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Innovation Management in Polish Real Estate Developers in the Renewable Energy Sources Context

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Abstract: This paper analyses innovative activities, including renewable energy sources (RES) in the housing market, the motivations for their introduction, effectiveness, benefits, limitations and management—which are open and current problems of Polish and international sustainable construction. This problem is part of a research gap concerning, among others, the role of developers and entities responsible for introducing energy innovations into housing construction. The aim of the paper is to analyse innovations, with particular emphasis on RES, introduced by residential developers in Poland in the context of global trends. The work is based on the results of surveys conducted among developers of the primary housing market. The research of 130 questionnaires received from entities such as multi-storey buildings and multi-family houses in Poland, was carried out on a nationwide sample using the CATI Computer Assisted Telephone Interview method. The results of the survey research were summarized by setting research hypotheses, which were verified using the significance test based on the Laplace normal distribution. The research conducted has shown that residential developers in Poland point at, among others, competitive pressures, concern about the quality of products and services offered, increasing market share or satisfaction and increasing customer requirements. This clearly shows that the implementation of innovation is perceived through the prism of increasing competitiveness. Furthermore, developers operating in the more competitive markets—nationwide and on the market of the five largest Polish cities, usually larger companies, showed a greater willingness and even the need to introduce innovation in their activities. In the study, developers as one of the barriers of introducing innovations, apart from the lack of adequate support, mainly from public entities in the field of, inter alia, appropriate law favouring the implementation of innovations and financial support, indicate difficulties of the client's market manifested by the lack of knowledge and identification of needs in the field of innovation, and the lack of willingness to pay a higher price in regard to the product with higher innovation level. In the paper, the authors recommend developers, among others, to implement in the management process the identification of possible to implement innovations and the customers' needs in innovations with education in the field of possible innovations and its benefits. The article indicates the need to intensify the implementation of innovations in housing projects in order to increase competitiveness and to meet the European Union's requirement regarding the use of renewable energy sources.

Keywords: green building; housing projects management; innovations; sustainable construction; renewable energy sources; real estate developers

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1. Introduction

Continuous processes of intense globalization and accelerated economic growth are stimulated by increased competitiveness. In the case of the European Union, the main problem for economic success at a time when global energy markets are changing as a result of the transition to clean energy is to maintain competitiveness. This is why the

European Commission presented the Clean Energy for all Europeans package in Brussels on 30 November 2016 stressing that the transition to clean energy will be the main growth sector (smart money) in the future [1]. The Clean Energy for all Europeans package is a set of ambitious requirements whose authors have set themselves the goal of building a better, more efficient and sustainable energy system for future generations. As tools to achieve this objective, solutions that are as free-market as possible, thus increasing competition for, and ensuring efficiency in, the microeconomic sense have been adopted [2–5].

The proposed package of measures has three main objectives: energy efficiency as a priority, to make the European Union a leader in renewable energy, and to ensure fair treatment of consumers (European Commission 20192). In 2015, clean energy sources worldwide attracted investments worth €300 billion. The European Union is well prepared to use its research, technological development and innovation policies to turn the transition to clean energy into concrete industrial opportunities. By mobilizing public and private investments of €177 billion per year from 2021, this package can generate close to 1% of GDP growth over the next decade and create 900,000 new jobs [6].

The Clean Energy for all Europeans package of legislative proposals addresses issues of energy efficiency, renewable energy, electricity market structure, the security of energy supply and governance for the Energy Union. It also addresses actions to accelerate clean energy innovations and those that will help mitigate the social impact of the transition to clean energy.

In October 2014, the European Council agreed on a climate and energy policy framework for the EU by 2030, setting an ambitious objective of reducing greenhouse gas emissions from all sectors of the economy by at least 40% by 2030 (especially CO_2). The Paris Agreement on Climate Change confirms the EU approach. The implementation of the climate and energy policy framework agreed by the European Council until 2030 is a priority issue in relation to climate the Paris Agreement and the Energy Union strategy, one of the priorities of the Juncker's Commission [7].

In 2015, the Commission proposed to reform the EU Emissions Trading System (EU ETS), whereas, in summer 2016, it prepared proposals to accelerate the transition to an European low-emission economy. The package currently presented addresses the remaining key elements necessary to fully implement the EU's climate and energy policy framework, in particular concerning renewable energy and energy efficiency.

Therefore, it can be concluded that renewable energy represents a cost-effective source of energy that isolates energy markets and consumers from instability, promotes economic, and stimulates sustainable growth.

As the main problem of economic success for the EU in times of changing the global energy market is maintaining competitiveness, besides the abovementioned EU programs, the HORIZON EUROPE 2021–2027 framework program for research and innovation is becoming the most important (the Next EU Research and Innovation Program 2021–2027, as a continuation of HORIZON 2020 program) [8]. It is the largest project implemented by the EU, with a budget of EUR 95.5 billion.

All legislative proposals for the Energy Union presented in 2015 and 2016 are treated as a priority by the European Parliament and the Council.

Since the construction sector generates as much as half of the waste generated in the world and buildings consume 40% of the energy produced in EU countries, it is very important to implement and manage innovation in real estate. In property and asset management (PAM) innovations plays, nowadays, one of the key roles. PAM can be divided into three pillars: asset management, property management and facilities management [9].

Activity of housing developers refers to asset management because developers—investors usually sell flats after the investment is completed, sporadically keep them in their portfolio for rent. Therefore, their objectives are maximizing value and increasing returns from property. Innovation will increase the value of property but not necessarily the rates of return as the innovations will also increase costs—that is why proper management of the investment project is very important in this case. The framework of the

management process of the construction process implementing the innovations indicates the need for identification of external environment variables like location, procurement form, innovation acceptance of the client, regulation degree and critical variables of the internal environment like service offer, knowledge strength, cooperative behaviour, financial strength and time needs [10]. Innovation's management in construction life cycle starts from opportunity exploration, where market trends, client insights, technology trends, data analytics, regulatory and competitor information plays an important role to manage the pro-jects or the contractors to investigate new innovations. At the front end of innovation level the project needs are studied, if a new tool, method or technology is identified and whether the new innovation is suitable, usable, and scalable. Then user experience tests are carried and whether the project team will be able to sustain using this new innovation is determined. During the backend design level aspects such as usability, serviceability, robustness and assembly are considered. At the commercialization level, change and leadership that are required for continued operational excellence are applied. At the daily management and project engagement level, training and project team engagement are important, and reporting and innovation implementation progress monitoring is applied. The final phase is improvement, where the effects from applying this new innovation is evaluated and innovation evolvement is investigated [11–15].

