
Sustainable Solutions in Construction from the Perspective of Innovation Activity

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Joanna Markiewicz¹

Abstract:

Purpose: The imperative of sustainable development is perceived to be the most important path for socio-economic development. Sustainable goals influence all aspects of human activity, covering also a construction sector. Therefore, the aim of the work was to examine the impact of sustainable solutions in construction on the innovation activity of a company managing an environmentally friendly business complex.

Design/Methodology/Approach: Besides theoretical consideration, empirical data was collected. In-depth interviews and investigation of materials (provided by the company for research purposes) led to an analysis of a case study of Posejdon Center – a sustainable business complex.

Findings: All sustainable solutions have impacted the broad spectrum of innovation activities undertaken by the operator. The study showed that sustainable solutions influence the processes of managing the building and also affect the marketing efforts, which cover the area of business process innovation.

Practical Implications: Environmentally friendly solutions implemented in buildings are innovations related with new technologies in the phase of a construction process, but when the building starts operating on a real estate market, such solution influence the broad spectrum of innovation activity of operators of such buildings.

Originality/value: The examination of the impact of sustainable solutions in construction on the innovation activity of a company managing an environmentally friendly business complex provide valuable theoretical and practical knowledge that combines sustainability with boosting innovation performance. Moreover, it implies a series of further studies, eg. how to improve the efficiency of sustainable building management.

Keywords: Construction sector, innovation, innovation activity, sustainable development.

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¹Dr., University of Szczecin, Institute of Management, ORCID: 0000-0002-1419-3275
Joanna.markiewicz@usz.edu.pl,

1. Introduction

The construction industry is one of the sectors that contributes the most to global warming, being responsible for around 37 per cent of energy and process-related CO² emissions in 2021 (UN, 2022). With such a high level of emissions (compared to other sectors), the provisions the Paris Agreement (2016), which sets out an action plan to limit global warming to 1.5°C, are all the more important from the perspective of this sector.

Therefore, the construction sector faces many challenges. Apart from modern architecture, solutions which affect the maximum usability of a given building, low operating costs and care for the environment are crucial to meet sustainable development requirements. When creating buildings of the future today, it is necessary to take into account how they will affect the immediate surroundings and that their use should be economical and above all energy-efficient.

This paper aims to answer the question of how ecological solutions in the construction industry, so necessary due to the need to implement the idea of sustainable development, influence the innovation activity of operators managing environmentally friendly buildings. The plan of the article was adjusted to this goal.

The literature review presents the theoretical foundations for innovation activity and the requirements for the construction industry contained in the most important European and Polish strategic documents. The next part describes the research methodology used and justifies its choice. The empirical part encompasses the presentation of a case study of the Posejdon Center building, which in 2022 was rated as one of the three most ecological commercial buildings in Poland. At the end, conclusions from the study were presented, thus realizing the scientific goal of this paper.

2. Literature Review

Considerations on the topic should be started with the precursor of innovation, i.e., J. Schumpeter, who identified the entrepreneur with a creative destructor who destroys the existing order in order to offer a new value (Schumpeter, 1995). The creation of novelty manifests itself in the criteria proposed by Schumpeter that describe the entrepreneur. He included (Schumpeter, 1960):

- launching a new product or a new type of already known product on the market,
- application of a new method of production or sale of a given product,
- opening a new market,
- finding a new source of raw materials or semi-finished products,
- a new organizational form of some industry.

The inseparable alliance of innovation and entrepreneurship was identified by P. Drucker. According to Drucker, "entrepreneurship is a feature or way of behavior of an entrepreneur and enterprise, which is understood as the readiness and ability to take up and solve new problems in a creative and innovative way, with the awareness of the associated risk, the ability to take advantage of emerging opportunities and flexible adaptation to changing conditions" (Drucker, 1992, p. 35).

Other authors indicate (McConnell, 1987) that an entrepreneur, by creating an enterprise, acquires the rights to manage its resources and is responsible for the generated profit or loss. Therefore, it is indicated that the entrepreneur performs four basic functions:

1. Organizes resources to produce products or services.
2. Makes basic, non-routine decisions in the company.
3. Implements innovations in the form of new products, processes, marketing or organizational methods.
4. Bears the risk related to the above functions.

The importance of innovation for the enterprise should also be considered from the point of view of the external environment. The functioning of the company is determined by many factors coming from both the closer and further environment. Within the specific industry environment, the introduction of innovations may be imposed by suppliers or recipients. Definitely an important source of innovation for companies are consumers, including prosumers and lead users (Szopik-Depczyńska et al., 2020), who are the main point of reference for defining product or service needs.

Competition in the industry in a given market also plays an important role. In turn, in the further environment, factors such as the political and legal system and state policy (including innovation policy, international policy (e.g., European Union policy), socio-cultural specificity, scientific and technological development or demography have an impact on innovation activity.

