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# The Impact of Certification Systems for Architectural Solutions in Green Office Buildings in the Perspective of Occupant Well-Being

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**Abstract:** The green building certification system has long-lasting benefits by improving building efficiency and sustainability. The ultimate goal of such classification is to promote the preservation of the global environment as well as the occupants' well-being and their health. In this paper, we present examples of buildings that have been designed and built in Poland and have been certified with BREEAM, LEED and WELL. Our study investigates human factors in certification systems and examines the WELL Building Standard as a supplement to other green systems, which will probably be the most popular in the future. The green building movement should prioritize pro-human factors and the associated environmental beliefs to improve indoor environment quality for users' needs. We present this matter on the example of the Polish office space market, providing statistics and analyzing the architecture of six certified office buildings from Warsaw, Poznań and Wrocław. They are a representative sample of buildings designed following the certification regime. It was demonstrated how this aids in improving work comfort, enhances the program of office spaces and the organization of service spaces within buildings, which increases the rank of this architecture and positively affects the urban environment.

**Keywords:** architecture; office buildings; sustainable development; WELL Building Standard; green building; rating tools; Poland



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## 1. Introduction

City centers are filled with office buildings of various types: mixed-use, corporate, coworking, those that belong to banks or those that are occupied by administrative institutions. They occupy entire blocks, forming business districts, and their peculiar architecture generates the appearance and rank of main city streets and squares. Due to their size and structure, the construction of office buildings leaves a significant carbon footprint. In addition, over the course of their use, they become enormous sources of heat emission, as they are a place of everyday multi-hour stays of numerous employees, whose global number is in the hundreds of millions. They should all be provided with an optimal work environment, which is provided using various, yet always energy-consuming, technical means. Because of this, in the 1980s, certain organizations began efforts to rationalize architectural and infrastructural solutions in these types of buildings, which were tied with the spread of the idea of sustainable development. This notion first appeared in the report Our Common Future (also known as the Brundtland Report), published in October 1987 as the effect of the work of the World Commission on Environment and Development (WCED) [1–3]. The first Green Building Council was established in 1993, thus marking the birth of a global movement. The US Green Building Council was founded by Rick Fedrizzi, David Gottfried and Mike Italiano, with the mission of promoting sustainability-focused practices in construction [4]. A study by KPMG International conducted in highly developed countries in 2004 demonstrated that over a decade, between 1993 and 2002,

the number of large companies that prepared sustainability reports increased from 12 to 28% [5]. This trend manifested itself buildings with architectural solutions that implemented sustainability postulates, which was especially visible in new office buildings, particularly those housing the headquarters of corporations and banks. This was tied with improving the standard of buildings and work comfort, for instance in terms of access to daylight and efficient ventilation. Around the beginning of the 21st century, building sustainable institutional and office buildings became trendy. The top architects from this period: Norman Foster, Stefan Behnisch, MVRDV, Ian Ritchie, Jean Nouvel, Renzo Piano, Frank O. Ghery and Cook + Fox Architects all had a key role in this [6–8].

As shown by World Green Building Council (WGBC) and Association of Business Service Leaders (ABSL) statistics, over the past dozen years or so, office buildings with parameters at the level of "green buildings" were a constantly growing group, which in some countries amounted to as much as 80% of the sector. In Poland, at the start of 2021, this amounted to 82.7%, while in Warsaw alone, certified office buildings formed 94.3% of all office buildings [9,10]. Such buildings feature consistently perfected and highly developed spatial and technical solutions that lead to a reduction in their carbon footprint. Accounting for the scale of these efforts, which concern a total of over a million buildings, can be seen as a step towards preventing the feedback loop that leads to catastrophic climate change [11].

To optimize architectural solutions of various types of office buildings (which differ in terms of height and use) and to allow for an objectivized assessment of their quality, one can use various types of international classifications. The three-class classification (classes A, B and C) by the Buildings Owners and Managers Association International (BOMA International) [12], as well as the classification by CoStar Building Rating System SM [13] can be considered basic systems. In the US, each state uses various types of the three-grade classifications, as well as five-grade classification that includes high-rise buildings (T, A, B, C, 1). Global corporations such as KPMG International, Rolfe Judd Architecture or CB Richard Ellis [14] offer statistical, certification and consulting services concerning such buildings. In these classifications, the primary office building standard assessment criteria are site attractiveness and urban linkages, as well as architectural parameters, wherein a wide range of elements that affect programmatic, functional, spatial and compositional solutions are assessed, as the prestige of a company is largely tied with the attractiveness and uniqueness of its main building. Technological and infrastructural parameters are also inspected, as are ergonomic and medical ones.

There are also certification systems such as BREEAM (Building Research Establishment Environmental Assessment Method), LEED (Leadership in Energy and Environmental Design), HQE (High Quality Environmental standard, Haute Qualité Environnementale), GBS (Green Building Solutions), DGNB (German Sustainable Building Council, Deutsche Gesellschaft für Nachhaltiges Bauen) and WELL (WELL Building Standard) [15], which are focused on the parameterization of buildings primarily in terms of the quality of their indoor environments (which include uses such as housing, workplaces and recently also retail and culture) in combination with meeting all types of pro-environmental requirements. These certifications support and stimulate various types of development programs intended to produce architecture with maximum accessibility, comfort of use and a low carbon footprint. They are used for all types of buildings but are especially important in the case of structures classified as: Civic and Institutional Buildings and Administration office buildings, in whose case government subsidies are often a very strong impulse and encouragement to developers to employ pro-environmental solutions. The second group of widely certified buildings are Commercial Buildings and especially Office buildings. Here, the encouragement to meet the requirements set out in certificates are high expectations of potential tenants, such as tech corporations and companies. This "race" to carry out pro-environmental programs and workplace environment optimization, brought about by competition, has been a catalyst for highly positive change over the past two decades.

The dynamic of qualitative and quantitative change concerning office buildings, as well as the essence and mechanism of pro-environmental building certification, in which improving workplace environment optimization and standards are the main axis of analyses presented in this paper. We present this matter on the example of the Polish office space market, providing national statistics and describing a representative sample of buildings from Warsaw, Poznań and Wrocław, which have BREEAM [Appendix B], LEED [Appendix A] and/or WELL [Appendix C] certificates. The presented study specifically analyzed the human factor in certification systems, which is most broadly investigated in the WELL Building Standard. It functions as an enhanced version of previously used green system certificates, and probably, as a result of changes and expectations concerning office building structure brought about by, among other things, the pandemic, they can be expected to become the most popular certificate in the future. COVID-19 has significantly contributed popularizing this movement, yet we should see its success also in the fact that it also attempts to counter a wide range of 21st-century diseases of affluence, i.e., obesity. WELL directs a great deal of attention to promoting a healthy lifestyle, nutrition, sports, etc., and is globally characterized by a greater focus on human and, therefore, employee wellbeing, as at least one-third of one's day is spent in an office.

Design following the WELL standard is a relatively new phenomenon that has been functioning only since 2014 and there are few studies that focus on it, which is why we carried out the investigation presented, assuming that it can contribute to formulating conclusions that can aid in making accurate programmatic and architectural decisions, useful in the design of green office buildings.