In the field of property management, and in particular facility management, innovations implemented in the construction phase allow for achieving higher efficiency by reducing the operating costs of buildings, improving the functionality, the environment in-side the building, or the impact on the natural environment through the emission of greenhouse gases or materials used in construction. These elements, especially reducing the operating costs of buildings, such as the consumption of energy needed to central heating, water heating, electricity, water consumption or generated waste, increase the value of the property. The innovations implemented in a building are often, nowadays confirmed by certificate granted by specially entities, which are an indisputable factor in increasing the value of real estate. For the most prestigious certifications we can include LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment's Environmental Assessment Method).

The aim of the paper is to analyse innovations, with particular emphasis on RES, introduced by residential developers in Poland in the context of global trends.

The research topics, covered in this paper, include:

1. The assessment of the position regarding the introduction of energy innovation in housing in the light of benefits and barriers.
2. Analysis of the introduction of innovations in Poland and worldwide in terms of RES.

2. Literature Review

In the case of the construction sector, the implementation of sustainable urban development assumptions, especially those concerning housing, is the responsibility of engineers, managers and research and development entities, focused on the implementation of innovations already in the processes of preparing materials for use in construction. In the case of the real estate market, especially residential real estate, the implementation of the assumptions of environmental sustainability is the responsibility of real estate developers and property buyers [16–18].

Green housing development requires a complex approach based on using green or technologies and on the behaviour of housing market actors. Many governments across the world introduce requirements or incentives to introduce innovations according to green housing and especially with energy efficiency. The Chinese government promotes energy efficiency in the new urban building sector by requiring 50% of new buildings to be green buildings [19,20]. Moreover, the European Union energy objective 2020 assumed having 20% of the energy consumption acquired from renewable energy sources. That leads to an increase in sustainability through the introduction of renewable energy innovations [21]. In UK nearly one third of total consumption of energy devoted to the domestic household

sector, therefore sustainable housing developments have an important part to play in reducing greenhouse gas emissions and implementation of renewable energy sources in order to combat climate change [22]. Furthermore, in the perspective of the future 20–30 years the consumption of energy will be continuously increasing because of upward trends of using primary electric heating or electric cars. That is why the role of governments in implementation of RES is so important [23–25].

According to Uidhir et al. [26] in Ireland, improving the energy efficiency of residential flats will play a key role in achieving energy efficiency and GHG emissions reduction targets in 2020 and then to 2030. More than 80% of residential buildings have an energy efficiency rating (BER) of C. Ireland's Climate Action Plan 2019 aims to achieve 500,000 retrofits to a B2 standard by 2030, including the installation of 400,000 heat pumps. As exposed, the implementation of RES in residential buildings is becoming a standard, not the innovation.

Introducing the RES could also be an alternative for progressive tariffs. For example, in Italy and California, they seem to function well; however, they are not easily introduced. A free social minimum energy supply paid by progressive prices for high-end users can seem to be unfair. As exposed, the implementation of RES in residential buildings is becoming a standard, not the innovation [27].

Zhang et al. [28] research is interesting, and it is found that one of the engines of innovation in the Chinese real estate market is uncertainty. He shows that uncertainty has a positive impact on firms' innovation performance, including R&D investment, innovation level and other innovation outcomes.

Increasing of using RES is also important in the context of the existing trend in housing exactly growing floor space per capita. Forecasts for the EU increase from 20 m^2 in 1960 to 45 m^2 until now per person in the UK or 15 m^2 in post-war Germany to 45 m^2 in 2016 to over 50 m^2 per person until 2030. Increasing of using RES is also important in the context of the existing trend in housing, exactly growing floor space per capita [29].

Furthermore, trends referring to other than EU countries are the same, e.g., in the USA, an average is 74 m^2/cap. Despite the increasing trend, the EU figures compared with an average of 18 m^2/cap in Shanghai, 20 m^2/cap in Japan and 30 m^2/cap in Singapore are relatively high [30]. More floor space needs more energy for heating, cooling, ventilation and lighting. In this context, a good example is the GAG Immobilien AG (Köln, Germany), an incorporated housing company owned by the city of Cologne, that decided to withdraw from the stock market after 60 years of being listed, to do not have to maximize profit but instead be able to build smaller flats, thus, less energy-consuming ones [31].

Killip et al. ([32]) report that to investigate the process of implementing in investments, the analysis should be carried out of two markets: the first market of repair, maintenance and improvement (RMI) of homes, in which energy efficiency is not the most important; and the second market for deep retrofit, where energy performance is the main objective. The first RMI market is dominated by small enterprises, especially micro-businesses, working in local markets. These companies are not profiting maximisers or focused on building energy performance. In the second market, companies are focused on energy efficiency and are usually small and medium or large enterprises cooperating at the regional and national market. The same situation is in the primary housing market. According to Brown et al. ([33]), several elements can be distinguished for a successful business/management model for retrofit, including:

- A value-based on comfort, well-being, health and aesthetics
- Guaranteed energy savings
- Integrated supply chains able to provide a whole-home approach
- A single point of contact for customers
- An integrated low-cost financing model
- Coordination of all these elements

As we can see, energy efficiency is one of those basic elements. Introducing the innovations on the housing market refers not only to the use of homes but, also, nevertheless important, to resource efficiency in the industrialization of housing production. Industri-

alized Housing Construction (IHC) has been a strategy to deploy emerging innovations for resource-efficient housing construction [34,35]. It is important because the building construction industry alone is estimated to comprise 25% of virgin wood and 40% of raw stone, gravel and sand globally each year. It is also responsible for 40–50% of the global output of greenhouse gas [36]. In the process of management and value creation within IHC, the authors have distinguished subthemes presented in Figure 1, which include, among others, innovative and industrial materials and operational energy efficiency. It shows that innovations, including RES, are factors creating value in the real estate market.

