considered one of the most important requirements for companies. Strong competition together with the need to compete with new market players requires the development of new skills in managers and employees. Thus, it becomes important to study the extent to which innovations may affect the company's performance that leads to the business's stable position on the market, to evaluate them in terms of their potential in the process of creating competitive advantage and to analyse the relationship between the level of innovation efficacy and market efficiency. Research studies regarding innovation are mostly focused on developed countries, and very little is known about transition economies [*4*].

Empirical data and available research papers show that innovation efficiency is greatly enhanced through close cooperation between the entities involved in innovation activities [*5*]. According to Pelse et al. [*6*], bioeconomic enterprises in Latvia have highly valued the cooperation with research institutes in the development of innovations. This cooperation is embodied in the formation of the global innovation system that is currently characterized by certain trends, among which; the functioning of the world technology market occupies the leading position. Innovation activities can be enhanced through stakeholder engagement, which is aligned with strategic goals and supported by adequate incentives and management mechanisms. This includes, among others, CRM (customer relationship management), GR (government relations), and PR (public relations). At the same time, such relationships (communications) with stakeholders are considered as part of the company's intangible assets [*7*]. Moreover, collaboration with stakeholders promotes structural changes in the economy and society and is able to influence the entire value chain, from suppliers to end users. When studying the issue of conflicts of interest between stakeholders with respect to sustainable territorial development [*8*], key components of a modern industrial strategy have been identified based on stakeholder collaboration (Fig. 1).

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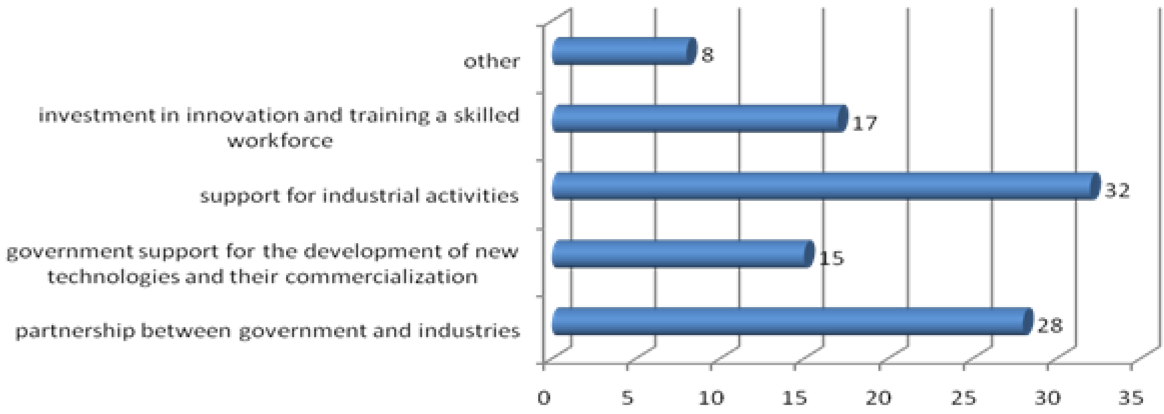

Fig. 1. Key components of a modern industrial strategy identified through stakeholder collaboration. *Source: Source: Own research*

Of the respondents, 28% identified the partnership between government and industries as an institutional mechanism for innovative change, 15% noted government support for the development of new technologies and their commercialization in accordance with the strategy, 32% identified support for industrial activities in enhancing the economy of the country, and 17% emphasized investment in training a skilled workforce of the future for a term beyond 5-10 years including medium and long-term goal setting based on the analysis of identified challenges for the future of development; defining strategies by type of activity; creation and support of development institutes by priority activities (32% of respondents).

Transition to an innovative type of development offers great prospects but also creates significant risks to the stability and balance of the development itself at macro and microeconomic levels. Risks can have a negative impact on the design of innovation projects including financial, marketing, intellectual, technical, information and institutional projects. Therefore, experts are invited to apply methods of reducing investment risks when implementing projects at enterprises by clearly identifying sources of investment risks and their possible impact; timely observation of the macro and microenvironment during the implementation of innovation projects; clearly controlling the risk management process; and through available resources needed to ensure fast actions and a sufficient timeframe for project implementation [*9, 10*].

Addressing conflicts of interest between stakeholders in sustainable territorial development has made it possible to explore and isolate barriers to building an effective innovation policy at the macro-level. The most significant are identified as follows: low-developed innovative infrastructure and weak development institutions, economic and political instability, migratory aspirations among highly educated youth and scientists, weak venture funds and underdeveloped system of regulating their activities as well as taxation (Fig. 2).

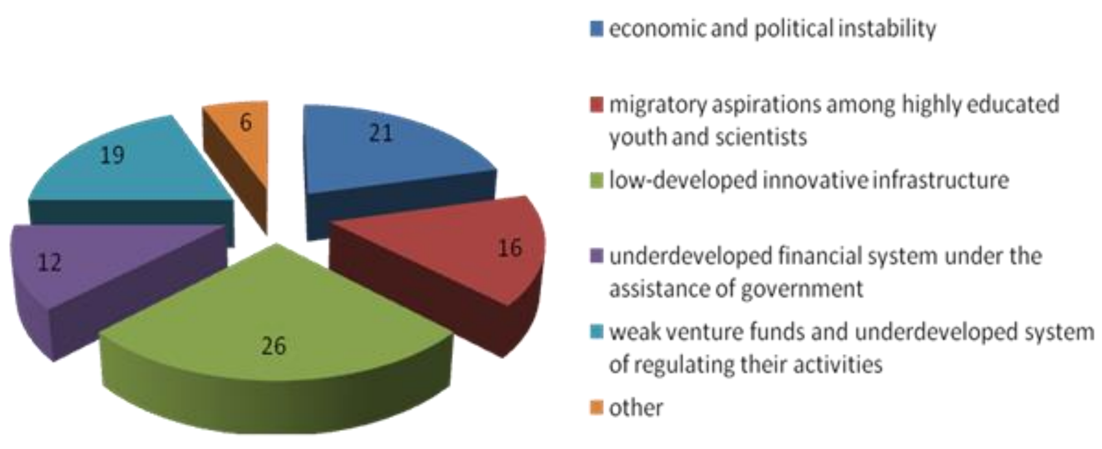

Fig. 2. Barriers to building an effective innovation policy. *Source: Source: Own research*

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According to E. Witjara, et al. [*11*], innovation processes in industry are predominantly extensive in their nature and new products are being mastered mainly through the use of scientific and technical assets of previous years. This type of innovation development is certain to have narrow limits and will not allow enterprises to maintain long-term competitiveness. Thus, the elimination of barriers to a modern innovation policy also comes down to the active use of strategic innovation. The researchers' findings [*11*] confirm the importance of strategic innovation for shifting to a new level of technological structure. The concept of strategic innovation lies at the intersection of strategic and innovation management and defines strategic innovation as a preventative innovation aimed at creating new competitive advantages for companies to ensure their competitiveness and increase business value. When studying the role of strategic innovation in digital companies, Perevozova et al. [*12*] emphasize the integrative, multidisciplinary, and "holistic" nature of any strategic innovation.

The main goals of the innovation management system are those of the entity itself. The development of an innovation management system must be geared towards achieving these goals. The effectiveness of the company's innovative growth management processes is characterized by a number of indicators that reflect the efficiency of implementing innovative solutions. Researchers Freeman and Dmytriyev [*13*] determine the following indicators to evaluate the actual state of enterprise innovation management systems as follows: level of material and financial resources, social and psychological climate, leadership style, human potential, system of evaluation of work results and incentives, flexibility and mobility, communication processes and information support of innovation activities. According to the scientists, the indicators differ in their significance and unevenly affect the innovative management system activities [*13*]. At the same time, a number of scientists dealing with micro-level innovation management emphasize the need for monitoring the state of the system and achieving its goals, preparing operational data for senior executives on the current state and development of the system; accumulating and synthesizing information on the factors of the system development; organizing information exchange among employees of the system, creating options for the strategy of managing the innovation activity development considering the existing goals and objectives; evaluating possible consequences that result from implementation of regulatory decisions related to the management system development; and controlling and analysing the reasons for not having implemented these decisions [*13*].

The researchers Khaustova et al. [*14*] believe that the processes of managing innovation activities regard social innovations and their evaluation. Indeed, innovations should cover both the development of socio-economic development strategies in general and the development of strategies for enhancing the competitiveness of human capital in particular. The role of social innovation must be diagnosed both as a whole and within individual activities. In terms of economic activity, this regards the development and implementation of economic management methods, accompanied by the needs of prognostication, synthesis of strategies, strategic and current plans, financing needs, remuneration, pricing, analysis and evaluation of the state of the environment, performance evaluation, monitoring of economic processes by directing them towards visionary and innovative development, application of new knowledge, experience and developed competencies.

Methods

The authors used general-scientific and special methods of cognition. An analysis of the current state and general trends in innovation activities at Ukrainian enterprises, the evaluation of the amounts financed and spent on innovation was carried out with the help of the comparative statistical analysis, which made it possible to identify barriers to the development of an effective innovation policy. The next step was to use logical and systematic approaches to build a system of analytical provision for the company's innovation management as well as to take into account interests of stakeholders and their engagement. This plays an important role in all types of innovation processes not only in business model innovation. The methodological approach to assessing the company's innovation activity was developed using a SWOT analysis and a SPACE-matrix, which makes it possible to determine and evaluate the indicators of innovation activities as well as to justify the choice of an innovation development strategy. The next step was to evaluate the effectiveness of innovation management within the company on the basis of the coefficient method. The further use of the graphical method was aimed at illustrating the results of the study. The research structure was built, and the conclusions were made with the help of the structural-logical method and the method of scientific generalization.

Results and discussion

1. Innovation activities as a key factor in the development of companies: analytical aspect

The main factor that determines the development of the national economy is innovation based on the use of new ideas, scientific knowledge, technologies and products in various sectors of industry and management. The analysis of the state of innovation activities at Ukrainian enterprises is defined as one that does not meet the needs of innovative development. According to the Global Innovation Index 2018 ranking, the top innovative economies are represented by Switzerland (number-one spot for 5 years), Netherlands, Sweden, United Kingdom and Singapore. The top 5 middle-income countries are represented by China, India, the Russian Federation, Brazil and Argentina. In 2018, Ukraine ranked 43rd, meaning it was among the countries with lower-than-average per capita income [*15*]. According to the European Innovation Scoreboard 2018, Sweden tops the list of innovative countries. The group of leaders also includes Denmark, Finland, Germany and the Netherlands. With respect to the European level, Ukraine's position has lowered, and our country is ranked as a European outsider for innovation (together with Romania and Bulgaria) [*16*]. The trajectory of Ukraine's development differs significantly from the general trends in modern transformations, which are characteristic of the highly developed economies where innovations are becoming dominant. The steady reduction in the actual amount of financing of the scientific and technical complex and the lack of effective scientific and technical policies are not grounds to conclude that there is a real basis for the transition to an innovative model of development. During 2010-2018, the number of innovatively active industrial enterprises in Ukraine decreased by 685 units. However, the percentage of the total number of industrial enterprises increased by 2.6%. According to the studies carried out in 2011-2018, the most innovative enterprises comprised small and medium-sized companies, the share of which as the total number of innovative enterprises was about 70% – this was due to the structure of the survey samples rather than the greater propensity of small businesses to innovate. During 2016-2018, the share of enterprises engaged in innovation activities by recommended types of economic activity was 18.4% including technological innovation – 11.8% (product [5.7%] and process [10.3%] innovations), non-technological innovation – 13.4% (organizational [8.7%] and marketing [10.2%] innovations); 72.8% of innovative enterprises were engaged in organizational (47.4%) and/or marketing (55.4%) innovations [*17*]. One of the indicators of company's innovation activities is innovation expenditure. Thus, in 2018, the cost of innovation at industrial enterprises increased by 51.39% compared to 2011 and by 33.59% compared to 2017 (Fig. 3).

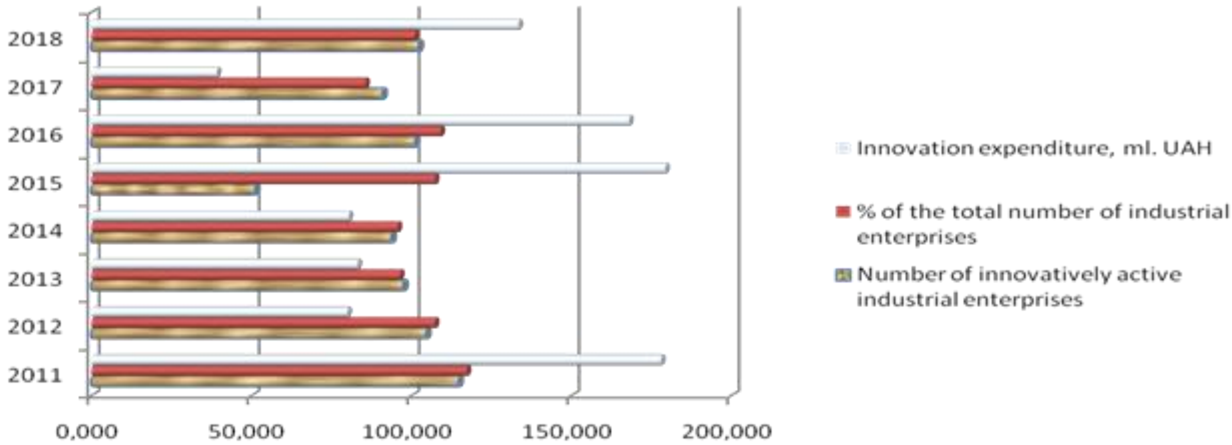

Fig. 3. Comparative analysis of innovation expenditures at Ukrainian enterprises. *Source: [17]*

The total amount of expenditures classified by the directions of innovative activities at Ukrainian enterprises comprised 13,813.7 million UAH (2016), 9,117.5 million UAH (2017) and 12,180.1 million UAH in 2018. Moreover, the change rate for internal researches comprised 5.845% in 2017 and 39.401% in 2018 compared to previous years, respectively. The change rate for external researches of Ukrainian industrial enterprises constituted 11.246% in 2017 and 119.96% in 2018 compared to previous years, respectively. The pace of change in purchasing machinery, equipment and software and acquiring other external experiences slowed down in 2017; however, in 2018, the innovation expenditure in these fields significantly increased. Thus, Ukrainian enterprises were unable to reach the level of innovation activity observed at the beginning of the 21st century — this confirms the urgency of the problem of enhancing innovation activities by domestic enterprises.