### *1.1. Literature Review*

The phenomenon of green office buildings was analyzed in this paper in terms of applying standards featured in BREEAM Excellent-level certificates, LEED Gold- and Platinum-level certificates, and Silver- and Gold-level WELL Building Standard certificates. In general, the subject of the green building movement that applies to the specificity of office buildings is extensively reflected in academic literature. It is described from various angles. The broadest research field consists of attempts to limit threats to the environment by minimizing anthropogenic factors that contribute to global warming. Studies show that the construction sector is globally responsible for consuming 39% of energy and for 28% of $CO_2$ emissions. Among non-housing buildings, office buildings were found to have a disproportionately high share in these emissions, as due to their function, they take on the forms of high-rises or are heavily fragmented, with the largest possible windows required by office work, and feature numerous energy-consuming installations: elevators, computer systems, central heating and year-round air conditioning [9,16,17].

In reference to macroeconomic statistical data, the information included in catalogs and reports of organizations such as the World Green Building Council (WGBC), the Polish Green Building Council (PLGBC) and the Association of Business Service Leaders in Poland (ABSL) proved to be helpful sources. The significance of office buildings in creating the program of downtown areas and their urban structures are likewise an extensive research field. This applies to a wide range of analyses that concern: the green city, masterplans, transport and architectural composition [18]. The problem of office buildings and the work performed in them is also analyzed through a sociological and economic lens [19–21]. All aspects that define the standard of the work performed in them are also investigated, be they organizational (open-space and cell offices, as well as additional uses implemented in office buildings), environmental (associated with building physics, including lighting, ventilation and noise), ergonomic (workstations and equipment, OSHA) as well as psychological and medical [22–26]. Numerous scholars also present the findings of specialist analyses that concern selected infrastructural, utilities-related and technological problems [27,28]. Currently, efforts intended to improve building parameters in terms of thermal balance can be seen to stand out and are tied with new technologies in generating energy from renewable sources (zero net energy buildings), heat recovery and enhancing

the building envelope's thermal insulation [29,30]. This current also includes extensively propagated solutions featuring so-called kinetic facades and futuristic designs of kinetic office buildings [31].

Apart from academic literature, a significant amount of essential data and detailed architectural drawings and photographs can be found in articles in trade magazines such as *Architektura Murator* and *Architektura i Biznes*, as well as websites such as *Archdaily*, *Architizer*, *Dezeen* or *Architectural-review*. In our study, we also used data obtained from repositories of development companies and design firms, such as Maćków Pracownia Projektowa, JEMS Architekci, W.P.I.P. or APA Wojciechowski, as well as by using surveys and interviews with architects from these design firms. Extensive information can also be found on the websites of real estate development companies [32–39].

Designing according to the WELL Building Standard is a qualitatively new phenomenon, which is why there is relatively little in the way of literature on this subject. Essential data are included in materials provided by the International WELL Building Institute, especially those that explain building assessment criteria, as well as papers by researchers who explore a given subject [40–43].

### *1.2. General Overview*

Advanced architectural solutions in the current of sustainability have been applied on a large scale in public and commercial buildings since the mid-1990s. In office buildings, we must acknowledge the precursory role of global corporations that openly propagate sustainability, such as ARUP or Skanska. Cases of first-generation buildings can be found in press articles and portfolios of leading architectural firms [6,7,44]. During this period, a great deal of influence on shaping awareness in this field was exerted by prestigious state administrative building projects (which are de facto a specific variant of office building), of which the complex that houses embassies of the five Scandinavian countries in Berlin is a great example [45], as is the historical Reichstag building, remodeled in 1999 by Sir Norman Foster into the seat of the German Bundestag [46].

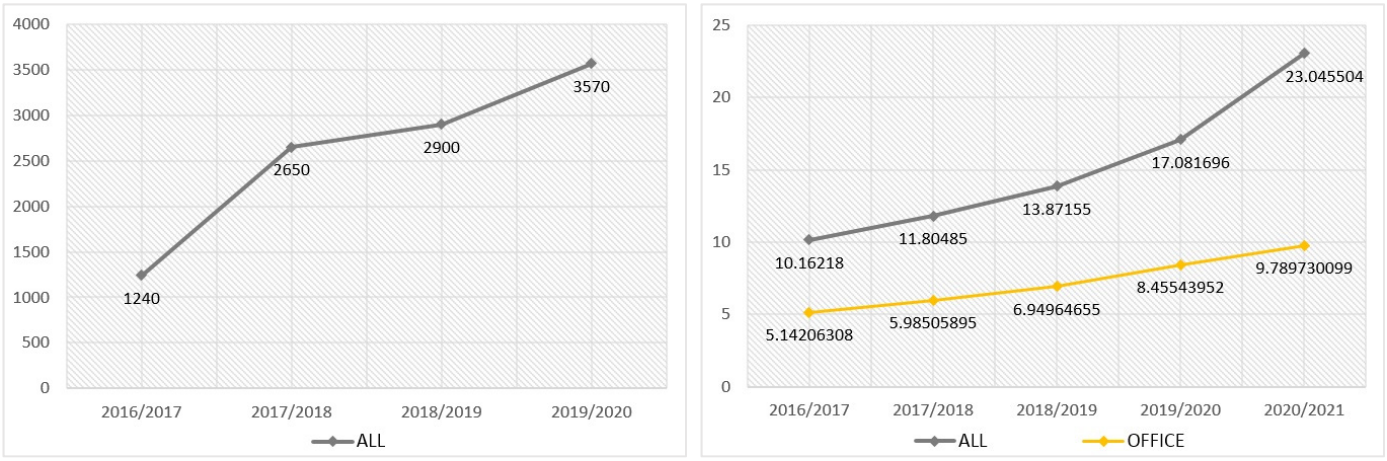
This building features all possible manners of solutions intended to build the institution's prestige, user wellbeing and environmental protection, achieved by creating a unique architectural design and innovative technical solutions, such as biofuel (from locally sourced rapeseed oil) powered combined heat (CHP), which covers 80% of the building's demand for power and 90% of its demand for heat, a ground-heat exchanger that acts as a seasonal heat and cold storage, photovoltaics installations, solutions that minimize waste consumption, a skylight-dome that introduces natural light to the interior, while also contributing to the main hall's natural ventilation, in addition to a building management system (BMS) [47].

The first office building to comprehensively implement green building assumptions was the Swiss RE building in London, designed by Foster [48]. On the global scale, the most advanced region in terms of sustainability is California, US, where the aspect of Zero Net Energy Buildings was codified already in 2008, which is why sustainable design is not a matter of choice there, but an obligation that leads to achieving specific goals. In practice, this means that since 2020, all residential buildings erected in California must be compliant with the 2019 Building Efficiency Standards adopted by the Energy Commission in 2018. In the case of commercial buildings, these standards will enter into force after 2025 [49].