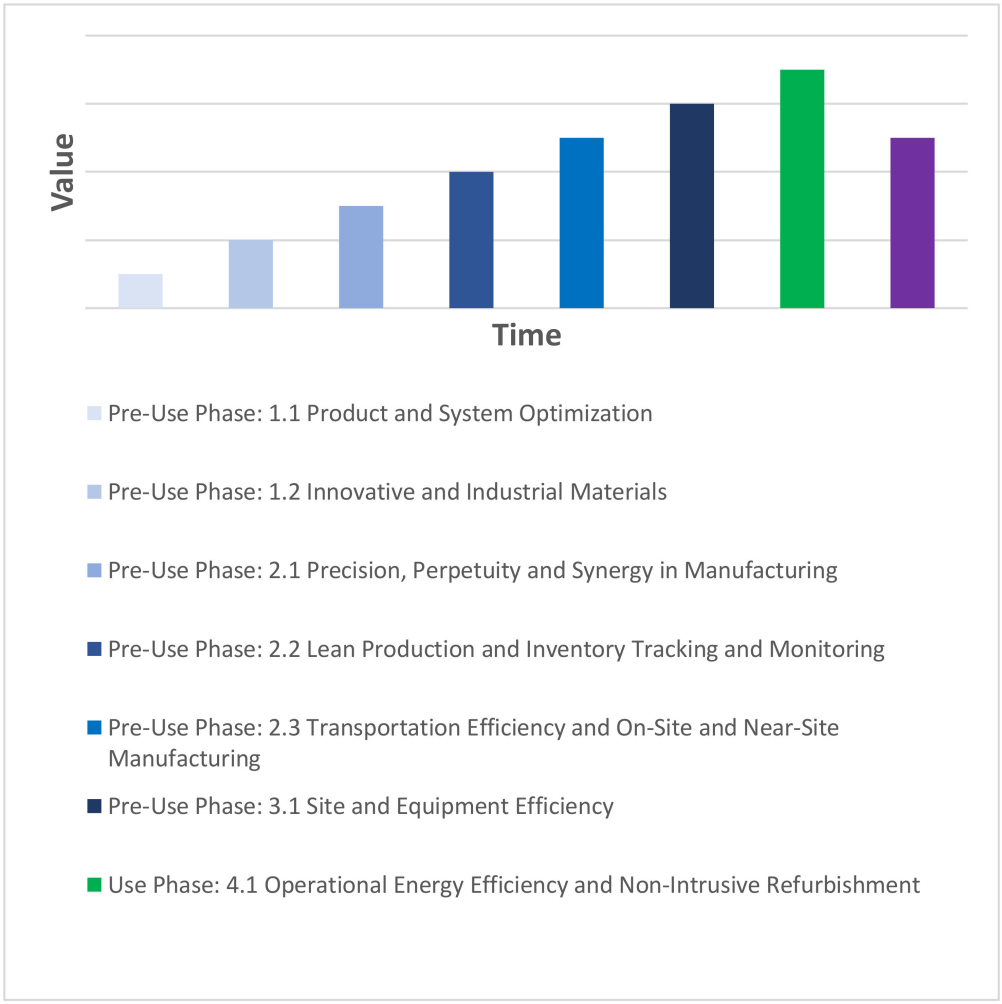

Figure 1. Subthemes in the process of management and value creation within IHC. Based on source: [34].

In relation to management, it should be stated that the core of modern society in the 21st century [37] (pp. 9–39), is not technology, information, or productivity: it is an investment managed as an instrument of society, responsible for producing certain results. In the case of RES, these results include, on the one hand, environmental protection by reducing gas emissions. On the other hand, they mean a reduction in operating costs of buildings and total or partial independence from external energy suppliers. A thorough analysis of management, according to the new quality paradigm, clearly shows that achieving and maintaining a high level of competitiveness requires continuous restructuring, including the improvement and introduction of new products or services, the development, search, and implementation of new technologies, the improvement of business management systems, production processes, sales, and marketing [38] (p. 13).

Therefore, it can be concluded that the basic determinant of global competitiveness in the 21st century will be the ability to create, share, and use knowledge, including, above all, generating and implementing innovation [39–41].

In the case of the construction sector, the implementation of sustainable urban development assumptions, especially those concerning housing, is the responsibility of engineers, managers and research and development entities focused on the implementation of innovations already in the processes of preparing materials for use in construction. In the case of the real estate market, especially residential real estate, the implementation of the assumptions of environmental sustainability is the responsibility of real estate developers and property buyers.

As presented above, innovations, especially renewable energy sources, play a significant role. The RES in the global energy mix is increasing from year to year. According to the International Renewable Energy Agency (IRENA), there were 2537 GW of renewable energy installations worldwide at the end of 2019. In 2019 alone, 176 GW of new power installed in RES was added.

The world's renewable energy sources are dominated by hydropower with an installed capacity of 1310.9 GW and wind power with an installed capacity of 622.7 GW.

The latest reports of the International Renewable Energy Agency [42,43] showed that the structure of RES in the world after 2019 was:

- 2537 GW of renewable energy installations (cumulative power),
- 176 GW was the renewable power added only in 2019,
- 54% accounted for new power installed in Asia in 2019,
- 72% of new generation capacities installed worldwide in 2019 were RES installations,
- the percentage of new wind and solar power in 2019 was 90%.

In Poland, the Institute of Renewable Energy (IEO) has already published the eighth edition of the report "Photovoltaic Market in Poland 2020" [39]. The report is a complete summary of the state and trends in the photovoltaic market in Poland.

The photovoltaics market is developing the fastest of all RES sectors in Poland. The total installed capacity of photovoltaic sources at the end of 2019 was almost 1500 MW, and, already in May 2020, it exceeded 1950 MW. The largest increase in new power is currently observed in the micro-installation segment, which illustrates the high activity of individual and business prosumers. In 2019, Poland achieved an increase in the new power about 0.9 GW and ranked among the top five in the European Union. New PV power installed in Poland accounted for 5.5% of the EU power growth.

According to the forecast, Poland will maintain its installed capacity growth rate this year and will be ranked 5th in the European Union. The Institute of Renewable Energy (IEO) estimates that at the end of 2020, the capacity installed in PV in Poland may reach 2.5 GW. IEO forecasts also indicate that the turnover in the photovoltaic market will increase this year compared to the previous one by as much as 25% and will exceed 5 billion PLN.

The most recent report by the Agency, containing a detailed overview that shows where and how much the percentage of renewable energy has increased, reveals that global RES increased by 7.6% last year. The leader is Asia with the growth accounting for as much as 54% of total added power. Although the expansion of RES slightly slowed down last year, the total growth of renewable energy still outpaced the growth of the use of fossil fuels (2.6 times), continuing the dominance of RES in the energy expansion achieved for the first time in 2012. Solar and wind energy accounted for 90% of the total renewable capacity added in 2019 [44,45] (pp. 58–80, 81–131).

Solar energy added 98 GW in 2019, with 60% being new power added in Asia. Nearly 60 GW increased wind power due to growth in China (26 GW) and the USA (9 GW). Both technologies generated 160 GW of global renewable power in 2019. It should be noted that wind and solar power, with 623 GW and 586 GW of installed capacity, respectively, cover almost half of global renewable capacity [44].