Innovation activity of enterprises is currently considered one of the most important factors in the development of modern economy. Terms such as sustainable economy (Bontoux and Bengtsson, 2015), knowledge-based economy (OECD, 1999) or economy 4.0 (Kaz et al., 2018) or economy 5.0 (Klein and Gutowska, 2022) describe economic systems driven by just innovation. In order to cope with dynamic economic changes and at the same time meet the needs of the market, modern organizations are doomed to implement innovations.

Therefore, all considerations about innovations and their specificity and types, which are characteristic of contemporary economic challenges, constitute an important scientific discourse in management sciences.

There are many definitions in the literature. The approach of Schumpeter (1960) should be included in a broad approach to innovation, but it should be remembered that this thinker described the entrepreneur and innovations of the first half of the 20th century. Innovation was also broadly defined by Drucker, who described it as a specific tool of entrepreneurship - an activity that gives resources new opportunities to create wealth (Drucker, 1992). Also, the definition proposed by Kotler is capacious, because it covers any good that is perceived by someone as new (Kotler, 1994).

A broad interpretation was proposed by Rogers, according to whom innovation is an idea, practice or object that is perceived by a person as new, regardless of the objective novelty of a given idea or thing (Rogers, 1962). The variety of definitions of innovation may raise some problems in the interpretation of innovative phenomena and their measurement.

Therefore, the proposal of defining and measuring innovation proposed by the Organization for Economic Co-operation and Development (OECD), commonly known as the "Oslo methodology", turned out to be helpful. OECD member countries have accepted this innovation measurement methodology and statistical offices collect data according to a unified standard, which is why it is possible to objectively compare the innovativeness of economies and innovation activity of enterprises.

According to the latest Oslo Manual (OECD, 2018), a distinction is made between the concept of "business innovation activity" in relation to the process, and the concept of "business innovation" in relation to the result. According to this criterion, innovation activity includes all development, financial and commercial activities undertaken by the company, which are aimed at bringing innovation to the company.

A business innovation, on the other hand, is defined as a new or improved product or business process (or a combination of them) that is significantly different from the company's previous products or business processes, and which has been introduced to the market or put into use by the company. A business process innovation is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use in the firm. Compared to the previous edition of the Oslo Manual (OECD, 2005), which distinguished four types of innovation: product, process, marketing and organizational, this number has been reduced in the latest edition (2018).

Today, environmental issues are crucial for sustainable economic development, therefore innovation activity should be related with sustainable solutions. The idea of sustainable development was officially introduced by Brundtland in 1987, who recognized the interplay of economic, ecological and social systems (Brundtland, 1987).

According to Hussain *et al.* (2014), theories of sustainable development should seek to prioritize and integrate social, environmental and economic models into solving human problems in ways that will benefit people on a sustainable basis.

The analysis of the literature should also concern the most important assumptions of policies and strategic documents regarding sustainable development in the construction industry, which will affect the specificity of the construction sector in the future. One of the areas of policy transformation that assumes the European Green Deal (COM, 2019) is construction.

This document proposes “Building and renovating in an energy and resource efficient way” (COM, 2019). It also indicates that buildings have an energy consumption rate of 40%, as many buildings still have not been renovated.

In addition, transformational activities in the construction industry should lead to the design of new buildings, as well as the renovation of old buildings in a way which will enable to achieve circular economy compliance, digitization of buildings and climate change resilience at every stage of building operation.

Energy Policy of Poland until 2040, which reflects the main highlights of the European Green Deal, has a set of goals, among others the improvement of energy efficiency (PEP, 2040). This document assumes the use of ecological energy sources that would ensure independence from external suppliers of electricity, heat or water. The owner of such a building would hybridise all the resources at their disposal, including:

- a) heat from the ground through heat pumps for heating and cooling,
- b) water drilled during the installation of heat pumps (both for heat recovery from such waters, which is also a potential source of domestic water),
- c) water from atmospheric precipitation (e.g., rainwater tanks),
- d) solar energy (e.g., through the installation of photovoltaic panels and solar collectors), while using energy storage and thermal modernization technologies for buildings (PEP, 2040).

The document also highlights the requirements for low energy consumption, which are easier to meet in new buildings than in existing buildings. Therefore, the role of extensive thermal modernization of buildings is emphasized (insulation, replacement of windows and doors, the use of intelligent energy management systems, increasing awareness of the effects).

In addition, due to the activities under the "Stop smog" or "Clean air" programmes, new solutions will be sought to ensure access to ecological heat sources in order to reduce "low-stack emissions".