Likewise, the European Commission is currently drafting standards that will lead to a near-zero energy use in buildings as a part of the Energy Performance of Buildings Directive (EPBD) [50] and the Energy Efficiency Directive (EED), yet these standards remain varied from country to country, which significantly complicates the situation. Different law depending on the country generates the fact that latest generation office buildings built in the most environmentally friendly countries, such as Germany, Great Britain, the US or Canada, are labeled as model works of sustainable architecture by all leading architectural design firms [51–55]. In 2018, as part of the 'Clean energy for all Europeans package', the new amending Directive on Energy Efficiency was agreed to update the

policy framework to 2030 and beyond. The key point of the amended directive is a headline energy efficiency target for 2030 of at least 32.5%. European legislation is compulsory for Member States, which were required to achieve new savings each year equivalent to 0.8% annual final energy consumption and to draw up integrated 10-year national energy and climate plans [56]. Poland transported this directive into national law by the Act on Energy Efficiency from 2016 [57].

As much as 3,570,000,000 $m^2$ of green building area [Figure 1a] has been handed over for use as a part of certification systems accredited by the World Green Building Council [9,58]. Poland is a part of this trend, as in 2020, the number of certified buildings reached 110, and their floor area was 23,045,500 $m^2$ [Figure 1b]. Poland remains a leader in terms of certified buildings among Central and Eastern Europe, where a total of 2384 such buildings have been constructed. In the period March 2020–March 2021, the growth rate of green buildings in Central and Eastern Europe was 44%; the growth rate was 30% in Poland (255 new buildings), while in the Czech Republic, this rate was the greatest, at 124% (259 new buildings) [15]. Office buildings comprised around 50% of these buildings on average.




(**a**) (**b**)

**Figure 1.** (**a**) The usable floor area of certified buildings in the world [million $m^2$]. (**b**) The usable floor area of certified buildings in Poland [million $m^2$]. Source: own work based on [15].

During the same period, most Western European countries showed steady levels, i.e., new buildings merely compensated for the demolition of older generation office buildings [59]. This was mostly caused by globalization and remote working, which became widespread as a result of the COVID-19 outbreak. Corporations active in shared services centers (SSC), business process outsourcing (BPO), IT centers and research and development (R&D) made attempts to relocate their offices to countries with qualified yet much cheaper workforces accompanied by a stable political and economic situation, as defined by international rating agencies such as Fitch Ratings, Moody's Investors Service or S&P Global Ratings. The potential of a given region is defined by generally available classifications maintained by companies such as Jones Lang LaSalle Incorporated (JLL), Cushman & Wakefield, Knight Frank or Colliers, which can also be commissioned to prepare dedicated reports.

Such reports include analyses that evaluate a local service market, verifying potential access to workforce, telecommunications infrastructure (especially broadband Internet connections), road (highways and bypasses), rail and aviation infrastructure, as well as the quality of public transport and the potential to use individual eco-friendly modes of transport. After Poland's accession into the European Union in 2004, all such parameters were improved in just a decade, with significant contributions made by European Union Funds, the promotion of cities at all manners of expositions or international conferences

and investment in infrastructure associated with organizing the UEFA EURO 2012 football championship.

Data on the functioning of high school- and university-level education are also a positive signal for Western corporations that search for highly qualified and innovative employees to locate their new headquarters in Poland. In international OECD PISA (Programme for International Student Assessment) tests, which assess the capacity to apply knowledge and analytical skills, Polish school students have routinely placed third in Europe for years [60]. Furthermore, 300,000 students graduate from Polish universities and colleges, with 200,000 majoring in business-, legal-, administrative-, engineering-, information technology- or economics-related disciplines [61].

In the light of the phenomena presented, the area and share of latest generation office buildings in Poland is growing every year. In March 2021, it amounted to 11,733,548 $m^2$, of which 9,701,644 $m^2$, i.e., 83%, belongs to certified buildings. Up to 2019, it was possible to sign lease contracts on all office spaces even prior to a project's completion. The situation deteriorated in 2020 after the beginning of the COVID-19 pandemic and the associated mass switch to remote working from home, yet despite this crisis, the rate of unleased spaces at the end of the fourth quarter of 2020 was at a low level of 12.1% (office space lease data for nine of Poland's largest cities). As a result of the pandemic, the growth percentage of new office buildings also fell. However, despite the economic slowdown, over 707,000 $m^2$ of office space was handed over for use, which is comparable to the level observed in 2019 [10].

In Poland, investing in latest generation office buildings takes place by following specific schemes that have been tested in highly developed countries. They are based on such buildings being planned, designed and built by real estate development companies such as Skanska, Echo Investment, Grupa Ghelamco, GTC or Warbud S.A. Afterwards, the buildings are either managed or sold at a profit, completed and with tenants, to global investment funds, which invest capital into such pieces of real estate. These funds manage the buildings, renting them either in whole or in part to corporations, typically signing contracts for at least five-year leases [62]. This system requires both developers and the design firms they employ to practice impeccable organization and planning during every project stage, which is performed following the research by design approach. In Poland, several dozen design firms have become specialized in such projects, including Maćków Pracownia Projektowa, APA Wojciechowski Architekci, Autorska Pracownia Architektury Kuryłowicz & Associates, JEMS Architekci, JSK Architekci, Medusa Group, Grupa 5 Architekci, HRA Architekci, Ultra Architects and CDF Architekci.

Such an effective system of erecting office buildings also requires informed tenants, who must understand the essence of the utilitarian and economic benefits resulting from green solutions. In Poland, there is no problem in this regard, as most spaces are leased by global corporations that are fully familiar with the subject. Encouragement mechanisms are presented by studies mentioned in a report by Skanska in cooperation with Cushman & Wakefield [16]. It concluded that developers saw the fact that by using certification systems one can achieve a 30% greater energy efficiency during use (which means a savings of even up to 500,000 PLN in operational costs a year) as a deciding factor in pursuing certification.

### *1.3. BREEAM vs. LEED vs. WELL*

Certification systems, such as BREEAM, LEED, WELL, GBS, DGNB and HQE, play a significant role in setting architectural trends for all types of architecture, including office buildings, directing towards solutions compliant with sustainable development. Each of these systems features similar parameters, such as the manner of obtaining, generating, processing and saving energy, water saving and recovery and air quality control. The most significant differences can be observed in fields such as user comfort and safety and indoor environment quality [28,63]. These programs are constantly verified and, depending on the occurrence of a given phenomenon, are supplemented and updated. The certificates in question have many shared points and complement each other in many ways. The