Hydropower, bioenergy, geothermal and marine energy showed a slight year-on-year increase of 12 GW, 6 GW, 700 MW and 500 MW, respectively. In the case of hydropower, an

exceptionally low growth rate was recorded. The experts explain this situation by the fact that some large projects did not meet the expected completion dates. Most of the expansion occurred in China and Brazil, with each country increasing capacity by over 4 GW.

Continuous processes of intense globalization and accelerated economic growth are stimulated by increased competitiveness. In the case of the European Union, the main problem for economic success at a time when global energy markets are changing as a result of the transition to clean energy is to maintain competitiveness. Analysing the above literature review, it can be concluded that the basic determinant of global competitiveness in the 21st century will be the ability to create, share, and use knowledge, including, above all, generating and implementing innovation.

The literature review revealed gaps in the presented research, in particular regarding the introduction of innovation, including RES, the management of this process, the causes and barriers to innovation, and the effects of not undertaking innovation in the realities of housing developers' activity on the real estate market in Poland. In addition, the confrontation of the presented international scientific achievements regarding innovation on the real estate market in the context of renewable energy sources with Polish literature in this area clearly indicates competitiveness as the main element of the EU economic development strategy, while there are no reports on the impact of the market on the demand for this type of construction in the context of Poland.

Problems related to renewable energy sources in the context of real estate and innovation management, as well as the evaluation of the statement of developers regarding RES in the context of sustainable development, allow formulating hypotheses which, after verification and confirmation, will summarize the role of innovation and management in the context of renewable energy sources in Poland [17,45–49].

As the effect of literature review the following hypothesis were proposed:

Hypothesis H1. *The innovations introduced by developers into the housing market depend on the scale/range of their activities;*

Hypothesis H2. *Lack of innovation by housing developers is caused by the lack of demand for such construction;*

and

Hypothesis H3. *Barriers to innovation by housing developers limit their competitiveness.*

3. Materials and Methods

Research on innovation among developers of the primary housing market was conducted from 24 to 28 August 2020. The survey was conducted in the form of a survey on a sample of 130 entities: developers of the primary housing market implementing multi-family housing investments.

The survey was carried out using the CATI method (telephone survey using an online questionnaire) on a nationwide sample. The questionnaires were filled and returned from 130 entities, with the number of the entities that built blocks of flats, i.e., multi-storey, multi-family buildings, estimated as on 13 July 2020 at 324 entities.

The questionnaire consisted of 6 questions of the record, such as company name, its headquarter, geographic scope of the company's activity, origin of its capital, internship in the real estate market and employment and 25 substantive questions.

The survey dealt with innovations among developers of the primary housing market, where RES were only a small part of this survey. Since the most important characteristics of RES power are measured as the maximum net capacity of power plants and installations using RES for electricity generation while the obtained and generally available data reflect the installed and connected capacity at the end of the calendar year. The data were obtained from various sources, including a survey and secondary data such as IRENA questionnaires,

Renewables Global Status Reports, IEO, ERO (Polish Energy Regulatory Office), Statistics Poland reports, industry association reports and information articles.

Descriptive statistics were used to present the research results. It was found that the main elements resulting from the implementation of innovations in the primary housing market are the concept of intelligent sustainable construction, having an impact on energy management. The basic research method used in the study was a survey. The research tool used was the original CATI questionnaire a method of collecting information in the quantitative market and public opinion research). The significance test based on normal Laplace distribution was chosen to verify these hypotheses [46,47] (pp. 411–470). The data for the analysis were prepared based on the author's questionnaire.

The applied method of statistical inference allows in a relatively simple way, based on the experimental data, to verify the substantive hypothesis on the basis of the probability calculus. Hypothesis verification methods or significance tests are often used to test the relationship between variables, e.g., the causality test or the cointegration test or significance tests as hypothesis verification [50].

4. Results

The research part of the study concerns the analysis of the survey conducted on innovation among the developers of the primary housing market. The analysis of innovative activity on the housing market is most often carried out in the nearest market environment using specialized market research and reports and results of analyses prepared and published by public and private institutions such as IRENA, IEO reports, URE and Renewable Global Status Reports. The survey conducted in the paper enabled conclusions to be drawn on the motivations for introducing innovations in the housing market, types of innovations, benefits, barriers, support and management of innovations.

The survey concerned the research on innovation in development companies operating on the primary real estate market. Innovation research among residential construction companies on the primary market was carried out in August 2020. The survey among enterprises was conducted using the CATI method. Research using this technique is often used to develop a company's strategy or marketing activities. The study was conducted on a nationwide sample. The research sample consisted of 130 entities, with the general population constituting ($\pm$ 5%) 324 entities building multi-storey, multi-family houses in Poland.

Developers—respondents (presented in Figure 2), representing companies operating in various geographical areas of the country, i.e., companies operating on the local market—61 companies; on the voivodeship market—52 companies; on the Polish national market—14 companies; and in the five largest Polish cities—three companies. Moreover, they represented companies with different origins of capital: Polish capital—122 companies; foreign capital—four companies; and mixed capital—four companies.

The presented companies were characterized by different years of operation from 5–9 years, for 10–15 years, to 15–24 years. Among the analysed companies, 65 companies employ up to 10 employees, 37 companies have employees from 10 to 49, five companies have employees from 50 to 249, two companies have more than 249 employees while the remaining companies did not want to disclose the number of employees.

The substantive questions are divided into four blocks—the motives for introducing innovations to the housing market and their nature, the reasons for cooperation and support for innovative activities, the effects of introducing innovations and their functional features, and managing the innovation portfolio.

The surveyed residential developers answered the question of whether they introduced innovations in their operations, giving 31.5% positive answers. Figure 3 graphically shows the answer to the question.

Figure 2. Characteristics of the research sample—entities building multi-storey, multi-family houses in Poland.