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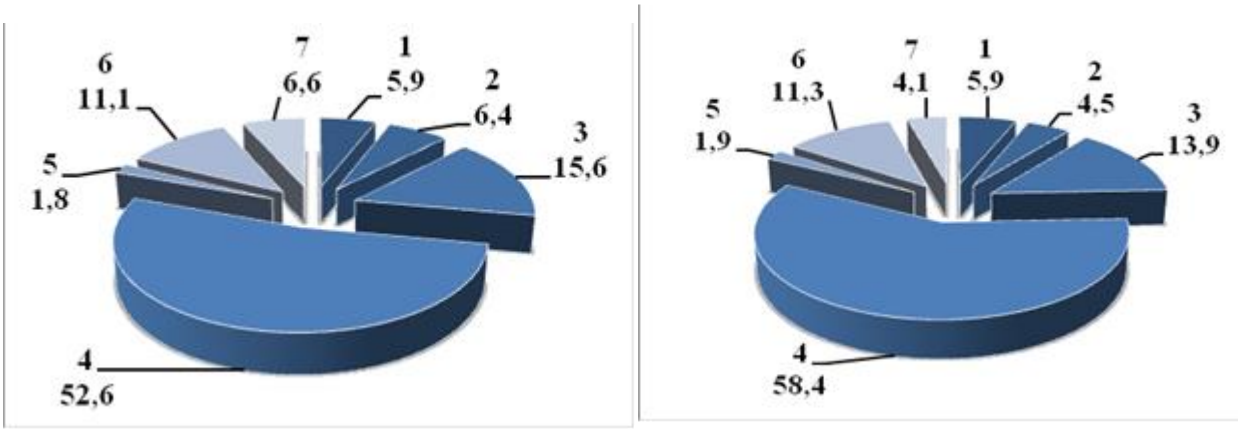
A significant factor that influences the implementation of innovation is the availability of financial security. Thus, the strategic priority innovation areas are defined as follows: 1.) Development of new energy transportation technologies, introduction of energy efficient, resource-saving technologies, and development of alternative energy sources. 2.) Acquisition of new technology for high-tech development of transport system, rocket and space industry, aviation and shipbuilding, armament and military equipment. 3.) Development of new technologies of production, processing and combining new materials, development of nanomaterial and nanotechnology industries. 4.) Technological renewal and development of agro-industrial complex. 5.) Introduction of new technology and equipment for high quality health care, treatment, and pharmaceuticals. 6.) Widespread application of cleaner production technologies and environmental protection. 7.) Development of modern information, communication technologies and robotics.

The analysis shows that in 2018, despite a slight increase in total amount, funding for all strategic priorities has increased compared to 2017. The shares of individual areas (2, 3, and 7) also increased in 2017 and 2018 in respect to the total amount of financing. The largest financing amount (153,444.23 thousand UAH or 52.6%) is directed to the strategic Priority 4 (Fig. 4), the smallest one (5,356.06 thousand UAH or 1.8%) — to Priority 5 [*17*].



2018 2017

Fig. 4. Assessment of financial support by strategic priority areas of innovation activities at Ukrainian enterprises. *Source: Source: Own research*

Kvitka and Kramarenko [*18*] identified the increasing role of small and medium-sized enterprises (SMEs) in many countries of the world. The researchers point out that the engines of scientific and technological progress are individual entrepreneurs, inventors and innovators who are witness to the complex and rigid structure of large organizations hampering their growth. Small and medium-sized enterprises are becoming the most convenient form of implementing and promoting innovation. Ziyadan et al. [*19*] concluded that special attention is paid to the development of organizational and managerial innovations, which, as a rule, lead to resultant effects. The indicators of innovative activities are widely used to evaluate the innovative activity within the company and its innovative competitiveness. At the same time, the need for product innovation management is emphasized by Vishnich, Wingarten and Neely [*20*]. The authors investigated the methods of managing innovation in business service models and evaluated their impact on productivity [*20*].

2. Analytical provision for innovation activities within the company

The peculiarity of this study is that accounting and analytical support for managing the innovation activity at an enterprise is a complex system in which the input information is registered, processed using analytical methods and stored for management purposes to evaluate the effectiveness of innovation activities and make efficient management decisions. A study by Bondar et al. [*21*] indicates the feasibility of presenting analytical data as a logical chain of strategic results. Fig. 5 displays the basic blocks in the system of accounting and analytical support for managing innovative activities within the company.

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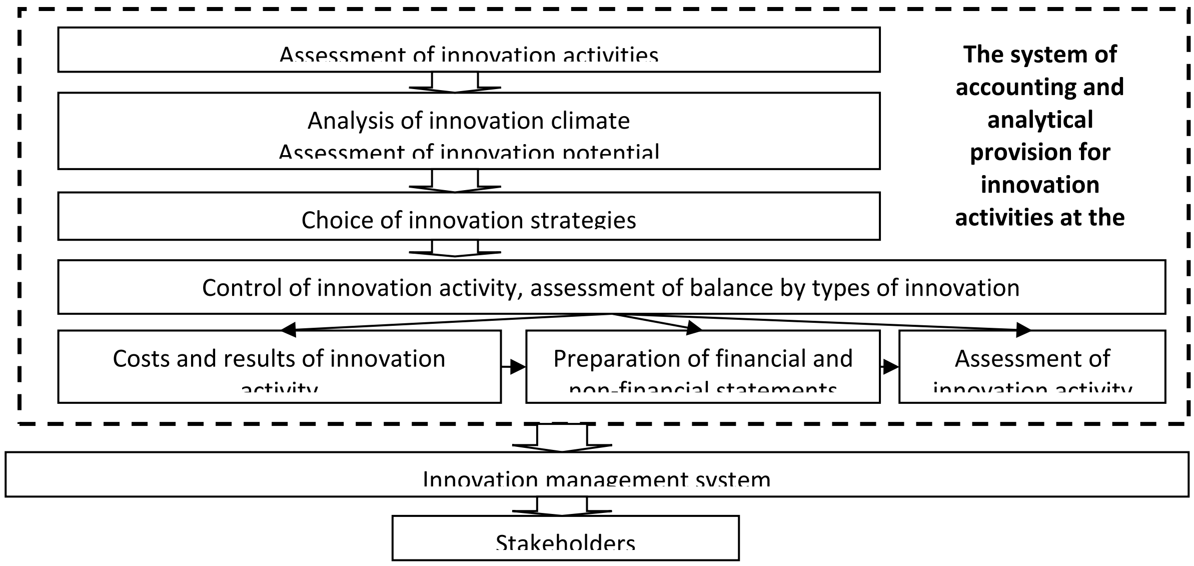

Fig. 5. Analytical provision for innovation activities within the company. *Source: Source: Own research*

Mutanov, Ziyadin, and Shaikh investigated the problem of improving the efficiency of eco-innovative projects aimed at ensuring sustainable development [*22*]. The researchers suggest evaluating innovativeness, competitiveness and environmental efficiency on the basis of graphical models.

Analytical support for innovation management should take into account stakeholder engagement, which plays an important role in all types of innovation processes, not only in business model innovation [*23*]. The stakeholder engagement system includes identification of stakeholders, gathering information on key stakeholders, identifying their interests, degree of influence on innovation activities within the company, and areas of influence; analysis of opportunities and prospects for stakeholder engagement; monitoring and evaluating the effectiveness of stakeholder engagement. For identification, it is suggested to make a separate entrance evaluation card for each stakeholder. An initially created stakeholder map is the primary planning document and will continue to change as the project progresses. The stakeholder engagement system is effective when the company goals are understood and accepted by all the stakeholders, i. e. nothing causes counteraction and all actions of the stakeholders are aimed at meeting the common goals. According to the authors of the present paper, the principles of effective cooperation with stakeholders to ensure the efficiency of the innovation activities within the company are significance, completeness and responsiveness. Significance requires knowledge of what is truly important for stakeholders; completeness is based on understanding the needs of stakeholders, ability to influence their expectations and perception of results; and responsiveness requires the ability to take adequate actions on issues that are relevant to stakeholders and companies.

3. Methodical approach to evaluation of innovation activities within the company

We suggest starting an analysis of innovation activities by selecting approaches to solve the issue of evaluating the company's ability to implement innovation projects and outline promising areas of development. The basis of information for evaluating innovation activities within the company is the data retrieved from accounting reports, planning and financial documentation, research and development papers of the company, statistical reports, and expert opinions in the field of innovation. The subjects of carrying out evaluation of innovation activities are specialists in managing innovative processes in a company, i. e. business analysts. We suggest dividing the system of indicators to evaluate innovation activities in a company into two groups — indicators that characterize the innovative potential and indicators that characterize the innovative climate. Each of the indicators in these groups can be expressed qualitatively and quantitatively. To assess the innovative potential, we selected the groups of indicators that characterize the material, technical, personnel, financial, and information and communication potentials.

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According to Bondarenko et al.[*24*], the innovative climate includes the factors of micro- (market) and macro-environment. Therefore, the groups of indicators that characterize the social infrastructure, technological and scientific-technical fields, economic and financial, political and legal sectors have been selected to evaluate the innovative climate. An instrument for evaluating the elements of innovative potential is a SWOT analysis. According to the latter, each element of the potential based on the nature of its impact on the company's activities is defined as S (strong), N (neutral) or W (weak) (Table 1). As a neutral evaluation, the average market value of the potential element is recommended in this case. The integral value of the innovative potential in a resource block is determined by the number of its strengths and weaknesses. When working on the contractual topic "Development of Recommendations for Improving Strategic Management Accounting and Analysis to Ensure the Economic Security of the Subject of Economic Activity in the Context of Adaptation to Market Conditions", the developers evaluated the innovative activities of the five Ukrainian machine-building enterprises. The results for Enterprise 1 are shown in Tables 1-2 and Fig. 6.

Table 1. Evaluation of the innovative potential for Enterprise 1. *Source: Source: Own research*

No	Indicators for evaluating the innovative potential by blocks	Qualitative evaluation of the position		
		strong (S)	neutral (N)	weak (W)
1	material and technical resources			
1.1	equipment and tools availability	+		
1.2	supply of raw materials, fuel and energy		+	
1.3	area, communications and transportation availability		+	
1.4	effective application of material and technical resources (material intensity, capital intensity, capital efficiency, profitability of fixed assets)	+		
2	manpower (staff)			
2.1	number of staff associated with innovation	+		
2.2	structure of the personnel engaged in innovation activities within the industrial production personnel			+
2.3	composition and qualification of management personnel			+
2.4	list of specialists and their qualification	+		
3	financial resources			
3.1	share of money for development			+
3.2	own sources of funds available to finance scientific researches		+	
3.3	use of long-term sources in financing innovation activities	+		
3.4	working capital provided for the innovation activity		+	
4	information resources			
4.1	databases accessibility		+	
4.2	patents availability	+		
4.3	communication resources availability			+
	overall score	6	5	4

The factors of the company's macro-environment (macro-climate) (Table 2) are evaluated the same way as the innovative potential with each factor of the macro-environment affecting the innovative development of the company to be evaluated as an opportunity, a risk or one with neutral influence. The integral value of the innovative climate condition is determined by the number of opportunities and risks.

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Table 2. Evaluation of the innovative climate at Enterprise 1. *Source: Source: Own research*

No	Indicators for evaluating the innovative climate by blocks	Qualitative evaluation of the position		
		opportunities (O)	neutral (N)	risks (R)
1	Social			
1.1	level of education	+		
1.2	level of social stability		+	
1.3	proportion of employees involved in scientific and research work	+		
1.4	new methods of managing social processes			+
2	scientific and technical			
2.1	quality of innovation infrastructure	+		
2.2	advanced production technologies (developed and implemented)		+	
2.3	volume of innovative products, works, services and supplies and their share in total production	+		
2.4	level of technology commercialization			+
3	Economic			
3.1	tax policy		+	
3.2	level of financing for the innovation activity			+
3.3	macro-financial stability		+	
3.4	the scale of budgetary spending on science and innovation			+
4	political and legal			
4.1	the level of state support for high-tech industries		+	
4.2	legal acts in relation to property rights		+	
4.3	international cooperation			+
	overall score	4	6	5

The evaluation of innovation activities within the company provides recommendations for defining or adjusting the innovation strategy. A four-dimensional SPACE matrix is used to determine the projected position of the company and the corresponding innovation strategy (Fig. 6) is modified according to the specifics of the tasks being fulfilled and integrated with the method of the SWOT analysis. In the SPACE matrix, the coordinates that reflect environmental factors are opportunities and risks (O, R) due to the innovative climate. The coordinates that reflect the factors of the internal environment are the strengths and weaknesses of the innovative potential (S, W). The number of strengths and weaknesses of the innovative potential are reflected in the positive and negative values of the abscissa (X) axis, and the number of opportunities and risks are represented on the positive and negative section of the y-axis (Y), respectively. The specific values of the indicators plotted on each axis are joined with straight lines resulting in a quadrilateral. The polygon side, which is at maximum distance from the centre, shows the vector of company development and, thus, the most innovative strategy under the given conditions. This procedure of evaluating the innovative potential and innovative climate is carried out for each scenario.

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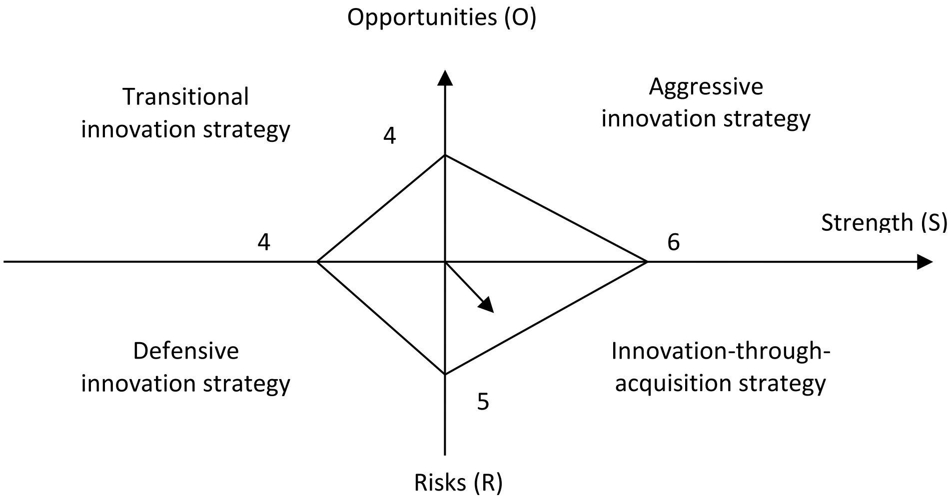

Fig. 6. SPACE matrix for defining a promising strategy. *Source: Source: Own research*

According to the foreseen alternative scenarios of environmental development as well as the existing innovative potential, there are four possible options for the company's position on the SPACE matrix, namely:

- position in S–O quadrant. The company has a high level of innovative potential and opportunities for innovative development driven by a favourable innovative climate. This is the best position in the matrix and the company is recommended to implement an aggressive strategy aimed at improving its competitiveness through the independent development of fundamentally new products and active work on fundamentally new innovation projects. The aggressive strategy requires high qualification and experience of the employees in innovations and a certain reserve of different types of resources. The implementation of this strategy is associated with significant capital investment and is characterized by an increased level of risk,
- position in S–R quadrant. The position identified for the company is characterized by an unfavourable innovative climate. However, there are some resources to reduce the negative impact of external threats. In order to maintain competitiveness and further innovative development of the company, it is recommended to implement an acquisition strategy focused on introducing innovative solutions. Such a strategy may not fully contribute to the achievement of the company's overall objective, but it does create the conditions for a balanced allocation of resources between conducting its own research and acquiring licenses and the know-how,
- position in W–O quadrant. The position defined for the company is characterized by the presence of certain external opportunities for the development due to a favourable innovation climate despite a low level of innovative potential. Under these conditions, the company is recommended to use a product differentiation strategy or innovation projects to maintain their competitive position in the market. Such a strategy will allow the company to occupy its own niche and evade direct competition with giants in the market and to use external opportunities for development of innovative potential,
- position in W–R quadrant. The position identified is the worst for the company, as the company does not have sufficient resources to reflect the external risks caused by the unfavourable innovation climate. In view of this situation, the company is recommended to employ a defensive strategy that minimizes risks and reveals hidden reserves for the development of innovative potential by carefully selecting promising innovation projects and paying special attention to the production and marketing sectors in the process of their implementation. The main purpose of this strategy is to select innovation projects that ensure the company to maximize profits in the short term to stabilize its position.