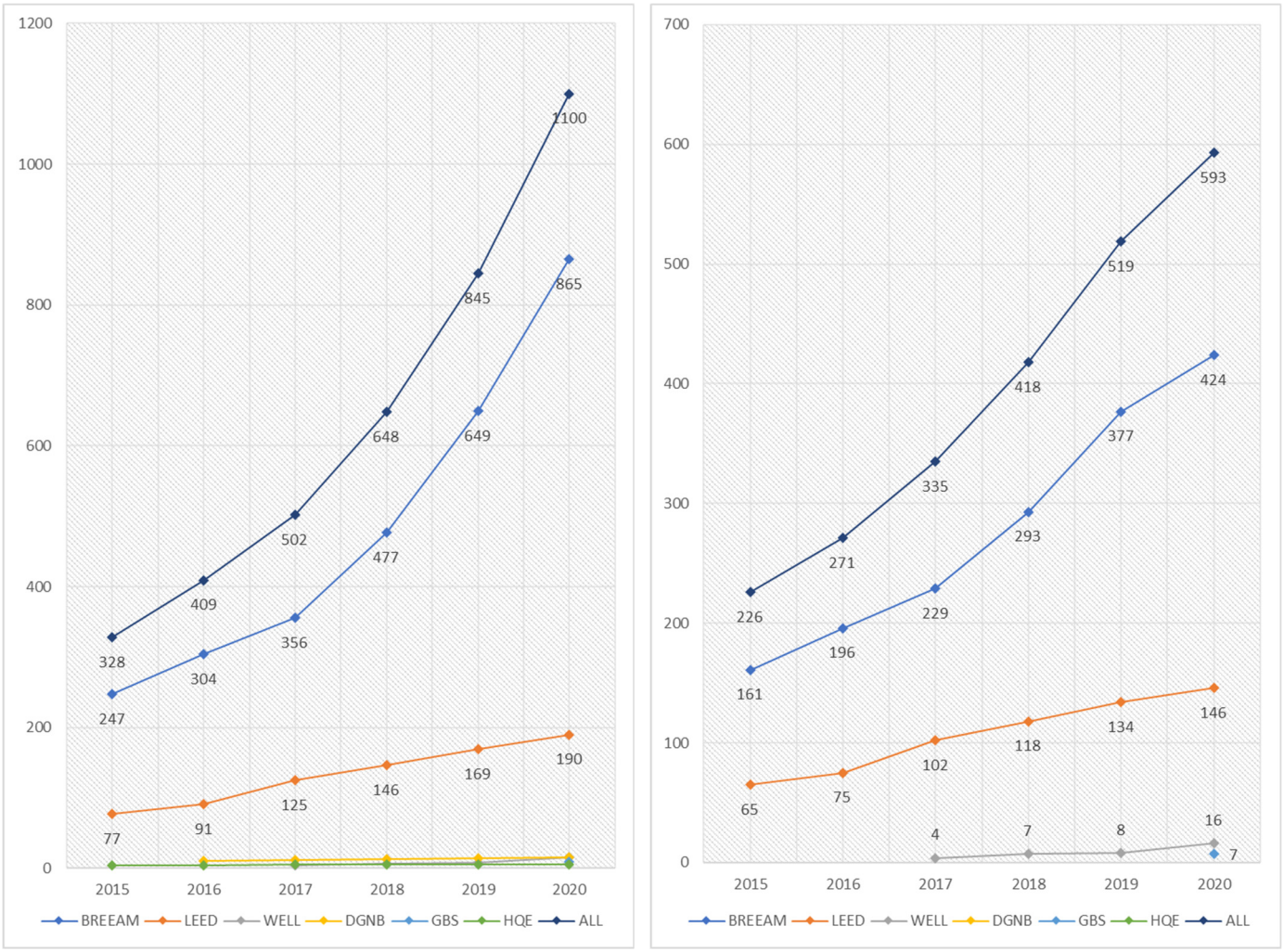
essential difference that sets WELL apart is that, while LEED and BREEAM focus on the building and its servicing, WELL focuses on its users. The WELL certificate, by focusing on a healthy and clean building, allows for the improvement of employee wellbeing, efficiency and productivity, while also reducing their absence [Table 1].

**Table 1.** Environmental categories of certification systems: BREEAM, LEED and WELL Building Standard.

| Rating Tools | Country | Level | Environmental Categories |
|---|---|---|---|
| LEED v4.1 | United States | Certified, Silver, Gold, Platinum | Integrative Process, Location & Transportation, Sustainable Sites, Water Efficiency, Energy & Atmosphere, Material & Resources, Indoor Environmental Quality, Innovation, Regional Priority |
| BREEAM | United Kingdom | Pass, Good, Very Good, Excellent, Outstanding | Energy, Health and Wellbeing, Innovation, Land Use, Materials, Management, Pollution, Transport, Waste, Water |
| WELL v2 | United States | Bronze, Silver, Gold, Platinum | Air, Water, Nourishment, Light, Movement, Thermal Comfort, Sound, Materials, Mind, Community, Innovation |

Another important aspect is the fact that WELL, in contrast to LEED, is managed by a public benefit organization, and not by a government institution. WELL is also formed by people who were closely associated with LEED many years ago, and as such, have comprehensive knowledge about the workings of the certification system, which they have successfully used to create a new certificate. WELL, as a human-centered system, attaches significant weight to visiting buildings under certification and directly verifying parameters and solutions declared by designers in the certificate application, while LEED focuses on documentation and cooperation with the developer's representatives [64]. LEED is naturally widespread all over the world and is the most popular in the United States and Canada, while the creators of WELL made it a priority to introduce their certificate all over the world and work towards having it achieve a universal rank. Furthermore, WELL uses medical data that refer to building–human health links to define its criteria [63,65–67].

Irn Poland, office buildings [Figure 2b] comprise 54% of all certified buildings [Figure 2a], with the certification performed in four systems: BREEAM, LEED, WELL and GBS. The greatest share of office buildings is certified in the BREEAM (424 buildings) and LEED (146 buildings) systems, which first entered Poland in the first decade of the 21st century. Since 2017, office buildings with the WELL certificate began to appear (16 buildings as of March 2021), and several dozen others are currently under certification. Studies show that, similarly to global trends, in Poland, the number of buildings with such parameters is growing. This phenomenon can be attributed to the manner in which the criteria for this assessment are formulated, as it is based on placing human beings at the center, as the individuals who are the users of the building, and their wellbeing and health. It is these features that have become the center of attention among developers and investors who wish to optimize working conditions in their companies, which in 2020 was reinforced by pursuing additional solutions to prevent the negative consequences of the COVID-19 pandemic.




(**a**) (**b**)

**Figure 2.** (**a**) Number of certified buildings in Poland by certificate type. (**b**) Number of certified office buildings in Poland by certificate type. Source: own work based on [15].

## 2. Materials and Methods

### *2.1. Methods*

Our primary research concerning contemporary Wrocław office buildings and issues related to the adaptive reuse of historical buildings as office facilities were conducted in the years 2015–2018 [68,69]. In 2019, we extended it to all of Poland and focused it on office buildings built following the precepts of sustainable development, matters concerning their certification in the WELL system and use standards resulting from this design approach [Figure 3]. The problems presented herein concern a relatively new phenomenon that has just recently entered the focus of research and—when the territory of Poland is concerned—has not been sufficiently explored, which is why we selected it as the object of our study.