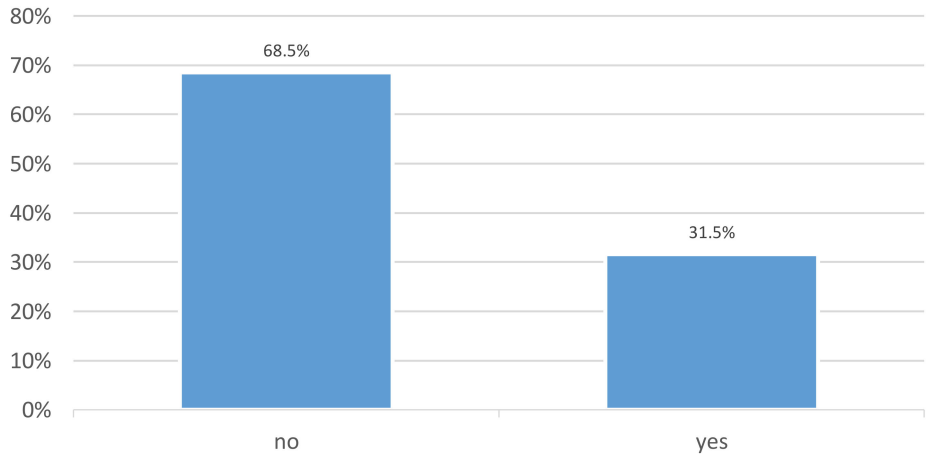

Figure 3. Do you introduce innovations in your activities in the housing market? (N = 130).

Other developers (68.5%) responded negatively. As can be seen, most of the enterprises studied do not introduce innovations in their operations, which may negatively affect their operations in the future. Furthermore, 53.9% of the respondents indicated that their customers chose conventional construction to implement innovative solutions. As arguments for not innovating, they mentioned the specificity of the enterprise (50%),

attachment to conventional construction (37.5%), lack of demand (33.3%), or preferences for best practices (33.3%).

It is important to analyse the motivations and conditions for introducing innovations in the housing construction sector.

As regards the motivations for introducing innovations in the activity of a real estate developer on the housing market, the respondents mentioned fast sales of apartments, cost reduction, and growing customer requirements. Companies with a voivodeship range preferred especially customer satisfaction, while for companies with a nationwide range, the most important motivation was to improve the quality of products (apartments) and services. Reducing the environmental impact and increasing the company's market share are the most important motivations for developers operating in the five largest Polish cities.

While answering the question concerning the types of innovations, the developers listed technical and technological innovations as the most important (mean $\overline{36.25}$%), followed by procedural and organizational ($\overline{27}$ %), marketing ($\overline{23.75}$%) and financial ($\overline{13.5}$%) innovations. The details of the answers to this question are presented in Table 1.

Table 1. Types of innovations introduced by developers in the housing market.

	What Innovations Do You Use?			
	Local	Within the Voivodeship	Nationwide	The five largest Polish Cities
Process and organizational innovations	29%	27%	27%	25%
Technical and technological innovations	43%	37%	40%	25%
Marketing innovations	23%	27%	20%	25%
Financial innovations	6%	10%	13%	25%

It is technical and technological innovations that determine the directions of development for innovations in housing construction, especially related to RES. Their percentage is on average 36.25% of all technical and technological innovations. However, it is the RES innovations, regardless of the scope of the company's activity, that qualify for technical and technological innovations, which may favour the implementation of RES in the activity of real estate developers carrying out investment projects.

In the developers' opinion, the calculation of benefits and barriers determines cooperation with other entities in introducing innovations and also determines the direction of support for these activities.

The processes associated with innovative activities in the housing market are accompanied by a balance of benefits and barriers. When asked about the benefits of introducing innovations to the housing market, developers ranked them in the following order higher selling price of apartments, their faster sale, higher quality of apartments in a finishing stage, and a significant benefit, i.e., maintaining employment, which helps stabilize the company and guarantees its development.

According to housing developers, the most significant barriers include complicated legal regulations, lack of sufficient qualifications of employees, lack of financial resources, time pressure and lack of recognition of market needs for innovation.

When asked about the support needed for investment activity by residential developers, 50% of the companies answered that there was no need for support. Developers paid attention to technical support (25%) appreciated by companies implementing investment projects. They also emphasized financial, equipment and personnel support (25%).

Quite an interesting and varied answer was given by the developers to the question from the block on the effects of introducing innovations and their functional features.

As a result of introducing innovations in the field of housing construction, developers mentioned a higher selling price of apartments (33%), their faster sales (16.7%), higher quality of apartments in the developer standard (16.7%) and an increase in customer confidence through the company's image and reducing damage to the environment.

Innovations as factors influencing the interest in housing construction (functional features) are, according to developers, its high functionality (28.5%), ease of use of the installed innovative systems (24.5%), reduction of building operating costs (24%) and the possibility of expansion and remote access (23%).

Local, provincial and national enterprises most often indicate high functionality, while only enterprises operating in the largest five Polish cities indicate all of the above-mentioned features.

In response to the question of whether the problem of innovation management results from the company's strategy, 31.7% of the developers answered positively (due to gaining a leading market position among the competitors). Furthermore, 22% of respondents also confirmed the role of management in the adopted strategy due to the need to adapt products to the level offered by the competitors, while 46.2% did not give a clear answer.

For companies, it is important to guarantee their future business activity and continuous development.

While answering the topic of management and corporate strategy, 56.1% of the housing developers stated that introducing innovations to housing projects leads to difficulties in terms of managing them. Furthermore, 43.9% of them answered negatively. According to 100% of the respondents, the company's development strategy and investment project management depend on funds, of which 14.3% confirmed the dependence of management on the type of investment. Of the respondents, 31.7% stated that the introduction of innovations is an element of the company's development strategy due to gaining a leading position on the market among competitors. A total of 14.6% denied this statement, and 31.7% had no opinion. The answers to this question show that management assessed from the perspective of innovation must change with the company's development, technology development, knowledge and competence.

The developers also commented on the environmental benefits of bringing innovations to the housing market (the answer to this question was given by developers on a scale from 1 to 6, 6 being the maximum score, and 1 being the minimum score). A table of environmental benefits and their importance resulting from the introduction of innovations into the housing market is presented below.

Regardless of the scope of the activities of real estate developers, the environmental benefits were ranked by the developers by determining the arithmetic mean of each indication. They ranked the items as follows: water management ($\overline{5.325}$), reduced CO_2 emissions ($\overline{5.25}$), green technologies and recycled materials ($\overline{5.2}$), rational use of RES ($\overline{5.175}$), waste management ($\overline{4.95}$) and improving the environment in sustainable buildings ($\overline{4.85}$). The ranking determined based on developers' statements is surprising, because, in recent years (2018–2020), Poland has seen a rapid and very dynamic development of renewable energy sources (RES), with the benefits of using this innovation being disproportionate to the costs of these installations, although they are spread over time. The answer to this question also points to climate-friendly innovations.