According to the accounting data for Enterprise 1, the company is recommended to implement an acquisition strategy focused on introducing innovative solutions.

To evaluate the effectiveness of innovation management, we suggest calculating the following indicators:

1. Growth rate of intangible assets (IA), GRIA:

$$GRIA = (IA_1 - IA_0) / IA_0 \quad (1)$$

2. Growth rate of net profit (NP), GRNP:

$$GRNP = (NP_1 - NP_0) / NP_0 \quad (2)$$

3. Growth rate of sales volume (SV), GRSV:

$$GRSV = (SV_1 - SV_0) / SV_0 \quad (3)$$

4. Sales expansion rate (S), SER:

$$SER = (S_1 - S_0) / S_0 \quad (4)$$

5. Innovation commercialization rate (C), ICR:

$$ICR = (C_1 - C_0) / C_0 \quad (5)$$

6. Eco-costs rate (Ec), ECR:

$$ECR = (Ec_1 - Ec_0) / Ec_0 \quad (6)$$

This is of particular relevance in the context of implementing the sustainable development concept, which provides for the compilation of appropriate G4 reporting to present information about the impact caused by the company's activities on the economy, environment and society. By including the indicators used to evaluate the efficiency of managing the innovative activity in the Sustainability Report of the enterprise (namely, in the section on corporate governance quality indicators) we make it possible to ensure balance of interests of stakeholders.

Thus, the scenario of choosing an innovative strategy is refined taking into account a specific strategy and efficiency of managing the innovation activity within the company. This allows identifying promising areas of the activity and evaluating the priority of developing innovation projects.

We agree with Slinták, Briš and Jurigová [*25*] regarding the priority of innovative solutions that implies the implementation of such measures resulting in the achievement of the objectives of innovation activities with minimum expenses but maximum economic effect. In doing so, the results of evaluating a company's innovation performance can be used to develop a marketing strategy to become an industry leader [*26*]. Brodowska-Szewczuk [*27*] presents the determinants for the development of innovative activities within the company in terms of economic competitiveness. To evaluate the company's innovation, researchers are offered tools of competitiveness such as an analysis of the introduction of new products, product quality, and evaluation of relationships between stakeholders. According to the researchers, the internal capabilities of a company to innovate [*27*] are presented by an increase of productivity or production capacity, modern methods of production and service, cost reduction, improvement of work processes, innovations in management. The consequences of this approach are as follows: increased number of customers, growth in a market share, enhanced brand awareness, expanded market outreach, increased profitability of production and services, higher revenues and net income growth. Pesti et al. also emphasize the importance of the four aspects (4P) of an innovation research including Product Innovation (that is, changing a product or service offered by a company),

Process Innovation (changing the way you create and deliver services and products), and Position Innovation that changes the context of Product Innovation Paradigm implementation, which alters mental models [*28*].

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Many experts offer to create a subsystem for monitoring the processes of increasing investment potential, whereby the company can track the indicators of the investment potential level through feedback channels and implement innovation projects to increase them.

The study of the theoretical and practical developments carried out by these scientists suggests that they have deepened the theoretical foundations and practical tools for analyzing innovative activities within the company. However, the analytical provision for managing the innovation activities requires improvement in order to evaluate the prospects for the company's development considering the goals of stakeholders — this issue determined the choice of the research topic.

Impact

Evaluation of innovation is an element of analytical support for general management, which affects the economy by improving the company's efficiency and sustainability. Business efficiency can also be enhanced by improving business processes. However, there are some limitations and risks that need to be identified. First, the resources owned by the company are limited; thus, they should be sufficient to finance on-going activities and implement innovation projects. Secondly, innovation is associated with a higher level of risk, and therefore innovation risks also impose limits on the scope of innovation projects. The third and the most important limitation is the need to consider and reconcile the interests of key stakeholders. All innovation projects implemented should comply with the interests of the relevant stakeholder group without running counter to the interests of other stakeholder groups. However, the approach to analytical provision for innovation management should be based on the belief that it is intended to provide opportunities and not to limit them. Therefore, the impact on the economy through the introduction of analytical support for the innovation management taking into account the interests of stakeholders has the following characteristics:

- better management of the company's innovation and reputation,
- comprehensive assessment of the external business environment including the development of markets and the identification of new strategic opportunities,
- building trust between the company and its stakeholders,
- receiving information from stakeholders that may lead to improvements in business processes,
- informing and influencing the stakeholders and the business environment to improve the decision-making process and facilitate the commission of acts that affect both the enterprise and society,
- and building the company's image as a socially responsible business unit.

It should be noted that the impact of innovation on the economic, environmental and social efficiency of production should be evaluated based on a systematic and structured accounting and analytical information and reflected in non-financial statements, in particular, the G4 Sustainability Reporting. In view of this, we consider it advisable to supplement the sustainability reporting with the indicators that characterize the effectiveness of innovation management.

Conclusions

Today, the economic growth and economic development of domestic enterprises depend on the conditions of the innovation activities, the analysis and evaluation of which defines opportunities for creating and implementing innovation and raises interest among stakeholders. The success of innovation depends on the availability of specific methods aimed at making the most objective decisions in the field of enterprise innovation policy.

The novelty of the present research comprises a methodological approach to the evaluation of innovation activity by comparing the innovative potential of the company and its innovative climate. This allows taking into account the specifics of the company's activities, choosing among various indicators as well as presenting the results in a graphic format to further define the most promising and realistic strategy.

Based on official statistics, generalized conclusions have been made about the number of innovation products developed and sold as well as the amount of financing for innovation activities, types of innovation, the amount of costs spent on innovation, etc. However, in the context of innovative development these indicators do not allow making objective conclusions about the prospects for the development of innovation activities at an enterprise.

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The development of a methodology for the analysis of an innovation activity will help to increase the level of the latter and provide an opportunity to choose an effective strategy for innovative development. In addition, the application of the suggested analysis method makes it possible to evaluate the prospects for the development of an innovation activity within the company and creates additional motivation for the implementation of innovation projects, thereby increasing the economic sustainability of the enterprise.

Considering the interest of stakeholders in the innovation cycle contributes to timely provision for resources and growth of innovation and business activities, creation of favorable conditions for doing business, prompt decision making and implementation processes. In general, in order to stimulate innovation activity, businesses are recommended to:

- pursue policies aimed at creating opportunities for the development and marketing of innovation products. For this purpose, it is necessary to pay special attention to measures aimed at increasing the efficiency of the scientific and production foundations of the enterprise,
- increase the consumer properties of the manufactured products (this will enhance the company's competitiveness),
- provide an opportunity to improve the level of scientific and technical employees' qualifications at the enterprise,
- maximize the use of the available technological potential in combination with the funds invested in the development of new or modernization of existing products,
- develop a system of staff motivation to overcome resistance to changes related to the implementation of the innovation development strategy.

It is also recommended to evaluate the effectiveness of innovation using the indicators that may be included in the section on Corporate Governance Quality Indicators in the G4 Sustainability Reporting.

Conflict of interest
The authors have no conflicts of interest to declare.

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PHOTOVOLTAIC SYSTEMS – TYPES OF INSTALLATIONS, MATERIALS, MONITORING AND MODELING - REVIEW

Angelika Anduła
Lodz University of Technology, Faculty of Process and Environmental Engineering
213 Wolczanska St., 90-924 Lodz, Poland, angelika.andula@wp.pl

Dariusz Heim
Lodz University of Technology, Faculty of Process and Environmental Engineering
213 Wolczanska St., 90-924 Lodz, Poland
https://orcid.org/0000-0002-1036-5818

Abstract
Photovoltaic systems have become a common solution for, both small residential buildings as well as large service buildings. When buildings are being designed, it is important to focus on the aspect of the object's energy efficiency as lowering the energy consumption of a given facility is crucial. The article discusses the use of photovoltaic panels such as so-called BAPV (Building Applied Photovoltaics) and BIPV (Building Installed Photovoltaics) installations as well as photovoltaic thermal systems (PV/T), which generate both electricity and heat. The role of PV installation in so-called zero energy buildings and proposals for future research and solutions are also discussed.

Keywords
photovoltaic systems, BIPV, BAPV, PV/T, energy sources, modeling

Introduction
Photovoltaics is the field of science dealing with the production of electricity from solar radiation. The sun's rays falling on the surface of a photovoltaic cell gives rise to a photoelectric effect. As a result of this phenomenon, the positive and negative ions are separated and directed towards the opposite surfaces of the cell, thereby generating electrical voltage. In this way, photons falling on the surface of the cell cause a flow through the DC circuit. The electricity produced by the photovoltaic system is constant current, while the alternating current (AC) is being charged from the grid. In order to be able to supply electrical equipment in the home, a power inverter, also known simply as an inverter must be used. Its purpose is to convert direct current (DC) into alternating current. The inverter also provides information on the performance of the installation at a given moment or time. The parameters of the generated current are dependent on the insolation and the number of photovoltaic panels included in the entire installation. Therefore, the intensity of the current depends on the amount of sun, while the voltage and power of the installation depends on the number of connected panels (the more PV panels, the greater the installation's power).

PV solar panels are a versatile solution due to the possibility of assembly, both on buildings with flat or sloping roofs or on the facade of a building (a wide range of fasteners allows maximum use of available space), as well as on the surfaces around them. The panels are easily integrated with the building itself, so that a limited installation area around the building is not a problem. The most important is that they provide energy production from a renewable energy source (RES) "on site", which is also a great advantage [1]. This is an extremely important issue, especially in large urban agglomerations, where the demand for electricity is very great and space for large installations is relatively small [2].

The limitations encountered from the usage and depletion of fossil fuels has contributed to the need for taking action to reduce greenhouse gas emissions. An interesting aspect in this era of pressing need to use renewable energy sources are the so-called zero-emission buildings. These are buildings with almost zero energy demand. In order for such buildings to be created, technologies limiting energy consumption should be used and the potential of unconventional energy sources such as solar installations should be utilized [3].

Methods

1. Materials

Technological innovations have affected the photovoltaic panel market by introducing more and more new

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solutions. In addition, the growing number of producers and ensuing increase in competition has resulted in a gradual decrease in the prices of solar panels. As a result, interested parties can find financially viable modern solutions [4].

The three basic divisions of photovoltaic panels:

- monocrystalline panels - a single crystal cell is made of one crystal. As a result of technological processes in manufacturing, single silicon cylindrical crystals are obtained, which are then cut into thin polygonal plates that are used in panels. The two most important advantages of photovoltaic modules composed of monocrystalline cells are high efficiency (in the case of currently manufactured modules on an industrial scale is up to 25%) and long life (at least 30 years). High efficiency is obtained because of precise, equal orientation of the crystal structure in one direction. Panels built of these links are black, although in the sunshine they appear navy blue,
- polycrystalline panels - consist of many silicon crystals. The efficiency of high-quality polycrystalline photovoltaic cells is not significantly lower than that of monocrystalline cells, the max. is 21% (average 12-14%). Due to their reasonable value for money, they are most often chosen by investors. Panels built of polycrystalline cells are blue,
- thin film panels - among this group can be distinguished amorphous silicon panels, CdTe panels as well as CIS and CIGS panels. The advantages of this group include low price, low weight (due to which they can easily be attached on the facades of buildings) and low susceptibility to high temperatures. However, these advantages tend to lower the efficiency of panels and raise costs of additional system devices (investment in a more expensive installation).

Fig. 1. Silicon solar cells with difference in structures of construction – monocrystalline, polycrystalline and amorphous. *Source: [5]*

The values of power output, specific energy yield, normalized power output as well as efficiency and performance ratio for monocrystalline and polycrystalline modules have been analyzed by Marzaei and Mohiabadi [6]. The test was conducted during 2014 in an outdoor environment in southeastern Iran. This site is characterized by semiarid climate conditions; hot and dry summer and relatively cold winter; the humidity values are generally below 25% and can reach 40% in cold months.

It was shown that due to the different light absorbing and thermal characteristics of each panel, the performance of monocrystalline module decreases with increasing monthly ambient temperature. The monthly average efficiency of a monocrystalline module showed a gradually decreasing trend in months with a higher ambient temperature, while the polycrystalline modules showed an inverse behavior [6].
As expected, the summer months of June and July appear to have the greatest amount of sunshine, which leads to the best specific energy, while for both modules, the least amount of specific energy is produced during the darkest winter months, November–February. This is shown in Fig. 2.
By comparing the results, it is also possible to observe that in non-summer months, the monocrystalline module had a significantly higher specific energy than the polycrystalline module, while during the summer months, this value for the polycrystalline module is higher [6].

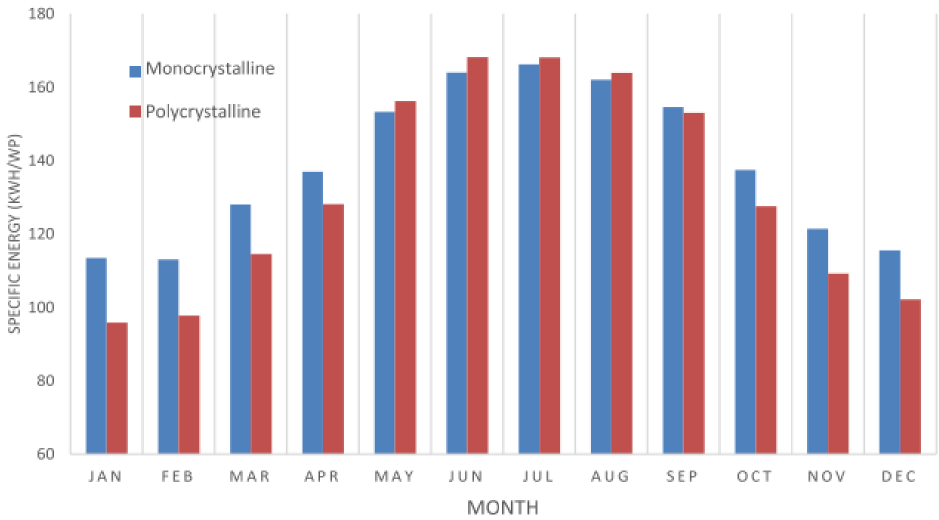

Fig. 2. Monthly total energy generated over the monitored period. *Source: [6]*

2. Types of PV installations – BIPV, BAPV, PV/T

PV (photovoltaics) systems are a new element in the design of building facades. Currently, two types of photovoltaic systems can be distinguished: BIPV (Building Integrated Photovoltaics) and BAPV (Building Attached Photovoltaics). The first are systems directly integrated with the building. The second consists in adding photovoltaic facades to the building surface using a separate assembly system.