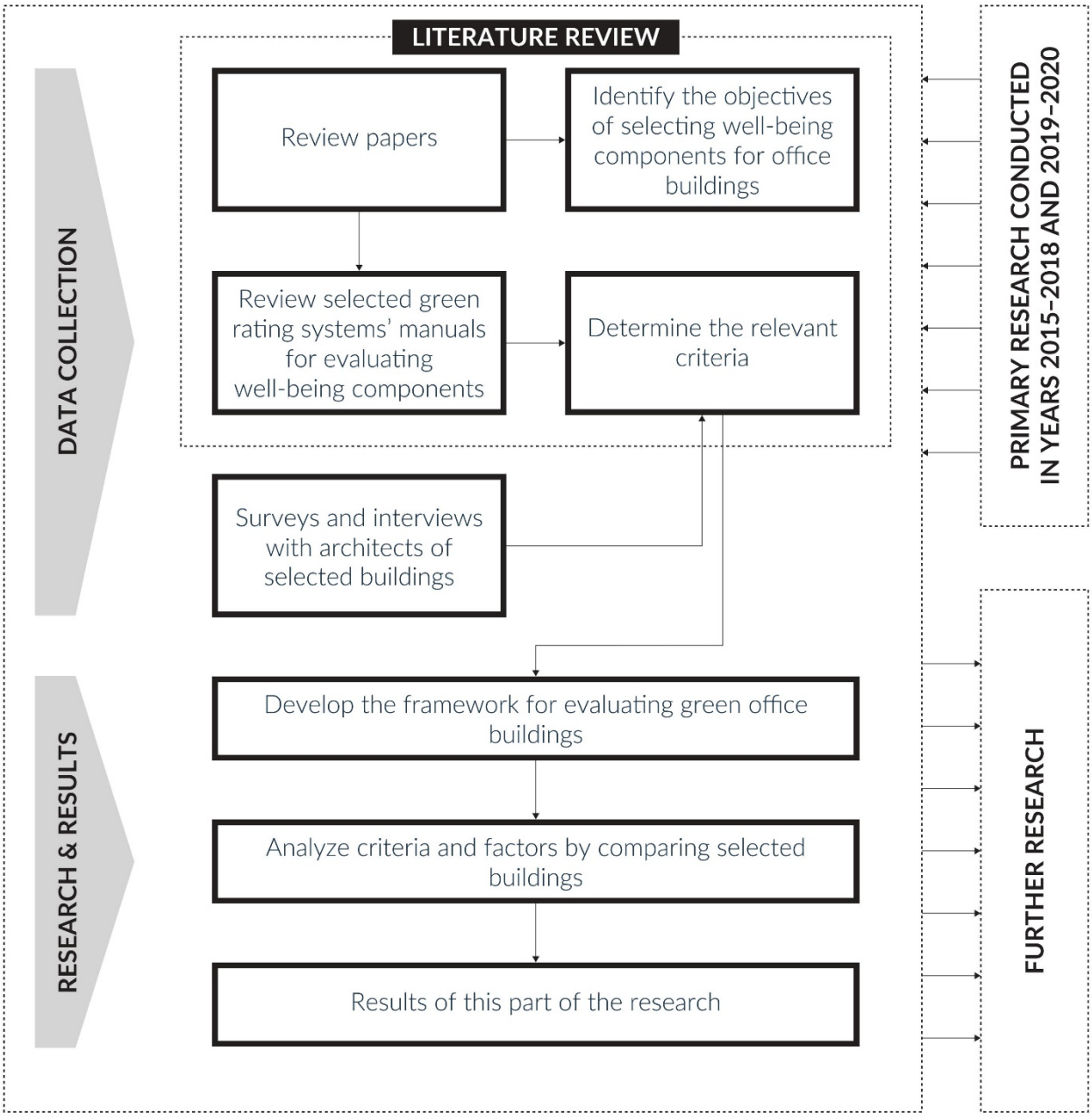



**Figure 3.** Research methodology. Source: own work.

The findings presented in this paper are a fragment of the abovementioned research. They were formulated based on:

- Statistical data that allowed us to determine the scale of the phenomenon and trends in the development of office building groups with shared architectural features;
- An analysis of the literature on architecture, specifically the design of certified office buildings, mostly in Poland, along with comparative materials dealing with solutions applied in countries with advanced sustainable construction programs;
- An analysis of data available on architectural trade websites and the homepages of companies that specialize in office building design;
- Detailed architectural case studies of selected buildings, including interviews with designers and study visits.

The objective of this work is to present analyses of architectural solutions used in latest generation office buildings, but most importantly, it was to present an investigation of the

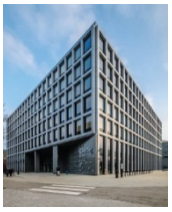
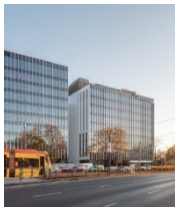
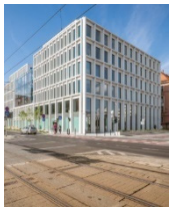
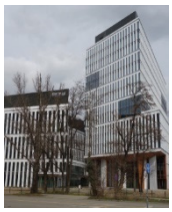
relationship between building user comfort and wellbeing, and the architectural solutions used. Based on a study of the literature and statistical analysis, as well as the comparison of architectural solutions observed, we selected a sample of buildings that we found to be representative of the phenomenon under study. The buildings that form this sample are located in Poland, where one of the greatest increases in office buildings in Europe is being noted. It is here that many international corporations decide to open their branches, seizing the opportunities offered by a stable economic situation and a relatively cheap but highly qualified workforce. We limited our investigation to buildings constructed over the past seven years. This was motivated by the fact that the WELL Building Standard certification system was active during this period. The buildings investigated were chosen based on shared architectural features, such as size, location, typology and the standard and certificates received. The buildings were verified primarily in terms of the factors and solutions that directly affect user health and comfort, accounting for criteria formulated by the International WELL Building Institute, which consists of experts in their respective fields, as well as researchers in the field of health and medicine.

As indicated in the introduction, the investigation was performed using a method based on a review of the literature and source materials on office building design and use. These diverse and mostly narrowly focused academic investigations typically concerned singular parameters chosen from among the almost one hundred items featured in LEED, BREEAM and WELL certificates, which affect a building's program, the quality of its architecture and the standards of office work. A synthesis of such data was a good theoretical basis and allowed for performing detailed analyses of specific architectural solutions in combination with a post-occupancy evaluation (POE) [70]. To gain the greatest possible insight, the site of each building was visited, and the designers, owners and users were interviewed. In this paper, detailed results for six selected buildings were presented. Each of these buildings differed in terms of siting, size, number of stories, spatial solutions and uses. In architectural terms, they represent a wide array of office buildings built in Poland.

### *2.2. Surveyed Buildings*

There are currently over four hundred certified office buildings built in the years 2014–2021 in Poland. An investigation of certificate effectiveness and their impact on workplace environment creation in office buildings was performed for 80 buildings. The methodology and initial findings of this investigation were shown for six representative buildings [Table 2] located in Poznań, Wrocław and Warsaw. They are office buildings of varying size, with an area ranging from 4000 to 38,000 $m^2$, with a height of three, six, seven, ten and fifteen stories. They have individualized architectural forms and varied functional and spatial solutions, generally based on five-bay layouts, where the chief priority was to optimize workstations, which are zoned and generally provide good access to daylight. Five of the buildings under study were class-A buildings erected for commercial purposes (sale, lease) and located in downtown urban areas. The W.P.I.P. building has a different character—it is a type of model building that presents the potential of its solutions and exists to encourage developers to create buildings that implement solutions with a positive impact on human beings.