The analysis of innovation effectiveness is most often performed from the perspective of the nearest market environment. There is a substantial variation in the assessment of the effectiveness of the innovations introduced. The most conclusive answers are those concerning the regional and national market. On the national market, the introduction of innovations results in a higher selling price of apartments, faster sales and higher quality of the final product, i.e., apartments in a finishing stage. A quite important factor, in this case, is the increase in customer confidence and improved corporate image.

The environmental benefits resulting from the introduction of innovations into the housing market are particularly based on energy efficiency through the rational use of energy as presented in Table 2. The most frequently chosen assessment of future activity by local developers is the attitude of maintaining an average level of innovation characteristic of the market in which developers operate. Real estate developers with a voivodeship and nationwide scope operating in the largest five Polish cities most often choose the attitude of conducting as many innovations as possible in their activities, which allows for

minimization of the risk of bankruptcy and gaining competitive advantage. In terms of assessing the effectiveness of innovation, the resources involved in innovative activities are producing the expected results.

Table 2. Environmental benefits connected with bringing innovation to the housing market.

Please Prioritize the Environmental Benefits of Bringing Innovations to the Housing Market?				
	Local	Within the Voivodeship	Nationwide	Five Largest Polish Cities
Energy efficiency through the rational use of energy (use of renewable energy sources)	5.0	5.4	4.3	6.0
Improvement of the environment in sustainable buildings	4.5	5.1	3.8	6.0
Reducing harmful CO_2 emissions	4.8	5.2	5.0	6.0
The use of green technologies and recycled materials	4.6	5.2	5.0	6.0
Effective water economy	4.9	5.1	5.3	6.0
Rational waste management	4.4	4.6	4.8	6.0

Generally, thanks to the effects of introducing innovations in the field of housing construction, it was possible to achieve a higher selling price of flats, faster sales of flats, higher quality of the final product, i.e., flats in a finishing stage, and, importantly, to maintain employment. Furthermore, by introducing innovations in terms of housing construction, it has been possible to increase customer confidence in the company, improve the company's image, and reduce environmental impacts.

Some of the survey questions related to renewable energy are very important for ecological and economic reasons. Therefore, in order to confirm and summarize the results of the survey on the implementation of innovations, substantive hypotheses were proposed for verification.

The significance test based on normal Laplace distribution was chosen to verify these hypotheses [46,47] (pp. 411–470).

The level of statistical significance in the analysis was set at $\alpha = 0.05$. If the distribution of a trait in the population studied is normal, with expected value x_0 and standard deviation 6, and the parameter 6 is known, the significance test for $x = x_0$ will be met by first calculating the sample mean $\overline{x}$ and the value of the random variable u:

$$u = \frac{\overline{x} - x_0}{6}\sqrt{n}, \tag{1}$$

where n is the sample size;

x_0 is the expected value; and

6 is the standard deviation.

It seems that it would be more reasonable to take the weighted arithmetic average instead of the expected value x_0 [50] (pp. 589–595).

Since the weighted average is successfully used to calculate the average value, and all uncertainties, $X_{ij,}$ are independent. Moreover, the weighted average gives the correct result only if the weights are independent, i.e., they are not correlated with each other.

For a pre-set level of significance α, the value of u_α is read from the table of cumulative distribution function, i.e., from the table of Laplace function, such that $|u| \geq u_\alpha$ is called the critical area for this test. If the value:

$$u = \frac{\overline{x} - x_0}{6}\sqrt{n}, \tag{2}$$

is such that $|u| \geq u_\alpha$, the hypothesis that $x = x_0$ is rejected. Otherwise, there is no reason to reject the hypothesis.

The significance test adopted in the paper verifies the hypothesis that certain features of set A and set B are statistically independent. Using the research tool such as the statistical method, the author considers the assumed hypotheses, which are calculated using the formulae reflecting the examination of the normality of statistical distribution.

It is essential to assess the statement of developers regarding renewable energy sources in the context of sustainable development. Therefore, data for the analysis were prepared based on the author's questionnaire. The data and calculations used to confirm the validity of the hypotheses are presented in Table 3.

Table 3. Empirical data used to verify the hypotheses.

n	H1	H2	H3
Local market	15	3	13
Voivodeship market	19	6	13
Polish market	6	13	9
Market of the five largest cities in Poland	1	1	6
	$\overline{x} = 10.25$ $x_0 = 12$	$\overline{x} = 6$ $x_0 = 7$	$\overline{x} = 10.25$ $x_0 = 12$

The sample mean was first calculated by $\overline{x}$, and a random alternate u value for a given sample size was calculated secondly. For a predetermined level of significance α, the table of cumulative distribution function, i.e., the Laplace function table is used to read the value of u_α such that: $P\{\lceil u \rceil \geq u_\alpha\} = \alpha$. The u_α value is called the critical value for this test and is 1.96.

Since the questions about the specifics of the expected investments, planned implementations in the future, their positive effects and ecological benefits show that especially renewable energy innovations such as photovoltaics, heat/energy, solar collectors and Smart Home technologies (home automation such as heating, lighting, alarms), gates, roller shutters, ventilation, ingress protection IP cameras (protection level)—a combination of a camera and a computer-based on energy sources, controlling installations and devices remotely) are expected by customers; therefore, the hypotheses were related mostly to RES.

Hypothesis H1:

Innovations introduced by developers to the residential market depend on the scale/scope of their operations. Hypothesis H1 concerns the location of housing markets as local, provincial, national, and the market of the five largest cities in Poland.

$6^2 = -50.68$; $6 = 7.12$; $u = -0.50$; $u_\alpha = 1.96$

There is a relationship: $|u| \geq u_\alpha$ i.e., $|-50| \geq 1.96$, which is untrue, i.e., there are no grounds to reject the H1 hypothesis.

Hypothesis H2:

The lack of innovation by housing developers is caused by the lack of demand for such construction. Hypothesis H2 is presented by questions about the strong increase in housing prices, better quality and higher and faster sales.

$6^2 = 17.75$; $6 = 4.21$; $u = 0.48$; $u_\alpha = 1.96$

There is a relationship: $|u| \geq u_\alpha$ i.e., $|0.48| \geq 1.96$, which is untrue, i.e., there are no grounds to reject the H2 hypothesis.

Hypothesis H3:

Barriers to innovation by residential developers limit their competitiveness.

Hypothesis H3 was verified based on the answers of the survey respondents concerning maintaining employment, reducing environmental impact and improving the corporate image on the global market as well as taking advantage of the opportunities offered by the common European market. Therefore, it can be concluded that the introduction of innovations results from the corporate strategy, which is ultimately expected to guarantee the economic growth of the country.