The idea of BIPV is to use photovoltaic elements as a component of traditional building components serving, for example, as windows, roofing or other glass elements on the facade or roof. These installations are intended to perform the functions of the elements they replace, e.g. they constitute roofing in place of traditional materials, additionally they positively affect the external aesthetics of the building [7]. BIPV systems come in a variety of forms such as transparent, opaque and translucent modules, as well as a thin photovoltaic film. PV panels can be vertically mounted on the surface of the building wall, but also at an angle, for example, as a shading overhang. Installation is also possible on roofs (Fig. 3). It is worth noting that cells installed at an angle on the building's wall generate higher energy gains than in the case of horizontal or vertical installations, which results from a more favorable angle of incidence of solar radiation. The BIPV installation generates electricity, which can be used to power various receivers inside buildings, as well as emits heat, which arises during photothermal energy conversion of solar radiation. In addition, glass modules (semitransparent systems) partially transmit solar radiation to the rooms inside the building. By using cells as shading elements, the amount of radiation reaching rooms can be additionally adjusted to avoid overheating. BIPV installations are an interesting alternative in regard to high-rise buildings, for example offices located mostly in dense buildings of city centers. However, when considering this solution, it should be remembered that increasing the surface covered with panels reduces the surface of windows, and thus glazing, that is, the effective surface illuminating the interior of the building with daylight [8].

BAPV systems are the most frequently used systems. In the case of photovoltaic modules, the installation does not affect the transference of solar radiation, but it also generates electricity [9].

Compared with BAPV systems, BIPV systems are more expensive and can cause complications in structures such as difficulties in maintenance and mounting [9].

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Fig. 3. Flat and tilted panel installation over building roofsand facades. *Source: [10]*

Photovoltaic-thermal (PV/T) systems are also worth noting. To improve the efficiency of traditional photovoltaic systems, hybrid photovoltaic and thermal collector systems have been developed. A photovoltaic-thermal system handles both the generation of electric power and collection of thermal energy simultaneously. Studies by Jia et al. and Sultan and Efzan [11- 12] presented that the applications and developments of PV/T systems defined the appropriate environmental conditions and applications for different kinds of this systems. A photovoltaic/thermal hybrid (PV/T) system is an integration of photovoltaic and solar thermal components. It consists of conventional thermal collectors with an absorber covered by a PV layer [13]. The PV modules produce electricity and simultaneously the absorbed thermal energy is transported away by the working fluids. As a result, the PV efficiency improves. The advantages of such systems include: using much less space (than installing two separate systems with PV and thermal collectors) more electricity and heat are produced; installation costs are lower than for two separate systems; using the PV/T system, the uniformity of architecture on the roofs can be maintained; the total energy efficiency of the PV/T collector is higher than that of conventional PV systems and conventional thermal collectors [11]. PV/T collectors can be classified into four basic types. For example, as Zondar and colleagues reported [14] there are sheet-and-tube PV/T collectors, channel PV/T collectors, free flow PV/T collectors and two–absorber PV/T collectors, as shown in Fig. 4.

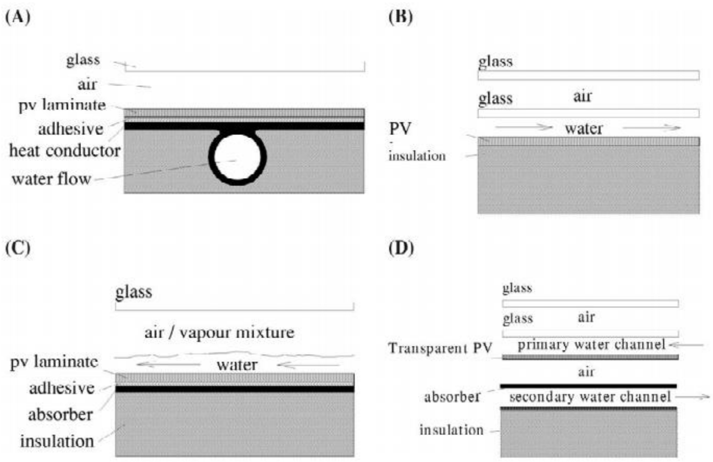

Fig. 4. Various collector concepts: (A) sheet-and-tube PVT, (B) channel PVT, (C) free flow PVT, (D) two-absorber PVT (insulated type). *Source: [14]*

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3. Energy production from PV

To achieve the highest possible energy gains generated by PV panels, at the design stage it is necessary to choose the best location of panels on a given object, taking into account the most favorable orientation, as well as the angle of inclination, so that sunlight will be at the highest level. Electricity in photovoltaic systems is produced only during the daytime, when the sun is out. The greatest energy gains can be counted primarily in the summer, as presented in the analysis by Anduła and Heim [15] in Fig. 5 and Fig. 2 where two types of PV panels were compared [6].

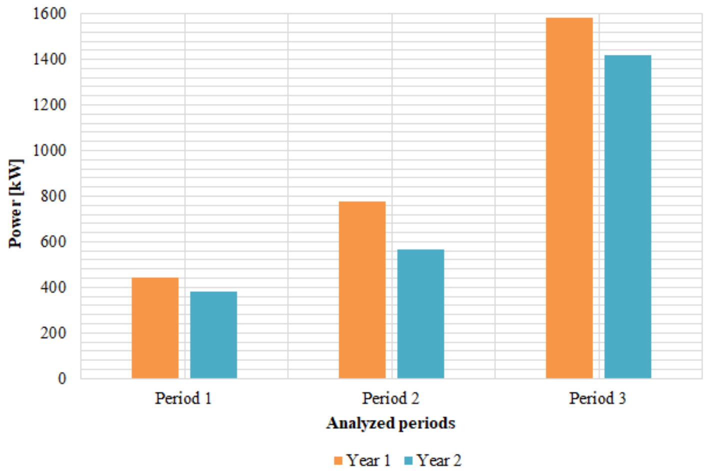

Fig. 5. Energy power generated by the PV façade. *Source: [15]*

A photovoltaic installation consists of eight PV panels, each panel at maximum capacity has a maximum power of 80 Wp. The study was conducted during three periods over the years 2015-2017: during the period of greatest demand for lighting, i.e. in the winter (October-February), during the period of average lighting demand, i.e. transition period (March-April and September) and in the summer, when the demand for room lighting is relatively small (May-August). The exact breakdown of the two analyzed years and periods is presented in Table 3.

Table 3. Characteristics of the analysed years and periods. *Source: [15]*

	Year 1	**Year 2**
1 - Winter period	10.2015 - 02.2016	10.2016 - 02.2017
2 - Transition period	03 - 04.2016, 09.2016	03 - 04.2017, 09.2017
3 - Summer period	05 - 08.2016	05 - 08.2017

4. Monitoring and software

Choosing the right PV system depends on a number of factors. These include the visual effects one wishes to achieve, possibilities for adapting the facility to the assembly system, the amount of sun exposure a given facility receives, how effectively the installation is intended to be used in terms of energy production, as well as financial considerations. In addition, installed modules must be durable due to the difficulty and expense of replacement, for example on facades. It is therefore important to ensure, as far as possible, monitoring of the operation of the PV installation with the help of remote monitoring systems. The effectiveness of work in a specific situation for specific installations can be estimated by analyzing the profitability of investments using various types of calculators and types of software.

Wijeratne et al. [16] presented 23 solar PV design and management software and 4 smart phone or tablet applications for this purpose. The researchers analyzed their features against 15 key aspects of solar PV design and management.

The analyzed online programs and applications included, among others: EasyPV, EasySolar, PVOutput and CalculationSolar.com. Also 14 problems related to the design and management of PV were identified such as lack of detailed meteorological data, lack of information for energy prices or information on local building regulations. The results showed that many programs or applications simply do not meet many aspects relevant to the design and management of photovoltaic installations. The platform shown in Fig. 6 was suggested to create effective and efficient design solutions in the field of photovoltaics and to provide the following features:

- a localized data repository, which will include weather information, building regulations, energy consumption of various building sectors, utility prices, construction and maintenance costs, contract types, financial modes, carbon emission factors and government incentive schemes,
- efficient 3D model creation of the physical environment,
- comparison of energy input and output,
- PV layout design optimisation,
- simulated installation process and impact analysis,
- monitoring and inspection modules with auto diagnosing function;
- PV system performance recording,
- sensitivity analysis and scenario based decision-providing support [15].

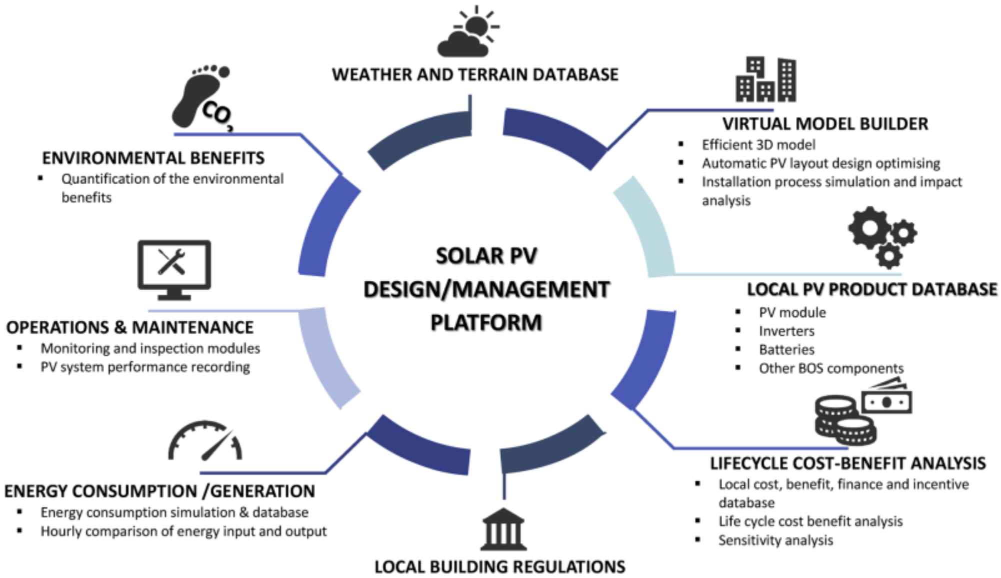

Fig. 6. Proposed platform for Solar design and management. *Source: [16]*

5. Mathematical models of photovoltaics and thermal panels.

An interesting solution is to create models of photovoltaic installations using computer software for objects with specific parameters. Such a model can help in the assessment of electricity production by a given installation [8, 17]. In addition, the successful implementation of PV systems requires an assessment of the potential of the system, which depends largely on exposure to solar radiation, which is different depending on the location [8, 18]. For example, Kovac et al. [17] described a model, which depicts the role of PV systems for small businesses. Single energy source models are quite accurate. Vulkan et al. [18] estimated the potential of electricity generation by BIPV installations in dense urban locations.

Castro et al. [19] presented a PV system model useful for steady state power flow tests of practical electrical networks. A characteristic feature of the proposed PV-based distributed energy resources (DER) power flow model is the consideration of three basic stages involved in solar energy conversion systems:

- PV arrays for the solar-to-electrical energy conversion,
- the DC boost converter along with the MPPT (maximum power point tracking) strategy,

The DC-to-AC power conversion by the VSC (voltage source converter) station enables the connection of the PV system to the AC grid.

A generalized model for distributed photovoltaic systems in power grids, i.e. generalized linearization of an n-bus AC network power grids containing *j* distributed photovoltaic systems, which in turn are comprised of *i* photovoltaic arrays each, is as follows [19]:

$$\begin{pmatrix} \Delta\mathbf{P} \\ \Delta\mathbf{Q} \\ \hline \mathbf{F}_{pvs1} \\ \vdots \\ \mathbf{F}_{pvsj} \end{pmatrix}^{(\gamma)} = -\left(\begin{array}{c|ccc} \mathbf{J}_{ac} & J_{mk1} & \ddots & J_{mkj} \\ \hline J_{km1} & \mathbf{J}_{pvs1} & & \\ \ddots & & \ddots & \\ J_{kmj} & & & \mathbf{J}_{pvsj} \end{array}\right)^{(\gamma)} \begin{pmatrix} \Delta\boldsymbol{\theta} \\ \Delta\mathbf{V} \\ \hline \Delta\mathbf{z}_{pvs1} \\ \vdots \\ \Delta\mathbf{z}_{pvsj} \end{pmatrix}^{(\gamma)} \quad (1)$$

$$\begin{pmatrix} \boldsymbol{\theta} \\ \mathbf{V} \\ \hline \mathbf{z}_{pvs1} \\ \vdots \\ \mathbf{z}_{pvsj} \end{pmatrix}^{(\gamma)} = \begin{pmatrix} \boldsymbol{\theta} \\ \mathbf{V} \\ \hline \mathbf{z}_{pvs1} \\ \vdots \\ \mathbf{z}_{pvsj} \end{pmatrix}^{(\gamma-1)} + \begin{pmatrix} \Delta\boldsymbol{\theta} \\ \Delta\mathbf{V} \\ \hline \Delta\mathbf{z}_{pvs1} \\ \vdots \\ \Delta\mathbf{z}_{pvsj} \end{pmatrix}^{(\gamma)} \quad (2)$$

Matrix J_{ac} stands for the conventional Jacobian matrix of the power grid. ΔP, ΔQ are the nodal active and reactive mismatch powers, respectively. Δθ, ΔV signify the nodal phase angles and voltage magnitudes, respectively. Entries F_{pvs}, J_{pvs} and $\Delta\mathbf{z}_{pvs}$ take the form of (3)-(5) for each of the distributed PV systems [19].

$F_{pvs} = -J_{pvs}\,\Delta z_{pvs}$, (3)

$F_{pvs} = [\Delta P_k\ \ \Delta Q_k\ \ \Delta P_0\ \ \Delta Q_0\ \ \Delta P_{pv}\ \ \Delta P_{loss}\ \ \Delta I_{opt}\ \ \Delta E_{opt}\ ]^T$, (4)

$\Delta z_{pvs} = [\Delta\theta_k\ \ \Delta m\ \ \Delta\phi\ \ \Delta B_{eq}\ \ \Delta\alpha\ \ \Delta G_{sw}\ \ \Delta I_{MPPT}\ \ \Delta E_{MPPT}\ ]^T$, (5)

The terms J_{km} contain the firstorder partial derivatives of the functions (6) with respect to the mth node of the AC system.
$\Delta P_k = -P_{kdc} - P_{dk} - P_k^{cal}$, (6)

The terms J_{mk} accommodate the first-order partial derivatives of the active power balance of the mth AC system node with respect to the nodal phase angle θk bus related to the point of connection of the PV system. At the end of each iteration (γ), the state variables of both the power network and the distributed PV systems are updated [19].