**Table 2.** Basic information about six surveyed office-type projects.

| Parameter | B-01 | B-02 | B-03 | B-04 | B-05 | B-06 |
|---|---|---|---|---|---|---|
| Photo |  |  |  |  |  |  |
| Name | Green Day | Smart Building Center–W.P.I.P. | Bobrowiecka 8 | Spark C | Nowy Targ | Centrum Południe 1 |
| City | Wrocław | Jasin, Poznan | Warszawa | Warszawa | Wrocław | Wrocław |
| Architects | Maćków Pracownia Projektowa | W.P.I.P. | JEMS Architekci | APA Kuryłowicz & Associates | Maćków Pracownia Projektowa | APA Wojciechowski |
| Investor | Skanska Property Poland, Stockholm Sweden | W.P.I.P., Poznań, Poland | Castor Park (Spectra Development), Warsaw, Poland | Skanska Property Poland, Stockholm Sweden | Skanska Property Poland, Stockholm Sweden | Skanska Property Poland, Stockholm Sweden |
| Tenants | Credit Suisse, Zürich, Switzerland | W.P.I.P., Poznań, Poland | Polpharma Biologics, Gdańsk, Poland; Future Electronics Polska, Pointe-Claire, Quebec, Canada; and others | KGAL Investment Management GmbH & Co. KG, Grünwald, Germany | SpyroSoft, Wrocław, Poland; Schaeffler, Herzogenaurach, Germany; Tillberg Design of Sweden, Höganäs, Sweden; and others | Coventry University, Coventry, United Kingdom; AmRest, Madrid, Spain; Nexontis Solutions, Walldorf, Germany |
| Class A | Yes | No | Yes | Yes | Yes | Yes |
| Area [sqm] | 21 588 | 4 222 | 24 430 | 18 288 | 30 072 | 36 217 (LEED)<br>36 730 (WELL) |
| Stories | 6 + 2 | 3 | 6 + 2 | 10 + 1 | 7 + 2 | 15 + 2 |
| Year of realization | 2014 | 2015 | 2017 | 2018 | 2019 | 2020 |
| Certification type | LEED | LEED | BREEAM | LEED | LEED | LEED |
| Certification phase | Certified | Certified | Certified | Certified | Certified | Certified |
| Certification date | Jul 2014 | Jun 2016 | Apr 2020 | Aug 2019 | Dec 2019 | Jun 2021 |
| Certification level | Gold [71 points] | Platinum [88 points] | Excellent [72.4%] | Platinum [84 points] | Platinum [81 points] | Platinum [87 points] |
| Certification type | - | WELL | - | WELL | - | WELL |
| Certification phase | - | Certified | - | Certified | - | Registered |
| Certification date | - | Nov 2019 | - | Sep 2019 | - | - |
| Certification level | - | Silver | - | Gold | - | - |
| WELL Health-Safety | - | - | - | Registered | - | Rated on 2020 |
| Office type | Open-plan | Open-plan and group | Open-plan | Open-plan and group | Cellular | Open-plan and group |

The presented buildings were designed by well-known architectural firms: Maćków Pracownia Projektowa, W.P.I.P., JEMS Architekci, APA Wojciechowski and APA Kuryłowicz & Associates. The developer of the four presented buildings was Skanska Property, which is a leader in the application of innovative architectural solutions in the field of ecology, sustainability and user health and comfort in the commercial office space construction sector. All of the buildings are certified in compliance with green building certification systems. The B-01 office building (Green Day) [Figure 4] was certified good by LEED. The B-02 building (Smart Building Center–W.P.I.P.) [Figure 5] was certified platinum (the

highest score) in the LEED system. The B-03 building (Bobrowiecka 8) [Figure 6] was certified Excellent by BREEAM. Buildings B-04 (Spark C) [Figure 7], B-05 (Nowy Targ) [Figure 8] and B-06 (Centrum Południe 1) [Figure 9] were certified platinum (the highest score) in the LEED system. Furthermore, building B-02 (Smart Building Center–W.P.I.P.) was certified silver by WELL, and the B-04 building (Spark C) was certified gold. Building B-06 (Centrum Południe 1) was registered and pending certification.

(**a**) (**b**)

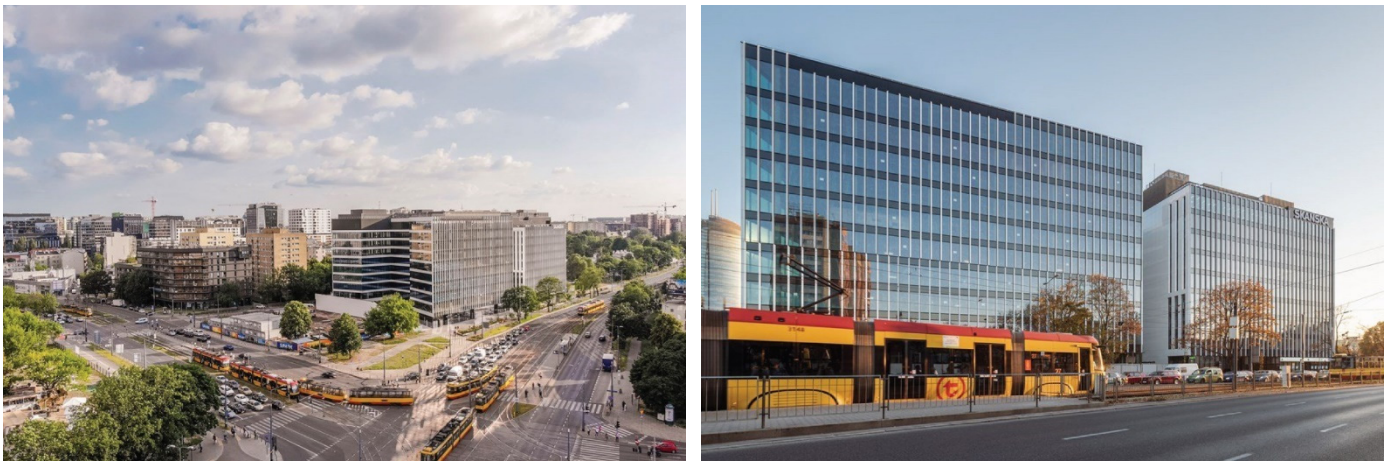
**Figure 4.** Building B-01 Green Day: the aerial view (**a**) and the entrance area (**b**) reprinted from ref. [71].


(**a**) (**b**)

**Figure 5.** Building B-02 Smart Building Center (W.P.I.P.): the aerial view (**a**) [photography taken by Grzegorzewska, M.] and the entrance area (**b**) reprinted with permission from ref. [72].

(**a**) (**b**)

**Figure 6.** Building B-03 Bobrowiecka 8: the aerial view (**a**) [73] and the entrance area (**b**) reprinted with permission from ref. [34].