$6^2 = 8.69$; $6 = 2.95$; $u = 1.19$; $u_\alpha = 1.96$

There is a relationship: $|u| \geq u_\alpha$ i.e., $1.19 \geq 1.96$, which is untrue, i.e., there are no grounds to reject the H3 hypothesis.

It can be seen that the verification of the hypotheses summarizing the results of the survey analysis confirmed their truthfulness for this market. It should be noted that, despite this fact, there is a good knowledge of the benefits and barriers to innovation in renewable energy on the real estate market, Poland was only a moderate innovator in the ranking of innovation systems of the EU Member States in 2020 [51].

5. Discussion

The percentage of energy generated from renewable energy sources remains small in Poland. The Polish power industry is still dominated by coal. The structure of electricity production in Poland in 2019 is presented in Table 4.

Table 4. The structure of electricity production in Poland in 2019.

Type	Percentage (%)
Utility hard coal-fired power plants	49.25
Utility brown coal-fired power plants	26.14
Wind power plants and other renewable energy sources	9.03
Utility gas-fired power plants	7.62
Industrial power plants	6.41
Utility hydropower plants	1.55

Source: [52].

Table 4 shows that the percentage of utility power plants in electricity generation in 2019 was 75.39% and renewable energy sources only 9.03%, while the percentage of utility hydropower plants was 1.55%. The capacity for renewable energy installations in Poland is almost 9.5 GW. The capacity for renewable energy installations in Poland is almost 9.5 GW. The largest source of electricity from RES is wind. Photovoltaic sources increased their percentage from 5% to 7%, according to the ERO publication on the capacity of individual types of installations based on renewable energy sources, as on 30 June 2020. During this period, the share of wind energy production in renewable energy is almost 64%, biomass—16%, water—10%, sun—7.5% and biogas—2.5%. From this, it follows that wind installations in Poland are the most numerous among the renewable energy sources, and their number is 1207. The second place is occupied by photovoltaics, with 1104 installations and water—771, biogas—371 and biomass—62. However, the ERO's comparison does not show the rapidly growing number of photovoltaic micro-installations, the owners of which settle accounts in the discount system or in the system of selling surpluses electricity at the average price from the wholesale market from the previous quarter. In 2020, the sector continued to develop very intensively. Home micro installations are currently experiencing a market boom due to the possibility of obtaining subsidies for the already relatively cheap PV panels.

RES in relation to multi-family and multi-storey houses can be used in two ways. First by introducing innovations-RES in heat plants supplying entire districts and even cities. This way of central heating and water heating is the most popular in Poland—called system heating. It is convenient for developers because heating costs fall on future owners or tenants, so the developer is not interested in minimizing them. Second way is to implement RES directly in buildings by developer. In this case developers should analyse the available RES and choose the appropriate for the particular project. It can be recommended that in the case of multi-family and multi-storey buildings, the most effective solution will be a combination of heat pumps and photovoltaic panels. The use of only photovoltaic panels is in most cases insufficient due to the need to find a large area for their installation. In

the case of buildings in large cities, due to the high land prices, the buildings have several or more storeys to obtain a relatively large number of apartments on a plot of small area. Initially, the introduction of home wind farms was also discussed, but the change in tax regulations from 2017 in Poland made this solution unprofitable.

Furthermore, in the context of the Green Deal, which is assumed to eliminate net greenhouse gases by 55% by 2030 and no emissions by 2050, RES become of prime importance. Reaching this target will require action by all sectors of economy, including decarbonizing the energy sector and ensuring buildings are more energy efficient. Therefore, both heating plants and developers will have to introduce RES in their activity. The sooner they do it the better for them because of the experience and efficiency of introducing RES [53].

The research conducted has shown that residential developers in Poland point at, among others, competitive pressures, concern about the quality of products and services offered, increasing market share or satisfaction and increasing customer requirements. This clearly shows that the implementation of innovation is perceived through the prism of increasing competitiveness.

The conducted research revealed that competition is the basic factor driving the implementation of innovations among developers. The developers operating in the area of the five largest Polish cities attach the greatest importance to implementing innovations in their activities. The area of their activity is characterized by very high competition related to the possibility of quick sale of flats at a high price. However, in order to attract customers and be able to achieve high rates of return on investment, developers must offer a unique and attractive product. Therefore, it is recommended to developers, not only operating on the market of the five largest cities, to introduce innovations, including RES, in order to ensure the highest quality of offered apartments. The process of implementing the RES should, however, be preceded by the study of customer preferences and even a combination of the study of preferences with the simultaneous process of presenting possible innovative solutions, which customers are often unaware of, as shown by the study. The best solution would be the ability to create a specific need among customers for flats with specific innovative solutions, and even fashion for them. Identification of tools that can awaken such a need among customers can be a good direction for further research.

One of the ways to make the project more competitive are certificates. In the largest Polish real estate market, namely in Warsaw, the investment completed in 2019 was pre-certified under BiodiverCity. It is an international certificate that emphasizes biodiversity in newly constructed buildings and their surroundings. Thanks to its unique character, confirmed by the above certificate, the investment achieved very good sales. Therefore, another recommendation already confirmed by the market is the use of pro-ecological innovations confirmed by special certificates, which highlight projects by facilitating their sale and obtaining high rates of return.

Growth of competitiveness through the implementation of innovations, including RES, is motivated not only by market conditions but also by the assumptions of energy policy and development strategies of particular governments. It is these top-down regulations that are the main driving force behind the implementation of RES innovations.

In the study, developers as one of the barriers of introducing innovations, apart from the lack of adequate support, mainly from public entities in the field of, inter alia, appropriate law favouring the implementation of innovations and financial support, indicate difficulties of the client's market manifested by the lack of knowledge and identification of needs in the field of innovation, and the lack of willingness to pay a higher price in regard to the product with higher innovation level. Of course, developers have no influence on the legal solution and the implemented facilitations and preferences that the government should introduce. They can only indicate their preferences and needs in this regard. On the other hand, they should conduct market research to identify customer needs in relation to innovation, while informing and educating about the possibilities and advantages of implementing individual innovations, with particular emphasis on RES. In addition, the abovementioned barrier, which reflects the higher construction costs of innovative build-

ings, which in turn results in the higher price of the offered apartments, should be justified by the limitation of future operating costs and, what is interesting, the uniqueness and character of the offered apartments. Flats that take into account innovations are currently rare in Poland, especially in smaller real estate markets, which may distinguish them from the competition and allow them to achieve high rates of return on sales at higher-than-average prices. Of course, this forces developers to increase the regime and monitor the project in accordance with the plan, so that the implementation costs do not increase even more. This is all the more important for the Polish realities because it has been shown that the construction costs of buildings taking into account innovations, e.g., heat pumps, recuperation or photovoltaics, increase on average by 10%, while in countries such as Germany or Austria only by 2% [54]. Moreover, markets that are more developed and thus more competitive require the use of innovative solutions, which was also confirmed by the study. Developers operating nationwide and on the market of the five largest Polish cities, usually larger companies, showed a greater willingness and even the need to introduce innovation in their activities.