3. Research Methodology

In order to obtain comprehensive knowledge on the impact sustainable solutions in construction on the innovation activity of a company managing an environmentally friendly business complex, a research method consisting of five stages was used:

1. Identification of the 3 highest rated commercial buildings in Poland that received the BREEAM certificate. BREEAM is an internationalized in 2016 method of certification of buildings, assessing how environmentally friendly the building is and how comfortable it is for its users. The categories assessed are: Management, Health & Wellbeing, Energy, Transport, Water, Materials, Waste, Land Use & Ecology, Pollution, and Innovation (Awadh, 2017). In order to narrow down the identification of the group, only the buildings that received the highest rating, the so-called outstanding, meaning obtaining more than 85% of possible points, were taken into account.
2. Contact the owners/operators of the identified 3 buildings to obtain detailed information about the building and building management system. At this stage, Porto Ltd., the owner and manager of Posejdon Center, expressed its will to participate in the study.
3. Analysis of materials provided by Porto Ltd. and description of the case study
4. The in-depth interview was the forth phase of the research. The in-depth interview, which took place on 5th Dec 2022, was structured, while the respondents were also allowed to speak freely (Morris, 2015). During the interview, 18 questions were asked.
5. Interpretation and conclusion.

4. Empirical Results and Discussion

4.1 Posejdon Center- General Information

The multifunctional Posejdon complex, which was commissioned on December 31, 2019, is the largest low-energy building recently completed in Poland (NZEB - Nearly-Zero Emission Building), meeting in advance the more restrictive standards and technical requirements in the field of energy consumption (WT 2021), which became applicable to all newly constructed buildings in Poland only on January 1, 2021.

The project is based on three stable pillars: modern office space with an area of nearly 18 thousand m², retail and service part (5,000 m²) and hotel space, offering guests a total of 255 rooms, a congress center with six conference and banquet rooms ready to receive nearly 1,000 people. A two-story, underground car park with 299 parking spaces for passenger cars, including at least 10 places for charging electric cars, is also important, and separate, modern facilities for cyclists with locker rooms and showers and a monitored car park for 62 bicycles. On the first

floor of the office part of the building, a public patio with the largest 150-meter green wall in Poland was created.

Posejdon Center is one of the most modern facilities in Poland and Europe. Most of the heat and cooling energy necessary to ensure thermal comfort for building users is generated within the building. Two renewable energy sources (RES) are used:

- geothermal, thanks to the implementation of a highly efficient, complete RES system, using the technology of passive heat and cooling energy acquisition, cooperating with the installation of vertical ground boreholes;
- solar radiation, thanks to the installation of PV photovoltaic cells to generate electricity for the needs of powering heating and air conditioning devices.

On October 13, 2022, the multifunctional Posejdon complex in Szczecin received the BREEAM certificate at the Outstanding level, obtaining 91.4% of points. The achieved result places the facility in third place in this category in Poland.

4.2 Sustainable Solutions – A Case Study

Posejdon has been equipped with HVAC (Heating, ventilation, and air conditioning) installations based on RES technology (renewable energy sources) and devices characterized by very high energy efficiency, including:

- a passive system for obtaining heat energy, consisting of 48 vertical ground heat exchangers placed in boreholes 300 m deep and 14,400 m long in total;
- heating and cooling of an individual office space based on 910 highly efficient inverter heat pumps;
- a system of 342 photovoltaic panels with a total nominal power of 102.6 kW, generating electricity for the needs of powering auxiliary drives of ventilation systems as well as HVAC systems and internal lighting.

The heat obtained from the ground is used to heat the office and service part of the building in winter and cooling it in the summer, using local heat pumps with a certificate of high energy efficiency class (A+), with indicators: COP (Coefficient of Performance) > 4.1 and EER (Energy Efficiency Rating) > 5.9. The pumps are equipped with inverter compressors in a special version, with low sound power, fully automatic. Thermal energy from the ground is also used to prepare hot water in the hotel part of the complex.

The average adopted temperature of water obtained from ground exchangers is about 15°C. It has been estimated that thanks to the execution of 48 wells, the power of the lower heat source will be approximately 800 kW. It is assumed that in winter the operation of the installation will be ensured only by RES ground heat exchangers, and in the case of extremely low temperatures, when the temperature at the return from the heat pump loop reaches the minimum temperature of 8°C, the system will

switch to the mode of operation supported by the built-in heat pump in the renewable energy plant.

In order to reduce energy consumption in ventilation and air conditioning systems, it was designed and ventilation systems with variable capacity, depending on the quality of the indoor air, were installed. The systems are controlled from the automation system and BMS (Building Management System). Ventilation capacity is reduced to a minimum during the absence of occupants in the facility.

The building provides many solutions to reduce the consumption of cold water, e.g., by using treated rainwater (grey water system) for flushing toilets and watering plants. Therefore, a separate installation was designed and built, which supplies treated water to the sanitary facilities and the patio located in the office part of the building. Public toilets also feature automatic solenoid valves that shut off the water supply when users are not in the room.