(**a**) (**b**)

**Figure 7.** Building B-04 Spark C: the aerial view (**a**) and the entrance area (**b**) reprinted with permission from ref. [38].

(**a**) (**b**)

**Figure 8.** Building B-05 Nowy Targ: the aerial view (**a**) and the entrance area (**b**) reprinted with permission from ref. [74].

(**a**) (**b**)

**Figure 9.** Building B-06 Centrum Południe 1: the aerial view (**a**) reprinted with permission from ref. [33] and the entrance area (**b**) [photography taken by Kirschke, P.].

## 3. Results

### *3.1. Criteria and Factors of the Analyses*

The group of buildings that comprises the representative sample of the phenomenon under investigation was analyzed primarily in terms of factors that directly or indirectly affect the comfort, wellbeing and health of users. The criteria [Table 3] that were investigated in the six office buildings selected were defined based on a review of the literature, the findings of studies Building the Business case: Health, Wellbeing and Productivity in Green Offices by WGBC [75], an analysis of design solutions and, most importantly, interviews with designers and specialists in office building certification. Eight groups of buildings were isolated, with seventeen aspects emphasized in each (among them, two, i.e., Sound and Interior Layout and Active Design, were not discussed in detail due to the specificity of their design and different tenant preferences in a given part of a building). The availability of research material and necessary tools was also a factor in the selection stage.

**Table 3.** Analysis parameters used in the scope of the review to address the research questions. *—significantly dependent on a given building's tenants and, thus, excluded from the study.

| Group of Parameters | Parameter | Selection Factors |
|---|---|---|
| Energy and Water Use | Obtaining and saving energy | Environmental impact, including air quality |
| | Overflow water management | |
| | Potable water source, inspections | |
| Thermal Comfort | Thermal comfort—design | Impact on employee productivity (overheating lowers productivity by 6%, while excessively low temperatures lower it by 4%) [75] |
| | Urban heat island mitigation | |
| Light | Daylight/views | Impact on employee sleep patterns (people who work near windows sleep 46 min longer) [75] |
| Sound | Acoustics | Impact on employee productivity * [75] |
| Indoor Air Quality and Ventilation | Adequate ventilation provision | Impact on user cognitive functions |
| | Outdoor air delivery monitoring | |
| | Chilled beams air conditioning | |
| Movement | Cyclist infrastructure | Impact on employee absence, immune systems and physical condition |
| | Physical activity spaces and opportunities | |

**Table 3.** *Cont.*

| Group of Parameters | Parameter | Selection Factors |
| --- | --- | --- |
| Mind, Community & Green Spaces | Restorative Space | Impact on employee loyalty, minimization of illnesses, including diseases of affluence, a view of a green area induces an information processing efficiency increase of 7–12% [75] |
| | Outdoor and indoor nature access | |
| | Health benefits promotion | |
| | Public art | |
| Interior Layout & Active Design | Height-Adjustable Work Surfaces | Impacts employee loyalty, minimizes spinal condition incidence, facilitates focus and improves work quality * |

Ensuring proper air quality, humidity and temperature, including the suitable ventilation of indoor spaces, is necessary to maintain the comfort of building occupants. Solutions such as Ultraviolet air treatment (used in building B-02) minimize the risk of building-related illness cases among users. Air quality is also impacted by external environment quality, including pollution from car exhaust and building heating. Furthermore, it is worth noting that employee productivity is directly correlated with temperature, light and access to green spaces and recreation. Transport infrastructure that provides an alternative to cars, especially bicycle infrastructure, is of immense importance. Apart from its obvious value in transport, it also aids in maintaining a healthy lifestyle. Another essential aspect are various types of solutions that promote such a lifestyle and minimize the risk of illnesses, such as tables and chairs adapted to a person's height.

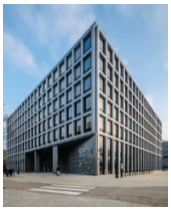
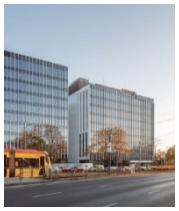
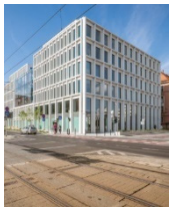
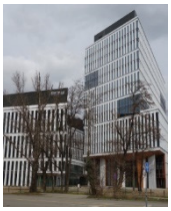
### *3.2. Design Process*

Each of the cases was analyzed via the lens of certification criteria and goals at every project stage, especially during the programmatic and design decision-making stage. The certification or pre-certification stage (at the design stage) can last up to four years. The architectural design solutions implemented to facilitate comfort were selected not only on the basis of ecological, technical, ergonomic and sociological aspects, but also economic factors linked to the project cost and the later occupancy of the building. The objective of the systems applied in the buildings was not only to ensure a maximally effective and friendly work environment, but also to raise the prestige and rank of a given building by obtaining a suitable certificate, and thus, create a building that can be deemed attractive by potential tenants. This often results in a balance between solutions that are rational and profitable both economically and in terms of points awarded during certification (the ratio of points gained/certificate level to cost).

### *3.3. Health and Human Wellbeing Factors*

The first factor analyzed in the buildings presented was the obtainment and saving of energy, a key parameter that has been applied since the beginning of the sustainable architecture movement. Efforts in this aspect can be observed in each of the analyzed buildings [Table 4]. Energy is generated from renewable sources. In the case of building B-06, green energy is also sourced from a windfarm located 60 km away. Energy produced by one wind turbine on one day can power the equivalent of ten workdays for two thousand of the building's employees. Meanwhile, in the case of building B-02, its office section is accompanied by an industrial plant that is not directly covered by a WELL certificate, but nonetheless also features an interesting solution—a solar wall [Figure 10a] that heats the assembly plant. The cooperation of the solar wall, solar collectors [Figure 10b], ground and air heat exchangers, along with the optimization of energy use based on indoor and outdoor environment monitoring allowed for reducing the building's energy demand by as much as 55%.

**Table 4.** Specific information about six surveyed office-type projects—overview of analysis used in the scope of the review to address the research questions. N/A—not applicable, depends on the tenants, tenant design and construction guideline prepared.