Taking into account all aspects of innovation in the light of RES from the adoption and support of the Polish Energy Policy until 2030 by the Polish government (sustainable consumption of energy from renewable sources), it has become necessary to develop new management principles ensuring constructive development of management theory and practice [38].

From the perspective of the research, new management principles should concern:

- Adequate financial management (acquiring sources of financing) to meet the need for a large amount of capital to carry out innovation;
- Appropriate project management to introduce innovation, strategic management tailored towards innovation and its introduction and creation in the long-term;
- In the phase of planning the investment appropriate identification of possible to implement innovation with the market survey in the field of determining the customers' needs in innovations;
- Introducing special tools connecting education in possible innovations and its benefits with simultaneous awakening the need for innovation in the housing among customers; and
- Increasing the regime in carrying out the project according to the plan because of the possibility of exceeding the costs related to the implementation of innovation.

Management is a tool to enable the organization to achieve this goal. Therefore, the main task of management is to meet the customer needs, so it is important to know the value and potential needs of the company's customers and adjust the quality of manufactured products (goods and services) to these needs. It should be noted that in the case of RES, such a need has not yet been identified by many customers due to the lack of full awareness of the benefits and, most importantly, future legal guidelines and their consequences (contained, for example, in the Energy Policy until 2030 for the EU).

In conclusion, it should be clearly emphasized that activities in the field of increasing innovation and, in particular, energy efficiency through, inter alia, implementation of RES, driven largely by strategies introduced by national governments or, e.g., the EU, will change the perception of RES as an innovation. Implemented programs, such as the program for the modernization of social housing in Ireland presented in the literature review, are carried out on such a large scale that the use of RES ceases to be an innovation on the market and is slowly becoming a standard.

6. Conclusions

The analysis of the results of the survey allows for drawing the following conclusions. First should be mentioned the factors motivating developers to undertake innovative activities in the real estate market. It has been identified that the most important factors include concerns for the quality of offered products and services, increased market share, reduction of environmental impact and pressure from the competitors. It can be observed that

the above-mentioned, most important factors driving the implementation of innovations mostly relate to increasing competitiveness. It is true that pressure from the competitors is in the top 4 factors, but not in the first place, which informs that when analysing the national situation, innovations are not implemented on a large scale by developers.

On the other hand, the situation in the most developed real estate markets in Poland has shown that developers operating there most willingly introduce innovations and believe that introducing innovations is slowly becoming a necessary requirement in their activities. Additionally, in the context of Polish Energy Policy until 2030 and EU Green Deal, introducing innovations, especially RES, will become a necessity. Smaller development companies operating on local markets have shown that they have, so far, largely failed to introduce innovations and currently maintain their average or minimum level in order to avoid bankruptcy. For companies of this type, it is recommended to change the strategy in order to increase the share of innovation in their activities, which will be forced overtime by both the market (competition) and legal regulations.

According to the implementation of innovations in the field of RES, the conducted re-search revealed that almost all developers—with local, voivodeship and 5 biggest polish cities activity, pointed at use of renewable energy sources as the most important innovation which brings the environmental benefits. Only nationwide developers pointed at effective water economy as the most important innovations which brings the environmental benefits. However, this factor partly, also referred to RES because usage of solar panels enabled heating the water. Therefore, it can be concluded that developers should focus on implementation of RES in their innovative activity. Furthermore, the future operation cost limitation will be the best incentive for clients to pay higher price for the flat. Furthermore, the future operation cost limitation will be the best incentive for clients to pay higher price for the flat. In the context of high lack of knowledge about innovations and its benefits, this type of innovation seems to be one of the most important and recognizable.

However, innovation still faces several barriers, which entrepreneurs consider to be the most important. These include lack of financial resources, complex legal regulations, the uncertainty of the results of innovative activities, lack of sufficient qualifications, lack of assessment of market needs for innovation, lack of updated information on available technology, and rush and time pressure. Nevertheless, the main barriers that should be emphasized, besides complex and unfriendly legal regulations, which are the greatest barriers, are a lack of sufficient qualifications, rush and time pressure and poor recognition of the enterprise's market needs for innovation. When analysing the above, apart from changes in the legal framework on which developers have no direct influence, it should be stated that in order to overcome the barriers to implementing innovations, it is necessary to transfer knowledge—knowhow—in relation to the implementation of innovations, which will also minimize the time pressure. When analysing the above, apart from changes in the legal framework on which developers have no direct influence, it should be stated that in order to overcome the barriers to implementing innovations, it is necessary to transfer knowledge—knowhow—in relation to the implementation of innovations, which will also minimize the time pressure. Moreover, as part of carrying out investment projects, in the planning phase, developers should identify the possibilities of implementing innovation along with the resulting benefits and the market needs in this regard.

From the perspective of the research, change in management principles should concern, among others, adequate financial management (acquiring sources of financing) to meet the need for a large amount of capital to carry out innovation. Then appropriate project management to introduce innovation, with emphasis on identification of, in the phase of planning the investment, possible to implement innovation with the market sur-vey in the field of determining the customers' needs. Furthermore, developers should consider introducing of special tools connecting education about possible to implement innovations and its benefits with simultaneous awakening the need for such innovation in the housing among customers. Increasing the regime in carrying out the project according to the plan because of the possibility of exceeding the costs related to the implementation

of innovation and strategic management tailored towards innovation and its introduction and creation in the long-term.

The research problems addressed in this study in the context of data obtained in direct research, studies and reports for 2020 were fully confirmed to be topical. Therefore, it can be assumed that they were realized and consistent with global data for the period analysed.

Since the study concerned broadly understood innovations in the activity of housing developers in Poland, and renewable energy sources of RES were only a small part of this study, it seems justified to undertake further research to identify the possibilities of introducing RES in residential development projects, identification of barriers and benefits resulting from the implementation of RES. Such research seems to be needed in the housing market, which was indicated by the respondents of the survey, at the same time indicating the use of RES.

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