This system reduces water consumption and protects the building against flooding in the event of a possible unsealing of the installation or failure of washbasin faucets or cisterns. Water consumption is also reduced thanks to the use of electronic washbasin faucets equipped with proximity sensors.

Thanks to the use of modern, pro-ecological solutions, the entire complex is able to reduce CO² emissions to the atmosphere by as much as 76% compared to the same building erected on the basis of traditional technologies

4.3 Innovation Activity

The collected materials and in-depth interviews with the representatives of the operator, allowed to indicate the main sustainable solutions and their impact on the innovative activities performed by the operator, which is presented in the Table 1.

Table 1. *Impact of sustainable solutions used in Posejdon complex on the innovation activity of the operator*

| Type of achievements/solutions | Description of achievements/solutions | Impact on managing the building | Innovation activity |
|--|--|--|--|
| Geothermal installation providing heating and cooling energy | 48 vertical wells 300 m deep and 14,400 m long in total; over 9,000 heat pumps in the lease area | The installed geothermal wells serve to promote the building. The fact that they are longer than the Eiffel Tower makes the visualization of the installation have a strong marketing message. | Marketing activity – business process innovation |

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| | | The use of BMS, which controls all RES installations to ensure the efficient operation of the building | Information systems – business process innovation |
| Photovoltaic installation producing electricity for the needs of heating and air conditioning devices and internal lightening | 342 photovoltaic panels with a total capacity of 97.2 kW mounted on the roof | The installed photovoltaic panels support the promotion of the building. | Marketing activity – Business process innovation |
| | | The use of BMS, which controls all RES installations to ensure the efficient operation of the building | Information systems – business process innovation |
| Charging stations for electric cars | 10 public stations in the underground garage | Charging stations open to the public make people come to visit the building, which gives them the opportunity to experience the complex | Marketing activity – business process innovation |
| Rainwater storage and use system | For flushing toilets and watering the green wall located in the public patio | The rainwater storage is used to water the green wall in patio, which is the largest 150-meter green wall in Poland. | Marketing activity – business process innovation |
| BREEAM certificate at the Outstanding level | The entire complex is able to reduce CO2 emissions to the atmosphere by as much as 76% compared to the same building erected on the basis of traditional technologies | BREEAM certificate as an internationally recognizable guarantee of ecological solutions reaches the most demanding tenants who focus on sustainable development in their strategies | Marketing activity – business process innovation |
| | | Posejdon complex as an innovative and sustainable building. | Innovative building – product innovation |

Source: Own elaboration.

As shown above, all sustainable solutions have impacted the innovation activities undertaken by the operator. The interviewers underlined that sustainable solutions influence the processes of managing the building and also affect the marketing efforts, which cover the area of business process innovation. What is more, the operator treats the whole building as an innovative product on a real estate market.

5. Conclusions

The study assumes that sustainable solutions in the construction industry affect the innovation activities undertaken by the operator of a sustainable complex. Theoretical considerations indicated that innovations are crucial for organizations to maintain their competitive advantage. What is more, innovations related to environmental protection are solutions that can lead to sustainable development. It should be emphasized that low energy consumption, the use of renewable energy sources and reducing the impact on the environment are the main challenges that the construction industry must face in order to meet the idea of sustainable development.

That is why it is important to analyze how environmental solutions in construction impact the innovation activities of operators who manage sustainable complexes.

The research was focused on Posejdon Complex, which obtained the outstanding level of BREEAM certificate. The study showed the following impact of sustainable solutions on the innovation activities of the operator of Posejdon:

A. Business process innovations:

- managing processes related with the usage of specialist digital programmes (like BMS) to plan, manage and control HVAC based on geothermal heat pumps, photovoltaic installation and rainwater storage;
- managing the marketing processes like marketing methods, activities related to sales and after-sales service and maintaining relations with customers using the offer of sustainable solutions (heat pumps, photovoltaic pannels, rainwater storage, BREEAM certificate, the biggest green wall in Poland or charging stations for electric cars).

B. Product innovation:

- Posejdon as an innovative and sustainable building.

The study encountered some limitations. The main barriers concerned limited access to data. Owners/operators of sustainable buildings do not want to share detailed technical and management knowledge, hiding behind business secrets.

Therefore, taking into account buildings with the BREEAM certificate gave a guarantee that these are complexes verified in terms of ecological construction. According to the presented limitations, the research results may constitute the basis for a broader and in-depth diagnosis of innovations related with sustainable development in construction.

Moreover, they may constitute a starting point for the design of research how to improve the efficiency of managing sustainable buildings. What is more, researchers

could focus on the impact energy policies on the innovative solutions implemented in a construction sector.

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