Das et al. [20] have developed a new thermal model considering the thermal contact resistances between different layers of a PV/T module along with solid contact resistances.
For one-dimensional heat conduction with uniform heat generation per unit area and incident radiation falling on the substance, the energy balance can be expressed in a simplified way by the formula, where R is thermal resistance, T_a – ambient air temperature, and G_T – solar radiation:

$\delta_{layer}\,\rho\,C_p \frac{dT}{dt} = \frac{\Delta T}{R"} + Q''_{generation} + h_{equivalent}\,(T-T_a) + G_T$, (7)

A portion of solar radiation incident on the front glass PV T is transmitted to PV layers, where then its part is absorbed by the PV cell. The expression $f\alpha_c\,\tau_g\,G_T$ denotes the amount of solar radiation absorbed by PV cell layers. $\frac{T_c - T_g}{R_1"}$ provides the conduction heat flux from the cells to the front glass and $\frac{T_c - T_g}{R_2"}$ provides the conduction heat flux from the cells to the back absorbing plate. The variable $\frac{i^2\,R_{internal}}{A}$ represents the area averaged Ohmic loss and the expression $\eta_c\,f\alpha_c\,\tau_g\,G_T$ represents the electrical output per unit area of the PV/T module [20]. Using the formula (7) for the PV layer, the following equation was obtained:

$\frac{dT_c}{dt} = \frac{1}{(\rho C_p)_{av}}\,[-(\frac{T_c - T_g}{AR_1"})-(\frac{T_c - T_{ab}}{AR_2"})+\frac{i^2\,R_{internal}}{A} + f\alpha_c\tau_g\tau_{EVA}G_T(t) - \eta_c f\alpha_c\,\tau_g\tau_{EVA}\,G_T(t)]$, (8)

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For the PV cell layer the average specific heat capacity becomes module [20]:
$(\rho C_p)_{av}= f(\rho C_p)_{PV}+ (1-f)\ (\rho C_p)_{EVA}$, (9)

The developed model can be applied under varied climatic conditions since it uses the ambient conditions as an input.

Interesting studies were conducted and described by Maadi et al. [21]. A coupled thermal-optical 3D model was developed, combining computational fluid dynamics and ray tracing to evaluate the performance of a glazed PV/T module. The greenhouse effect in the simulation had a significant effect on thermal efficiency, but the electrical efficiency was not significantly altered by the greenhouse effect. The results indicated that increasing the tube number and bonding width have a significant effect on the temperature distribution of the PV cells, and performance of the PV/T module.

Impact

Solar installations are an ecological alternative to traditional energy sources whose negative impact on the environment is widely recognized. Thanks to solar installations the amount of consumption of raw materials such as coal can be reduced, which positively contributes to reducing emissions of pollutants into the environment, and consequently has a positive effect on people and the surrounding nature. It is a myth that the production of solar panels requires more power than they can produce during the entire period of their functioning. Solar panels have a lifetime of between 25 and 35 years. During this time, they are able to generate at least 10 times more energy than used for their production, and in countries with the highest saturation with this type of systems, this amount doubles.

Much of society remains convinced that solar power is still unprofitable and too expensive an investment. Of course, the actual result depends on the type of installation and the materials from which it will be made. This is discussed in detail in chapter 2 of the above work. Many state institutions aid citizens by offering various types of subsidies that make the cost of building installations much lower. In addition to economic concerns, many people are convinced that it is only profitable to build solar installations in countries where sunny days occur all year round. Such fears are not justified, as can be seen from many countries that invest in this technology where sunlight conditions are relatively similar to the United Kingdom. It should also be remembered that photovoltaic cells produce energy depending on the amount of sunlight delivered, and not depending on the ambient temperature. What's more, the panels work better at lower temperatures than at very high ambient temperatures (a decrease in power is associated with an increase in temperature), therefore, the amount of energy generated on a sunny winter day can be similar to the energy yield on a hot summer day. Low temperatures are beneficial for installations because the panels increase their voltage and energy yield.

Investing in PV installations is also beneficial for the economy. Many users, above all, those with on-grid installations (installations connected to the electricity grid) are not only consumers but also producers of electricity. Each photovoltaic micro installation can be connected to the network, thanks to which any surplus of produced energy can be discharged to the network, and then (depending on the regulations in force in a given country) the appropriate amount uploaded to the grid can then be downloaded when it is needed, which provides a huge benefit for both society and the state.

It should be mentioned that like all new technologies, PV installations also poses threats to people and the environment and work on improving their safety is an ongoing challenge for scientists. Standardization documents of European countries, as well as in the United States and Australia, draw attention to many threats, and display the correct ways of making photovoltaic installations and their protection. The small number of recorded accidents shows that the probability of a negative event occurring from a photovoltaic system is low, especially if the entire installation is designed correctly, made of good quality materials, has properly selected equipment and has been correctly maintained. Nevertheless, there are some potential threats posed by photovoltaic systems that have been noticed by various security experts in many countries. Many countries also pay attention to the level of safety service during maintenance of installations and in the event of random events related to fires of buildings on which solar panels are installed. Threats posed by a PV installation include fire hazard, a risk of electric shock (especially in the case of installers or system conservators) and a threat associated with damage to other electrical devices in buildings where the installation has been installed in the event of a possible failure.

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Solar installations are becoming an increasingly popular source of renewable energy. An important element that will allow for greater interest in solar systems in the future will certainly be the decline in the price of modules and the possibility of resale of produced electricity at even more favorable prices. Photovoltaic installation projects made in accordance with high standards and regulations will certainly significantly extend the lifetime of the investment. Correct installation and proper cable routing increase the efficiency of overvoltage and lightning protection. In addition, the use of lightning and surge protection systems will eliminate the risk of damage to photovoltaic installations that may arise because of lightning and power surges from power lines.

Conclusions

The article presents issues regarding the field of photovoltaics. The application of PV systems depends highly on climatic conditions. It is common that PV systems can transfer solar energy into electricity in summer, however in winter, additional energy input is needed to satisfy the supply of energy. It should be remembered that the largest production of electricity from photovoltaic panels takes place during the day, when solar energy is in abundance. In order not to lose the energy produced, the best solution is to use energy storage systems.

Future studies should examine materials from which it is possible to produce technologically better PV facades to expand the market with new materials meeting specific needs. As the demand for renewable energy sources is high, the market potential of PV provides a solution that will help solve environmental problems (solar rays are free, non-polluting and is an inexhaustible source) and introduce new technologies to the global market. To make this happen, a larger investment in accurate computer programs is needed, thanks to which it will be possible to run accurate simulations that provide modeling and designing of modern systems that meet specific needs.

Conflict of interests

There are no conflicts to declare.

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CHANGES IN WASTE PACKAGING MANAGEMENT AND IMPLEMENTATION TO ACHIEVE A CIRCULAR ECONOMY - POLISH CASE STUDY

Joanna Zarębska
University of Zielona Góra
9/9 Licealna St., 65-417 Zielona Góra, Poland, j.zarebska@wez.uz.zgora.pl

Berenika Lewicka
Technische Universität Berlin
Straße des 17. Juni 135, 10623 Berlin, Germany, belewiki@campus.tu-berlin.de

Abstract
Currently, within the European Union, the importance of resource efficiency is being highlighted. The issue has been well established within the Europe 2020 strategy and above all within the concept Towards a circular economy: zero waste for Europe'. Using the example of Poland, the authors show changes that have occurred in the management of packaging waste after Poland joined the EU. The data of the Central Statistical Office concerning both municipal and packaging waste allowed to determine changes in waste management and to address them, and the literature on the subject indicates gaps as well as barriers in this area. Building a circular economy (CE) for both packaging goods and waste from packaging in Poland not only requires increasing the involvement of enterprises but also the need for Polish society to be willing to embrace the objectives of the concept of "Zero Waste for Europe" in the European Union.

Keywords
packaging, circular economy, zero waste, waste management

Introduction
The Polish Ministry of the Environment defines circular economy (CE - Polish: GOZ) as "a concept aiming at rational use of resources and limiting the negative impact of manufactured products on the environment, which similarly to materials and raw materials, should remain in the economy for as long as possible and the generation of waste should be minimized as much as possible" (Ministry of the Environment 2019). A circular economy, to which the concept of 'cradle-to-cradle' (C2C) is closely linked, preserves the added value of products for as long as possible and aims to eliminate waste completely, thereby saving raw materials. It consists in closing the life cycle of products so that the product does not end up in a waste bin or landfill at the end of its life cycle but is reused through recovery, recycling, repair, refurbishment, replacement of parts or complete conversion into another good. This concept also applies to in-production recycling by companies and the so-called "waste exchange" (based on the principle of environmental communication and cooperation between different companies) (Zarębska 2019, p. 31-66).
The implementation of CE measures was initiated with the adoption of many programme documents by the European Community, (e.g. by the European Commission, the Council of the European Union, the European Economic and Social Committee and the Committee of the Regions).
The Treaty on European Union, whose main objectives are to achieve sustainable economic growth, sustainable production and consumption, a high level of protection and improvement of the quality of the environment, sustainable management of natural resources, etc., has been adopted by the European Community. These include:

- Directive 2008/98/EC - achieving the so-called "recycling society" amended Directive (EU) 2018/851, which emphasizes the promotion of the principles of circular economy (CE), strengthening efforts in the field of preparing for re-use and recycling of waste,
- COM(2011) 21 - A resource-efficient Europe - Flagship initiative under the Europe 2020 Strategy,
- COM(2011) 571 - Roadmap to a Resource Efficient Europe - Improving products and changing consumption patterns, improving production efficiency, transforming waste into resources, supporting research and innovation towards a resource efficient society,
- COM(2014) 398 - Towards a closed-loop economy: A zero-waste programme for Europe.

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The main objective of these documents is to achieve a waste-free economy, in which every commodity used (waste), and in particular packaging, is considered a valuable secondary raw material that needs to be reused for the economic cycle. CE is moving away from a linear model to a closed/circular waste management system. In the case of packaging waste it is considered 100% recyclable and wholesome recyclable secondary raw materials can be used as well.

Using Poland as the study example, the aim of the article is to show the dynamics of changes that have occurred in the management of packaging waste after Poland's accession to the EU, i.e. after 2004. The developed lists of municipal and packaging waste allow to determine changes in waste management and responses to them. On the basis of the literature review and analysis of the compilations, the authors identified exemplary gaps and barriers in this area. Removal of these barriers may lead to the acceleration of changes in waste management and lead to implementing a so-called "recycling society" in Poland.

1. Legal basis for the pursuit of a CE

Like other Member States, Poland's legislation must be adapted to meet EU requirements. However, in some cases, concessions have been made to EC directives by Polish national regulations. An example of this is the regulation concerning management of municipal and packaging waste. According to the Regulation of the Minister of the Environment regarding annual rates of recovery and recycling of packaging waste from households (Journal of Laws 2018, pos. 2306), Poland is bound by its obligations until 2020:

- up to 35% reduction of the mass of biodegradable municipal waste transferred to landfills,
- at least a 50% increase of the level of recycling, preparation for reuse and recovery by other methods of paper, metals, plastics, glass,
- at least 70% increase of the level of recycling, preparation for reuse and recovery of non-hazardous construction and demolition waste.

Table 1 presents a comparison of Polish and EU legislation as far as the planned percentage recycling rates for packaging waste by 2030. As shown, the planned percentage recycling rates of packaging waste in the years 2014-2020 (old) / 2018-2020 (new) were changed in the regulations in the direction of reducing the recycling rate, rather than increasing, as in COM(2014) 397. The EU assumes the elimination of waste to "zero", and within this concept, packaging waste is theoretically the easiest to recover and recycle in its entirety and to achieve the objectives of the Regulation. However, Polish national legislation has clearly slowed down efforts to make changes to achieve the highest recycling rates. This is likely a result of the municipal waste management policy, which is closely linked to lack of financing as well as shortcomings in introducing modern waste treatment technologies, cleaner production technologies, etc.

Despite small changes in the planned percentage recycling rates, the management of municipal and packaging waste in Poland is making dynamic changes. These changes are in line with the EU assumptions and are particularly visible in the multiannual financial statements covering the years from 2004, i.e. after Poland's accession to the EC.

Table 1. Comparison of Polish and EU legislation in terms of planned levels of recycling of packaging wastes. *Source: Source: Own research based on a study by Zarębska et al. 2018, p. 59; Journal of Laws 2018, pos. 2306.*

Type of packaging material	**Recycling and preparation level to reuse of packaging waste till end of the year [%]**						
	2014	**2020**	**2018**	**2020**	**2020**	**2025**	**2030**
	national legislation				**COM(2014) 397**		
	old		**new 2014 (2018)[1)]**				
Paper and cardboard	60	61	30	50 (24)	85	90	90
Plastic	22,5	23,5	30	50 (44)	45	60	60
Glass	60	61	30	50 (56)	70	80	90
Ferrous metals	50	51	30[2)]	50[2)] (34) (56)	70	80	90
Aluminum	50	51			70	80	90
Wood	15	16	-	- (0)	50	65	80
Multimaterial[3)]	25	-	40	61	By the dominant material		
Total	55-80	56	-	-	60	70	80

1) Levels are calculated together for all of the specified fractions of municipal waste. 2) Metal in general. 3) For multi-material packaging the recycling rate is the same regardless of the dominant material (Art. 25 paragraph 1 of the Act on packaging and packaging waste).

2. Changes in municipal and packaging waste management

According to Directive (EU) 2018/851 "municipal waste represents approximately 7 to 10% of all waste generated in the Union. However, it is one of the most complex waste streams and its management mode generally demonstrates the quality of the overall waste management system in a given country.

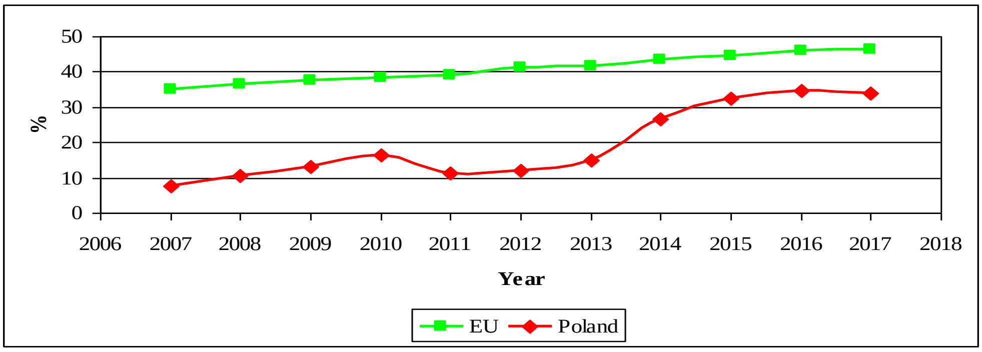

Fig. 1. Level of municipal waste recycling for the period 2007-2017 [%]. *Source: Source: Own research based on the Eurostat 2019 study.*

Changes in the management of municipal and packaging waste in Poland are particularly visible when the data for several or more years are compiled. Fig. 1 presents a comparison of the percentage shares of municipal waste recycling between 2007-2017 in Poland to the EU percentages. In the EU, the upward trend in municipal waste recycling has been linear, uniform and stable, while in Poland the growth has been uneven, depending on the year of compilation. Overall, there is a trend for Poland to approach the EU average, but the growth rate is quite slow. Fig. 2 presents the level of municipal waste recycling in 2017 in European countries (Eurostat 2019). Poland is ranked as the 9th country below the top EU average (28). At that time, its recycling rate was 33.8% and was lower than countries such as the Czech Republic (34.1%), Bulgaria (34.6%), Hungary (35%), Norway (38.8%), Finland (40.5%), France (42.9%), United Kingdom (43.8%) and Denmark (46.3%).

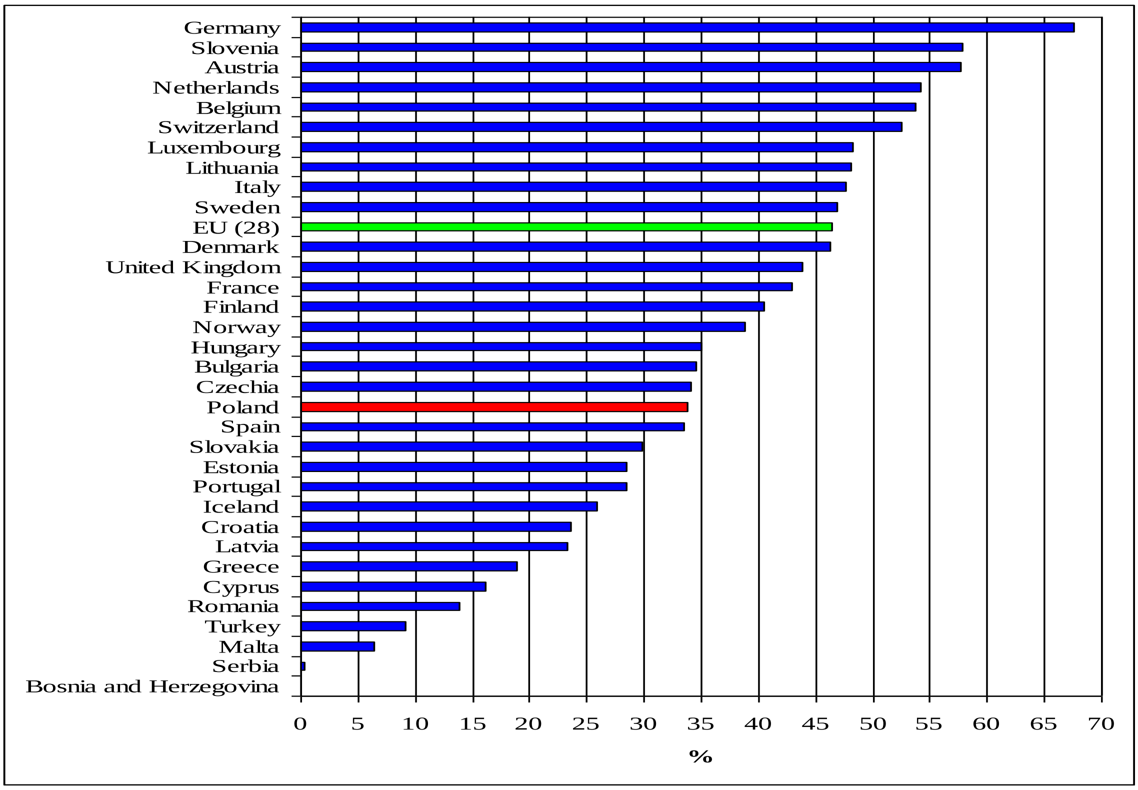

Fig. 2. Level of municipal waste recycling in 2017 by selected EU countries [%]. Source: *Source: Own research based on study based on Eurostat 2019.*

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Fig. 3 presents the percentage shares of packaging waste recycling during the years 2007-2016 in Poland in comparison to the EU average. In the EU, the upward trend in packaging waste recycling was linear, similar to that of municipal waste (Fig. 1). In Poland, the level of packaging waste recycling was 58%, which was not uniform, but approached the EU average of 67.2% in 2016 (Eurostat 2019).

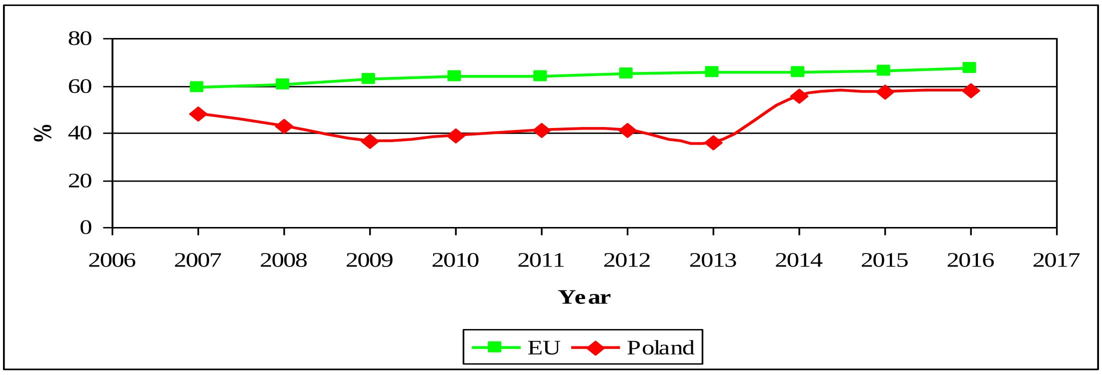

Fig. 3. Level of packaging waste for the period 2007-2017 [%]. *Source: Source: Own research based on the Eurostat 2019 study.*

The recycling rate of packaging waste in 2016 in selected European countries is presented in Fig. 4 (Eurostat 2019). In this comparison, Poland rated even worse than in the case of municipal waste, as it was the 15th country below the EU average (28). Its recycling rate of packaging waste in 2016 was 58%, while the European average was 67.2%.The highest ranked countries recycling rates were: Belgium (81.9%), Denmark (79%), Czech Republic (75.3%), Netherlands (72.6%) and Germany (70.7%).

Despite Poland's low position in Figs. 2 and 4 in relation to other European countries, the dynamics of change has been in favour of waste management and clearly indicates Poland's aspiration to implement the CE concept. These changes are particularly visible in the list of masses of collected municipal waste in Poland recovered or disposed of during the years 2004-2016 (Fig. 5). Increasingly more municipal waste is being recycled, composted or incinerated with energy recovery and continually less in landfills.

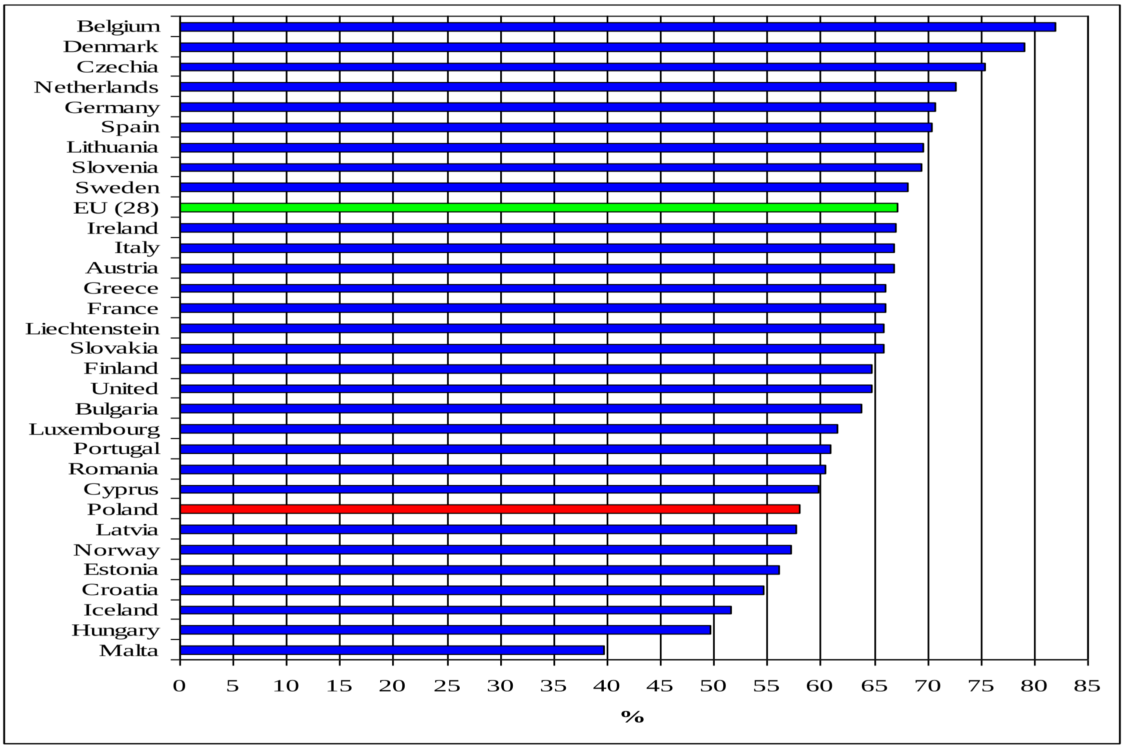

Fig. 4. EU countries packaging waste recycling levels in 2016 [%]. *Source: Source: Own research based on the Eurostat 2019 study*

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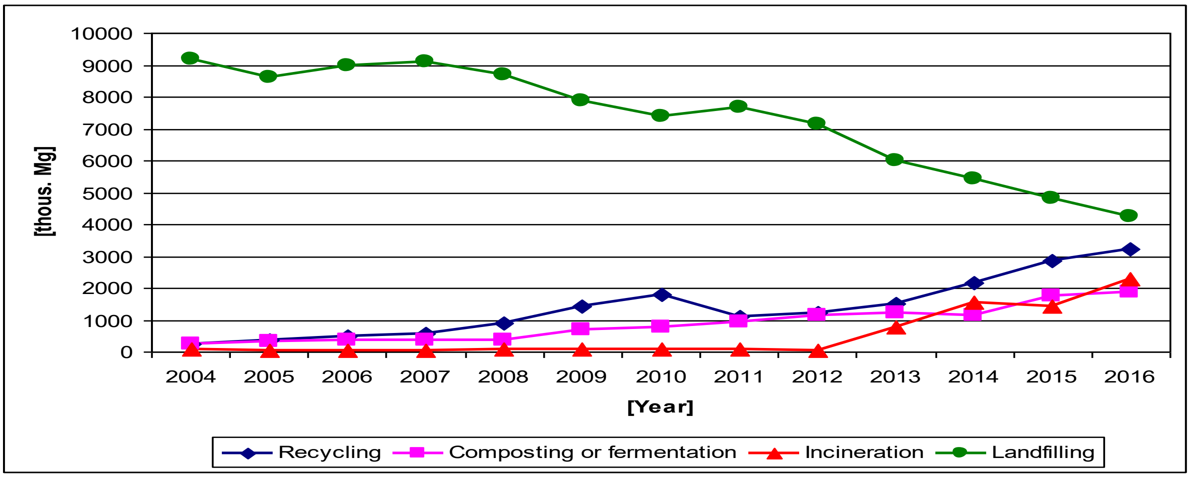

Fig. 5. Comparison of statistical data on the weight of collected municipal waste in Poland subjected to recovery or disposal. *Source: [Zarębska et al. 2018, p. 58].*

According to the Central Statistical Office (CSO - Polish: GUS) data, Poland has produced less municipal and packaging waste every year than in the other EU countries. In 2016, the average European generated 483 kg of municipal waste, while the average Pole generated 303 kg. However, it is worrisome that each year Poland has produced more municipal waste (in 2018, on average over 312 kg per capita; for example, in Białystok - 358 kg, and in Wrocław - 522 kg). Poland continues to send much waste to landfills, which is considered by the Polish and EU legislators to be the least desirable way of dealing with waste. Four Polish cities use landfills for almost 25% of the waste they generate, with the largest number of landfill sites being Łódź (27.6%), Rzeszów (25.8%), Kielce (24.3%) and Zielona Góra (23.8%). This is much considering the fact that by 2035 Poland is expected to reduce the amount of landfill storage to 10% by 2035 (CSO 2018).

Continually more packaging is being produced and introduced to the market, and thus in turn, more and more packaging waste is being produced. As shown in Fig. 6, more and more packaging waste is also being recycled and recovered.
Research conducted in Poland during the years 2015-2016 by Joanna Zarębska (Zarębska 2019) showed that according to respondents, the reason for the still low level of packaging waste recovery in households and lack of segregation is most often due to:

- lack of containers at the place of residence - 19.9%,
- lack of space at home for containers - 19.1%,
- lack of proper habits in waste segregation - 8.6%,
- lack of time - 7%,
- lack of faith in the proper functioning of the "at source" segregation system - 33%.

Of the respondents who declared themselves as persons segregating municipal waste, only 70% stated they segregate waste in all groups (paper, metal, plastic, glass separately). Additionally, 76% of respondents do not pay attention to labels and markings placed on the packaging, so they probably do not always segregate it correctly.

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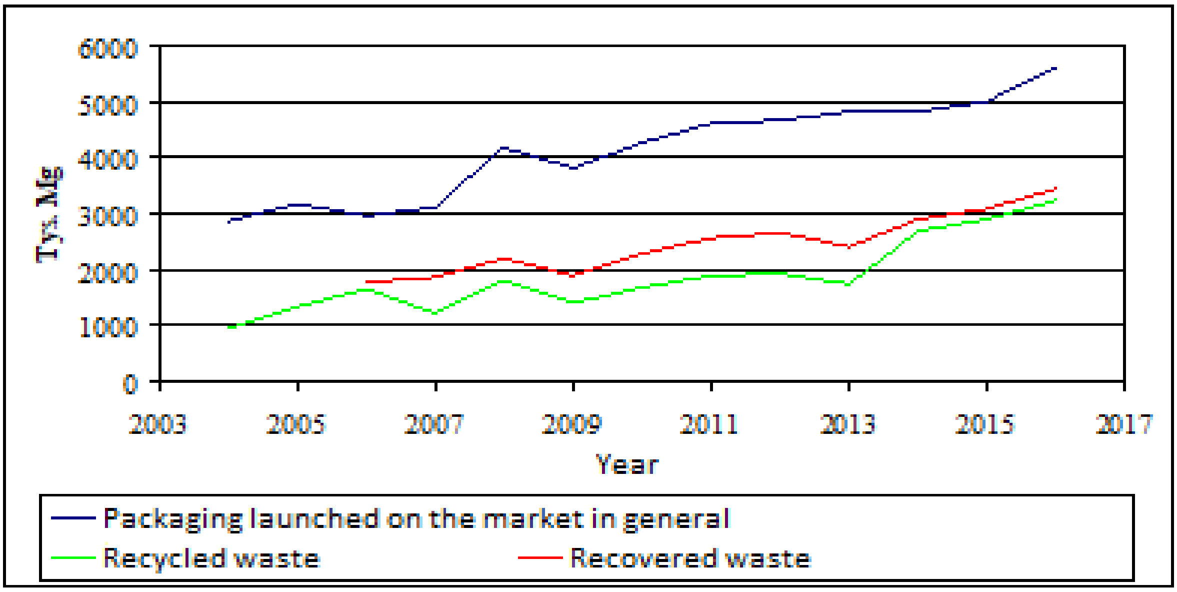

Fig. 6. Packaging launched on the market and achieved levels of recovery and recycling of packaging waste [in thousand Mg]. *Source: [Zarębska 2019, p. 43].*

Respondents see the possibility of increasing the effectiveness of the selective collection system for packaging waste by education of children, purchase of selected waste by large-area stores (supermarkets) and smaller housing estate stores, media information programmes and social demonstration actions concerning proper waste segregation (Fig. 7).

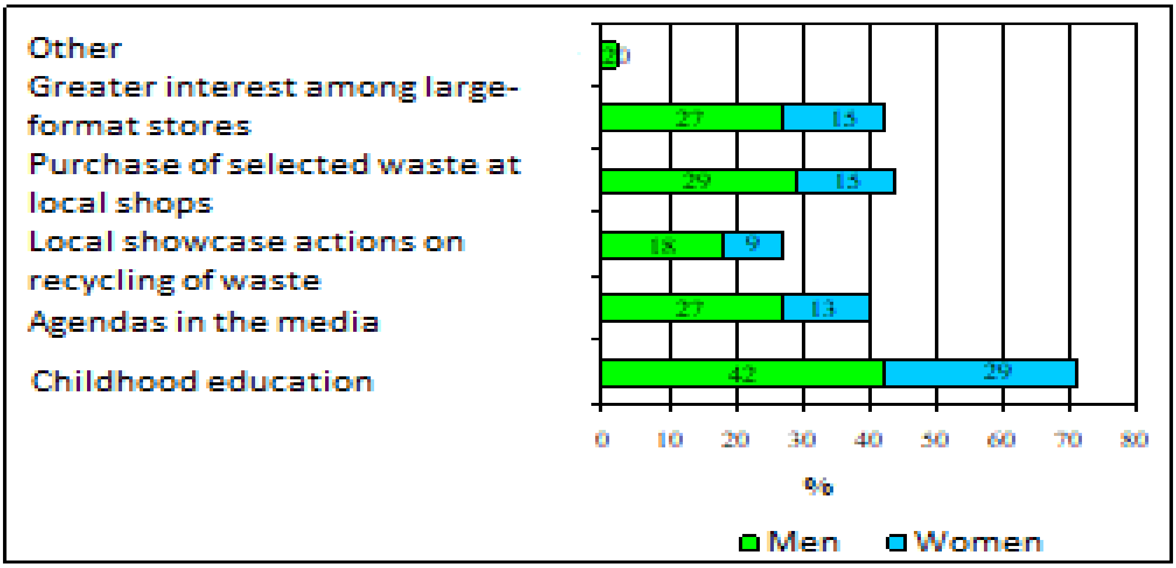

Fig. 7. Proposals to increase the effectiveness of the selective collection system for packaging waste. *Source: [Zarębska 2019, p. 265].*

The CE concept will not be achieved without the support of a "recycling society", so there is still much room for improvement and catching up to do. Effective waste management can be achieved by increasing the level of segregation of municipal and packaging waste in households, the involvement of citizens and businesses to increase the recovery and recycling of municipal waste, subsidizing the infrastructure of waste management, developing education and consumer awareness and unifying labelling on packaging and containers for waste.

Impact

Without introducing innovative system solutions, applying modern waste processing technologies and cleaner production methods, by 2025 Poland will not be able to match the European average level of municipal waste

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recycling (above 46%) and recycling of packaging waste (above 67%). By 2025, EU Member States will have to achieve a recycling rate of 55% of municipal waste, 60% by 2030 and 65% by 2035. This level is rather unrealistic to achieve in Poland, but nevertheless, can be achieved through the implementation of innovative measures, as well as increased education of the society and the most appealing option of economic tools. Unfortunately, economic tools are most often associated with increased fees for utilities, which are already high and which arouse widespread social discontent.

To solve the problem of municipal waste management (in particular packaging waste), in September 2019, the Council of Ministers approved the "Roadmap for transformation towards a closed-loop economy" prepared by the Ministry of Entrepreneurship and Technology. The closed-loop economy (CE) is rational, low-emission, innovative and competitive. The Polish GOZ road map is a signpost for the development of this economic system in Poland and indicates specific actions to be taken at all stages of the product life cycle, starting from raw material acquisition, through design, production, consumption, waste collection and management. As mentioned earlier, the implementation of the GOZ concept and the related increase in the recovery and recycling of packaging waste is not possible without a proper organisation process and product innovations. All these activities are aimed at reducing the uncertainty related to the achievement of ecological and economic success, which would be the implementation of GOZ intended to lead to a "recycling society". The involvement of the Polish society in specific activities of the "GOZ Roadmap" is already becoming visible, e.g. the use of biodegradable dishes and paper straws for beverages, reduction of packaging, use of reusable shopping bags, recovery of recyclable materials. However, these activities are not universally applied.

Conclusions

By studying the analysis of the Polish example in terms of the dynamics of changes in the management of municipal and packaging waste in the context of the CE, one can safely emphasize the great achievements made in this field. Positive changes can be seen in Poland’s national summaries over several years (Figs. 1, 3, 5), whereas in the summaries, which compare European countries and Poland (Figs. 2 and 4), there is a clear difference when compared to the leading countries. As continually more waste is produced by Europeans, it is highly important for the aim of the CE to intensify efforts to achieve high levels of recovery and recycling of municipal waste. This trend is particularly desirable in the management of packaging waste, which in practice should not be deposited in landfills or dumped in water.

Appropriate environmental communication between organizations of the entire waste management system (of which the public is an important link) may be helpful in establishing cooperation in the field of waste minimization (according to the concept of the "zero waste programme for Europe") and resource efficiency.

Conflict of interests

There are no conflicts to declare.

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RISK IN THE SCOPE OF RESEARCH AND INNOVATIVE TECHNOLOGICAL PROJECTS

Maria Richert
AGH University of Science and Technology, Faculty of Management
10 Gramatyka St., 30-067 Cracow, Poland, mrichert@agh.edu.pl
https://orcid.org/0000-0003-2233-6923

Rafał Hubicki
Grupa Kęty S.A.
111 Kościuszki St., 32-650 Kęty, Poland

Piotr Łebkowski
AGH University of Science and Technology, Faculty of Management
10 Gramatyka St., 30-067 Cracow, Poland

Joanna Kulczycka
Mineral and Energy Economy Research Institute Polish Academy of Sciences
7a Wybickiego St., 31-261 Cracow, Poland
https://orcid.org/0000-0002-4377-5506

Asja Mrotzek-Bloess
Clausthal University of Technology
9 Walther-Nernst-St, 38678 Clausthal-Zellerfeld, Germany

Abstract
Assessment and management of risk constitute the subject of many researches. Nevertheless, many more specific factors are applicable during the implementation of innovative technological projects. On the article identified risk factors, which have been supplemented, systematized and assigned to the individual risk categories. The risk assessment methods for R&D projects have been analysed, as well as the risk sheets have been developed for the R&D project through the use of dotProject application. Also shown that networking and clustering is a change for fruitful cooperation within difference EU projects, which create trust between business and sciences and reduce the risk.

Keywords
risk management, technological projects, innovations, research and development, cooperation

Introduction

One of the significant areas of enterprises' business activity is risk management, including limitation and reduction of its negative consequences, which may appear in various areas of business activity. The literature distinguishes many types of risk classification, related to business and financial activity. In more detailed aspect, it is possible to distinguish technical risk, management risk (for example: macroeconomic risk, legal risk, e.g. associated with increasing requirements in the scope of environmental protection), financial risk, organisational risk and technological risk. In the case of implementation of the technological innovations (product or process innovations), it is necessary to note the following: investment risk, risk of the lack of social acceptance or risk occurring in the supply chain.

For the purpose of limiting the consequences and improving the risk management processes, the ISO 31000:2009 standard concerning the risk management system has been developed, which was amended in 2018 (ISO 31000:2018, *Risk management - Guidelines*). Moreover, ISO published a new standard - ISO IEC 3110 *Risk management - Risk assessment techniques* in 2019, which offers more than 30 various techniques allowing for the identification and management of risk.
In addition, the risk management is an integral part of many project management methodologies, e.g. PRINCE 2, PMI or Ten Step. The PRINCE 2 methodology recommends that each project should have its own risk

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management strategy (that determines the risk management procedure adopted by the project, from its determination to the implementation), along with the control measures, i.e. risk register. The PRINCE 2 method proposes a risk management procedure that consists of 5 stages: identification, assessment, response planning, response plan implementation and communication, which is a repetitive task [2]. It is commonly used for project management, however much more specific factors may occur during the implementation of innovation, and they should be identified, as well as estimated. In the process of managing the innovative R&D projects, the key aspect consists of risk identification and assessment, while it should be taken into account that due to R&D, an enterprise can provide growth, profitability and survival to itself. There are also many instruments of EU policy related to innovation, fostering research and development or technology support by promoting collaboration between research and business, which can reduce the risk. [16, 19]

Methods

On the basis of literature review, analysis of research project documentations and experience of R&D project managers, the proposed risk management methods, identification and assessment of risk, as well as risk management methods have been reviewed. This allowed identifying the factors specific for R&D projects, which may affect the level of risk during the implementation of innovative technological projects. For the purpose of their systematisation, the analysed factors have been assigned to the individual risk categories, as well as the risk assessment methods for R&D projects have been analysed. Through the process of identifying risk factors and management methods for the selected case study, and through the use of dotProject application, the risk sheets have been developed for the R&D project implemented by the production company engaged in the manufacture of products made of aluminum. Besides, the technological and economic aspects connected with risk assessment, the organisational one, connecting with the integration of business, academic and research community to build long-term cooperation is discussed.

1. Identification and assessment of risk

For R&D projects, the literature indicated that the important problem in risk management of R&D projects is the difficulties in identifying and prioritizing R&D risks, because most of the R&D ideas are fuzzy, and the project management of R&D is largely poorly organized, forcing the waste of time and cost [14]. Moreover, the concept of risk has no unequivocal definition in practice [1]. The basic activity in the scope of risk assessment is its estimation, which is not synonymous with the protection against risk. It must be emphasised that in practice, there are no undertakings that would be risk-free, therefore firstly it is necessary to estimate the level of risk occurring during the implementation of projects. The simplest classification includes:

- low risk – occurs in the case of projects that are implemented with the use of previously applied methods, while the intended effects were previously achieved in other projects,
- moderate risk – occurs in the case of implementation of undertakings, which use so far unused methods, however the intended results are known from previous projects; this level of risk also occurs in the situations, in which we use previously used methods, but with intended results other than those achieved before,
- high risk – occurs in the case of using methods that were not previously implemented, while the intended effects are also completely new.

The risk assessment and classification methods include probability and impact method, risk sheets, expert assessment method, decision trees, cause and effect diagrams (e.g. PERT - Time, PERT - Cost, CPM0) and Monte Carlo method. In the case of a large number of threats, it is necessary to focus on the ones that are the most threatening to the project. The risk level is obtained by multiplying the weight of the project by the probability of risk occurrence. Moreover, it is necessary to prepare a tabular listing of all identified risks, which allows obtaining the project's risk profile. During assessment of the risk level or during preparation of its profile, it is important to select the person among those participating in the project, who will have the competence to determine the probability value, weight and limit value separating the acceptable risks from unacceptable risks or hardly-acceptable risks. Most often, this is the person managing the project. The risk management plan is approved by the steering committee (or the sponsor in the case of a project structure without steering committee) and it also decides on the level of risk acceptability. The project manager is the person preparing the risk management plan. [20]

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2. Specific characteristics of R&D projects and their impact on the level of risk

R&D projects are characterised by a very high degree of dispersion, because they can be implemented, among others, by academic centres, universities, institutes and scientific societies, enterprises, libraries, museums and national parks. A big challenge is to popularise the project management theory in the scope of implementation of these projects (maybe except for research teams operating in the scientific centres of large corporations, which have a strictly defined organisational structure), because they are highly dependent on the human factor. Experiences demonstrate that brainstorming can bring the opposite results to the expected ones - too many ideas, positions, views and instances of proving 'your own point', can threaten the successful completion of the project. Project management methodologies, e.g. PRINCE 2, usually operate with the use of too general concepts, leaving many matters for the individual assessment by the project leader. This results in the doubts concerning entrusting the project to persons who lack the appropriate expert knowledge.

For determining the sources of risk in the project, it is very helpful to adopt some systematics in the scope of project's risk categories. These include the groups of potential risk sources, which are associated with their occurrence during the project implementation. For the purposes of project risk management, the following risk categories are proposed:

- Technical risk resulting from technical aspects of the project implementation. In their nature, the research projects are burdened by high technical risk. This results from the fact that they are seeking to discover previously undetermined new correlations, which no one has ever studied before, and they also undermine the existing material and its claims, prove the functioning of other correlations, as well as attempt to expand the existing research,
- Project management risk resulting from actions undertaken at the project planning stage (project planning risk) and from actions undertaken as part of the project implementation (project implementation risk),
- Organisational risk resulting from the nature of the organisation, i.e. reluctance to change and difficulties in accessing the organisation's resources in the course of project implementation. In the scope of this category, it is also necessary to take into account the financial consequences of the project implementation, and in case of R&D project the risk connected with knowledge transfer and cooperation with the larger number of entities, i.e. universities or research organisation representing differences in goals and approaches,
- External risk resulting from the impact of factors outside the organisation, e.g. legal and regulatory changes,
- Technological risk - any type of uncertainty related to dynamic and variable technological process. Technology risk management is based on a procedure called Technology Assessment (TA), which results from the human - technology - environment relations. This procedure estimates the scope, size and type of all impacts of the activity on the environment and society in short and long periods of time.

Uncertainty regarding the results of R&D constitutes an element that significantly affects the level of risk. Appropriate coordination of all processes in the project requires the incurring of large financial outlays, as well as the involvement of a large number of employees - in the case of innovative projects, they constitute specialised interdisciplinary teams, which focus on the achievement of assumed objectives. The problems of technological nature emerge, when e.g. there is a need to use or develop a technology that did not exist until now and the lack of which suspends the implementation of basic assumptions. Other characteristics affecting the scale of threats may include: innovation of solutions that requires large financial outlays, or the engagement of rare specialists from unusual fields, the intensity of planned works, which may result in a decrease in the employees' efficiency and reduced motivation to achieve the objectives.

The R&D projects are characterised by a lack of precise and long-term planning, because it is difficult to predict what can happen during the research works. This results from high complexity of the involved elements. In this case, the risk may concern the following issues: path to solving the research problem may include false footprints, which will significantly prolong the works, the project team may receive a wrong (false) solution, the achieved solution may remain unrecognised, the solution may not be possible at the current state of science and knowledge, the solution may not be available due to the high cost of planned works of the project team, the team may achieve a competitively inferior solution.

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Due to the complexity and correlation of R&D projects, they are often implemented in the form of consortia. Among others, this results from the fact that the given project exceeds the implementation capacity of one organisation. In this case, there is a hidden possibility of the risk resulting from a lack of good cooperation, different approaches to the problem-solving and associated delays, failure to comply with the agreements and other. The consortium relies on the cooperation of several entities in order to implement the project development of new technologies would not be possible without the support of individuals academic and research centres, which have the necessary intellectual and technical resources essential to create of innovation. It is therefore necessary to strengthen cooperation under knowledge triangle (business, education and research, [4]) and to develop long-term organisational structure like, i.e. clusters. Cluster as a collection of modern, diverse links between enterprises, scientific world, self-regulatory organisation, administration and business support institutions has been recognized in the EU and the world as one of the proven ways to implement the policy of innovation and is described as one of the most effective instruments of development policy at the level of country and region [4].

Creation of an innovative project is only a half-success. The total success is achieved only in the case of introduction of a product or service on the market, its positive acceptance by recipients and increase in demand, which generates the supply. Only in this manner, it is possible to achieve the reimbursement of costs incurred during the implementation of the project or even the achievement of surpluses.

3. Risk estimation methods for the innovative and technological projects

Risk is any possible event, which may take place in the future, while its consequences may cause negative or positive changes in the project. In the case of equating risk with losses, it is determined based on two parameters. Firstly, it is necessary to reasonably assess the probability of occurrence of an event that causes the given risk. Secondly, it is necessary to estimate the size of potential losses resulting from the occurrence of negative events. In order to assess the technological risk, both qualitative (descriptive) and quantitative (empirical) methods can be used. Qualitative risk assessment methods include: risk matrix method , preliminary hazard analysis method with external, internal and other threats, failure mode and effects analysis what-if analysis, safety audit review, etc. [17]

In the case of occurrence of high level of risk - the most expensive and complex plans are used. For the negative ones - avoidance, i.e. leading to the situation, in which the given risk factor has no possibility to occur. For the positive ones - use, i.e. guaranteeing that the given opportunity will become real. For the risks of medium level - less expensive, but also less effective. Usually, the avoidance of risk consists of insuring against certain event or transferring the effects of the given risk to a counterparty (e.g. subcontractor). Providing access - reaction used for positive risk factors consists of implementation of the project together with an entity, in which the probability of a given opportunity becoming real is much higher (e.g. consortium participating in a tender, in which we do not meet one of the conditions, however our business partner meets it). In the case of low-level risks, we use acceptance and if the threats will come true, we incur the adequate effects.

Basic activity in the risk management, and in the Risky Project program, is its estimation. Only this way, it is possible to adjust the appropriate strategy of avoidance, mitigation or use of the risk. This can be approached with the use of several methods:

- scenario analysis, where the simplest tactic is to analyse the worst and the best scenario. This consists of presentation and estimation of the risk of many possibilities - usually 3-5 scenarios for which the appropriate actions are adapted,
- using a decision tree method, which presents a sequence of choices, most of which involve risks,
- simulations that constitute the most complicated, however the most precise probabilistic method of risk estimation. Monte Carlo simulations, which are widely used in the Risky Project, allow for a flexible risk assessment, which is the closest to the real state.

4. Examples of risk estimation in the scope of technological project - case study

While using the project management methods in order to assess the risk, the good practices of risk estimation in terms of the size of impact on the project, the probability of occurrence of the given threat, as well as the dotProject application [10, 11], an attempt was made to assess the risk for the processes of manufacturing

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aluminum sections [12]. A risk analysis was performed and it was presented in the form of a table of risks (Table 1), for which an assessment was carried out (Table 2). The risk matrix allows for a quick assessment whether the given process is sufficiently protected against the occurrence of problems. If too many risks are located in the red fields of the matrix, then it is necessary to undertake actions and get rid of the potential threats [13]. In the case of analysis of the technological process of extruding sections made of aluminum alloys, there is an insignificant or low probability of threats to the implementation. Estimated result of the analysis falls within the green fields of the risk matrix, which means that there are no serious threats. The identified micro-downtimes do not cause effects, which required intervention. The level of risk do not reach red colour therefore, it is sufficient to control it via standard operations.

Table 1. Table of risks for the manufacture of sections made of aluminum alloys. *Source: Own research*

No.	**Identified risk**	**%**	**Probability of the risk occurrence (%)**	**Impact of a risk on the performance**	**Score**
A	Defects	28	Very high 81-100	Medium	2
B	Rundown blocking	19	High 61-80	Low	1
C	Additional heating of inputs	10	Medium 31-60	Low	1
D	Jamming	7	Low 0-30	Insignificant	1

Table 2. Risk matrix for the manufacture of sections made of aluminum alloys.

Consequence	High	3	6	9	12
	Average	2	4	6	8
	Low	1	2	3	4
		Low	Medium	High	Very high
	Probability				

Investment and innovative projects - they use new technologies and thus contribute to maintaining the enterprise's strong position in the long period of time. These projects are associated with the introduction of new products or services (product innovation) on the market, as well as the introduction of a new technological process by the enterprise, which is aimed at offering the previous or new offer. Implementation may involve the need for investment, which increases the implementation risk. Table 3 presents the risk analysis for the implementation of a new production, based on the data and experiences of Grupa Kęty S.A., while Table 4 presents the risk matrix. The lack of knowledge to apply the technology in practice and too high costs of technology commercialisation were qualified as posing a potentially high risk in the case of their occurrence.

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Table 3. Table of risks associated with the implementation of a new product. *Source: Own research.*

Identified risk	**Probability of the risk occurrence**	**Impact of a risk on the project**	**Score**
No demand on the market - failure to activate the system	5%	high	3
Exceeding the planned budget	5%	low	1
Failure to achieve planned business benefits from the implementation	40%	medium	4
Delay of implementation	10%	medium	2
Too long time for implementation	15%	low	1
Lack of know-how for using the technology in practice	60%	high	6
Too high costs of technology commercialisation	60%	high	6

Table 4. Risk matrix for a new product

Consequence	High	3	6	9
	Medium	2	4	6
	Low	1	2	3
		Low	Medium	High
	Probability			

Table 5 presents the identification and assessment of a risk associated with the occurrence of micro-downtimes, whose data is included in the work [14], as well as other interruptions that reduce the productive working time of machines used for the extrusion of sections made of aluminum alloys. The model of this table was taken from the work [15]. As a result, the risk matrix assessment is presented in Table 6, whereas Table 7 presents the probability assessment of the occurrence of individual events.

The analysis of events, based on a risk matrix, indicates that there is a low probability of production process disruptions. Designations A, B, C, D, E indicate the type of response to the occurring risk.
A, B, E - Mitigation, withdrawal - risk response strategy
E - insurance, TPM - Total Productive Maintenance,
AM - Autonomous Maintenance
B - TPM - Total Productive Maintenance, AM - Autonomous Maintenance
A - monitoring, PDCA (principle of continuous improvement, kaizen)
C, D - acceptance
P-D-C-A, disseminated by circles associated with management through quality and ISO standards concerning the quality management.

Table 5. Table of risk associated with disruptions in the effective working time of machines, affecting the production efficiency. *Source: Own research [14]*

Score	Description	Designation	Consequence
1	Very low	A	Disruptions that can be eliminated by a person performing the given activity, *e.g. micro-downtimes*
2	Low	B	Short-term disruptions, however with the need to inform about the event, *e.g. repairs, minor failures*
3	Medium	C	Disruptions that require longer downtime, *e.g. control system failures, machine / device failures*
4	Serious	D	Disruptions that require reorganisation of the previous method of operation, *e.g. long-term failures or unexpected downtimes*
5	Disastrous	E	Disruptions that completely prevent the implementation of basic operations until their removal, *e.g. external factors, catastrophic failures*

Table 6. Risk matrix

Impact	**Disastrous**	**5**	**E 10**	**15**	**20**	**25**
	Serious	**D 4**	**8**	**12**	**16**	**20**
	Medium	**C 3**	**6**	**9**	**12**	**15**
	Low	**2**	**4**	**6**	**B 8**	**10**
	Very low	**1**	**2**	**3**	**4**	**A 5**
		Rare	**Unlikely**	**Medium**	**Likely**	**Almost certain**
		Probability				

Explanations:

(green)	*Low risk*	(yellow)	*Medium risk*	(red)	*High risk*

Table 7. Assessment of the event occurrence probability

Score	**1**	**2**	**3**	**4**	**5**
Description	Rare	Unlikely	Medium	Likely	Almost certain
Range of probability	0-20%	21-40%	41-60%	61-80%	81-100%

In the process of continuous improvement of the activities, which prevent the occurrence of catastrophic consequences of the failure to reduce the risk reduction, it is useful to use the Deming circle, which leads to the process of continuous improvement of the organisation by solving the problems faced by it, recommended in many publications and ISO standards. This type of actions are associated with an iterative way of monitoring the process and preventing the possibility of risk occurrence. [18]

Results and discussion

The proposed solutions of risk management in the project allowed to identify the risk level and to carry out the event probability assessment. Therefore, this is the basis for developing a set of actions for each identified threat. It is necessary to find a method for better control of the threats and their reduction to an acceptable level [5]. The chances of failure can be reduced by appropriate selection of assumptions, technologies, financing and management. Depending on the possibility of application, two threat reduction strategies are used in the project development phase. The first one consists of searching for and improving the sources of information and news about the project. It is definitely beneficial to develop action scenarios, aimed at controlling the threats accepted by the enterprise. It may consist of introduction of the warning systems, i.e. information processing systems

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allowing for quick identification of the emerging hazards and reduction of their consequences. The project should allow to react to the emerging changes during its implementation. The project can be changed under the pressure of external events. In addition, it may be changed because of new information, which entails decisions concerning changes in the method of solving the predicted threats or reacting to the already encountered problems. In the face of new problems, new decisions are often made, which are sometimes inconsistent with previous decisions or which completely question them. This may result in the introduction of changes concerning the implementation of previously determined tasks, e.g. through merging or shortening the time of their implementation.

The last stage of risk management consists of the capitalisation of collected information and experiences in the form of detailed documentation of hazards and potential threats, which occur at the individual stages of project implementation. For this purpose, it is useful to determine the form of risk-related documents, e.g. the form of Risk Management Plan or the Risk Management Book. PZR is a document describing the adopted procedure for controlling the given threat, including the principles and cycle of risk management (applied ideas, principles for identification, estimation and controlling the threats). The documentation of collected information should be kept in a periodic manner (after completion of each stage, from the beginning of project implementation and in its key moments). The threats are assessed in terms of nature of the project, as well as the organisation implementing such project. The risk of projects implemented in small companies with short time of operation and limited financial possibilities is higher. These problems are much better handled by large enterprises with a well-established position on the market. For the former, a failure in the project's implementation may often result in bankruptcy. The financial and organisational potential, as well as experience and trained staff are often crucial in the scope of handling the threats by a given company [7,8].

The second one consists of externalisation – transferring outside (in its entirety or in part) all the encountered threats. Usually, they are directed to: banks in order to protect against the threats of financial nature (insolvency, lack of liquidity, profitability, etc.), and insurance companies in order to protect against the external threats (changes, political threats, economic threats, market threats, natural disasters etc.), or possibly to the client in order to mitigate some of the guarantees assumed in the project. To a reasonable extent, the enterprise may share the risk among various parties interested in the project (e.g. partners, suppliers, subcontractors, co-workers and even the client) through cooperation and common investment in R&D.

One of the solution, which stimulate innovation, exchange of knowledge and provide common R&D, is networking i.e. in EU policy by promoting cluster cooperation, and applying for common grants. In Poland there are 2 of 16 Key National Clusters where entities connected with aluminum sector present active cooperation. One of them is Polish Aluminum Cluster, which was created to envisage cooperation between entrepreneurs focused on innovation and development, operating in the aluminum industry as well as research institutions and centres, which ensure regular contact with the most up-to date research solutions and the highest level of the quality control. Cluster's member are both business support institutions and enterprises operating in the industry [21]. The second is The Waste Management and Recycling Cluster (www.klasterodpadowy.com), aims to increase competitiveness, effectiveness of using possessed resources and the exchange of knowledge. It offers the possibility of implementing innovative products onto the market by the companies belonging to the cluster. The main scope is to deliver basic information and encourage SME's, public organisations and scientific institutions towards a common research and projects in circular economy economy and zero waste strategy [3]. Partners of the Waste Management and Recycling Cluster are active in KIC Raw Material by for example realisation common "Competitive Sustainable Business from Metal Recycling (BizMet)". BizMet project (2018-2020), which initiates a platform to bring together all regional actors within European countries to accelerate the transformation into circular economy for a sustainable future. It provides an interactive education, networking and knowledge sharing opportunity in the field of metal recycling especially for small and medium enterprises (SMEs), industrial experts, professionals, researchers/scientists, and graduated students. It is also a field for cooperation with to promote the metal mining and recycling industrials into circular economy by improving cooperation between SMEs and universities, understanding of sectoral needs and introducing cutting edge technologies, and to support Polish cluster German – i.e. REWIMET e.V. cluster, which combines as a local association SMEs, industrial partners, municipalities, business developers and universities in the field of recycling/recovery of secondary raw materials. The main regional focus of REWIMET covers the Harz mountain area (lower Saxony, Saxony-Anhalt and Thuringia). The Bizmet project was also a base for creation a next one supported by NAWA (International cooperation for Rational Use of Raw Materials and Circular Economy), which shows good example for possible cooperation between science and business to exchange knowledge and to reduce risk of future cooperation.

The novelty of this paper is to show for the first time the real risk assessment of the whole production process of aluminum alloys at Kęty SA the largest company of aluminum processing in Poland. The proposed method was implemented to assess the production process and to introduce possible changes when needed. Moreover, it was analysed the potential profit from participation in the national and international projects as a possible aspects which can minimise the risk due to better knowledge of market and possibilities of obtain support for more detailed research. The role of minimisation risk via cooperation between business and industry has not been evaluated as it is of foreseen for the next research.

Conclusions

Risk management constitutes an important element of every project. Especially, this problem is emphasised in the project management with the use of Prince 2 method. All undertakings require an assessment of risk, which can occur in any given situation. There are methods for the risk estimation, however due to the lack of absolutely certain output data, the conducted assessment must be subject to continuous verification and monitoring. It is not possible to predict situations independent of the enterprise's business activity, e.g. emergence of various external factors, which may disrupt the production process.

The results of risk analyses in the scope of innovative and technological processes indicate that too high commercialisation costs and the lack of appropriate knowledge are essential for the implementation of this type of projects. Based on qualitative risk analysis [9], that the risk factors with the highest probability of occurrence included: unreal project schedule, frequent changes in requirements, error in the estimation of project value (time, costs, etc.), technical problems, and lack of perception of the projects implemented in the enterprise in terms of project portfolios. Whereas, the risk factors with the greatest severity of consequences include incorrect identification of needs, unrealistic project schedule, insufficient competence of the project manager, change in the project's objectives, selection of inappropriate project.

Reduction of risk, in response to the occurred event, may take the form of [6]:

- risk avoidance - consisting of such change in the project that will eliminate the event's impact on the project. Resigning from the project is the final type of risk avoidance,
- risk reduction - consisting of reducing the impact of an event or the probability of occurrence of a cause of the given risk,
- transfer - involvement of a third party in order for it to take the responsibility (usually financial) for possible materialisation of the given risk. Example: purchase of an insurance policy,
- sharing the risk by the involvement of an external organisation, so that it has a share in profits/losses; example: a contract in which the payment for the delivered system depends on the number of completed transactions,
- risk acceptance - consisting of taking no action, except for the observation of status of the risk,
- seizing the opportunity - consisting of using the emerging possibility, strengthening the opportunity by using the emerging chance,
- rejecting the opportunity - consisting of intentional not using the chance emerging in the project.

It was also shown, that networking and cooperation with international projects can create a good base for risk limitation. Nowadays there are a lot of risk management software, however none of them are dedicated particularly to research projects as they are not standardised.

It must be emphasised that in every kind of projects risk estimation is of subjective nature, therefore it is important that it is carried out by competent and decision-making persons, who can (due to the iterative nature of this procedure) take appropriate remedial measures and prevent any possible adverse changes. Thus, it can be concluded that based on the literature data analysis, own experiences, assessment of the impact of events on the production, as well as analysis of individual cases, it is possible to estimate the risk in the implemented technological projects. Full risk management is associated with the need to develop emergency plans and preventive measures that allow for controlling of the risk.

Conflict of interests

There are no conflicts to declare.

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