| Parameter | B-01 | B-02 | B-03 | B-04 | B-05 | B-06 |
|---|---|---|---|---|---|---|
| Photo |  |  |  |  |  |  |
| Name | Green Day | Smart Building Center–W.P.I.P. | Bobrowiecka 8 | Spark C | Nowy Targ | Centrum Południe 1 |
| Typical office floor | [Figure 15a] | [Figure 15b] | [Figure 15c] | [Figure 15d] | [Figure 15e] | [Figure 15f] |
| Obtaining and saving energy | Renewable sources | 100% from dedicated renewable sources | Renewable sources | Renewable sources | Renewable sources | 100% from dedicated renewable sources |
| Overflow water management | √ | √ | √ | √ | √ | √ |
| Potable water source, inspections | - | - | - | √ | - | √ |
| Thermal comfort—design | - | √ | No information | √ | √ | √ |
| Urban heat island mitigation | - | - | - | - | Sunlight reflecting elements | Sunlight reflecting elements |
| Daylight/views | √/√ | -/√ | -/√ | √/√ | -/√ | -/√ |
| Acoustics | N/A | | N/A | N/A | N/A | N/A |
| Adequate ventilation provision | √ | √ | √ | √ | √ | √ |
| Outdoor air delivery monitoring | √ | √ | No information | √ | - | - |
| Chilled beams air conditioning | - | - | - | √ | √ | √ |
| Cyclist infrastructure | √ | √ | √ | √ | √ | √ |
| Physical activity spaces and opportunities | - | - | √ | √ | - | - |
| Restorative Space | √ | √ | √ | √ | √ | √ |
| Outdoor and indoor nature access | √ | √ | √ | √ | √ | √ |
| Health benefits promotion | N/A | √ | N/A | N/A | N/A | N/A |
| Public art | N/A | √ | N/A | √ | N/A | N/A |
| Height-Adjustable Work Surfaces | N/A | √ | N/A | N/A | N/A | N/A |

(**a**) (**b**) (**c**)

**Figure 10.** Solar wall that heats the assembly plant (**a**), a system of solar and photovoltaic panels on the roof (**b**) of building B-02, Smart Building Center–W.P.I.P. reprinted with permission from ref. [72] and the ventilation room (**c**) of building B-05 Nowy Targ [photographs taken by Kirschke, P.].

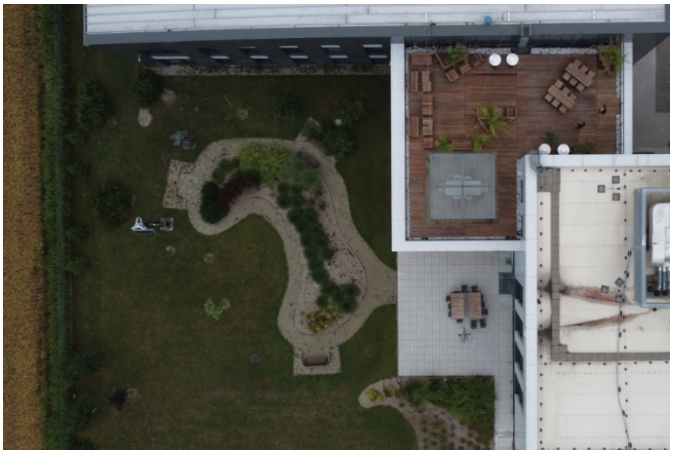
Another essential aspect linked to the placement of buildings in downtown urban areas is preventing their overheating by reacting to the urban heat island effect. In the case of buildings B-05 and B-06, their roofs feature elements that reflect solar rays. The heat island effect is also minimized by construction materials, such as white roof membranes (B-02), greenery or bright surfaces used in site development, such as pavers (B-02). Monitoring systems, which allow for thermal parameter monitoring (B-02, B-04) and $CO_2$ monitoring are also of considerable significance within the information system that supports managing a given building.

In the case of ensuring user comfort, all manners of architectural solutions linked to air conditioning and ventilation [Figure 10c] play an essential role. Here, we should first mention heat recovery units and air-cooling beams that provide thermal comfort without drafts and noise, while also supporting energy efficiency due to not requiring any power to run. In the case of this solution, adiabatic humidifiers ensure that the cooled air has the correct humidity. Good air quality is also provided by air purifiers that apply ultraviolet radiation.

Economic water management is another key aspect of pro-environmental buildings. In the case of all buildings under discussion, water-efficient fittings and equipment were used. In the case of building B-06, its graywater is reused by a costly installation. This building, as well as building B-02, also features high-quality potable water, and tests are run periodically to detect any harmful elements.

To ensure user comfort, one requires access to natural light—which is provided to between 80 and 100% of workstations depending on the building. It is also crucial to create an environment that features green plants that contribute to air purification and positively affect wellbeing. Access to greenery in the immediate vicinity of the building [Figure 11a], in atriums [Figure 12a] or on roofs [Figure 11b], was provided in most reference buildings. It is also worth noting that there are solutions that feature plants inside buildings [Figure 12b], such as via internal atria (B-04, B-05) or the presence of plants in work and common spaces—in the case of building B-04 [Figure 13b], there are as many as 850 plant species in its interiors.

(**a**)



(**b**)

**Figure 11.** Green zone for outdoor staff relaxation (**a**) [72] and green zones on the roof and in front (**b**) [photography taken by Grzegorzewska, M.] of building B-02 Smart Building Center–W.P.I.P.

(**a**)

(**b**)

**Figure 12.** Internal green block of building B-04 Spark C (**a**) [38] and the entrance zone of building B-05 Nowy Targ, featuring greenery (**b**) [photography taken by Kirschke, P.].


(**a**)


(**b**)

**Figure 13.** Individual workspace (**a**) and a workshop space for group work or relaxation (**b**) in building B-04 Spark C [38].

Physical activity has an invaluable effect on user health and supporting is highlighted in the criteria of investigated certification systems. Each project supports this activity by providing comprehensive infrastructure for cyclists [Figure 14], ranging from storage spaces, showers, to repair stations. In addition, owners or tenants support physical activity with benefits such as passes to yoga or fitness classes, gyms and rehabilitation services [B-03] which are offered at the building, as well as stretching zones and floor trampolines, as in the case of building B-04.


(**a**) (**b**)

**Figure 14.** Bicycle repair station in building B-04 Spark C (**a**) [38] and a bicycle storage space in building B-05 Nowy Targ (**b**) [photography taken by Kirschke, P.].

We should also note informational efforts in the process of supporting physical activity and a healthy lifestyle, such as via information policies—infographics displayed in the entire building that inform users of the beneficial effects of certain fruits or the caloric expenditure of choosing stairs instead of an elevator [B-02].

Another element that is assessed during accreditation is art and high-quality interior design that developers introduce to building interiors, and examples of such solutions can be found in buildings B-04 and B-02, where the company owner placed wooden sculptures from Bali, which are a peculiar form of recycling—the sculptures are made from the roots of removed exotic trees, which would have otherwise been discarded.

### *3.4. Rating Systems in the Perspective of the COVID-19 Pandemic*

The year 2020 marked the beginning of 'the Decade of Climate Action' and the COVID-19 pandemic brought the connection between the built environment and people's well-being to the forefront.

A series of lockdowns implemented in highly developed countries in reaction to the spread of the COVID-19 pandemic has shown just how crucial it is to create a safe work environment and the share of anthropogenic factors in global warming. Researchers from China, France, Japan and the United States report that the global emission of carbon dioxide over the first six months of 2020 fell by 8.8% in relation to the same period of 2019, which was caused by, among other things, the economic slowdown caused by the pandemic's spread [76,77]. These studies demonstrated that lowering fossil fuel consumption by transport and constraints placed on population mobility, including office staff, of which 70% worked remotely from home as opposed to 20% before the pandemic, all played key role in lowering the emissions. As a result of diversifying the operation of offices in urban downtown areas, a clear lowering of the temperature could be felt due to a diminishing of the urban heat island effect [78].

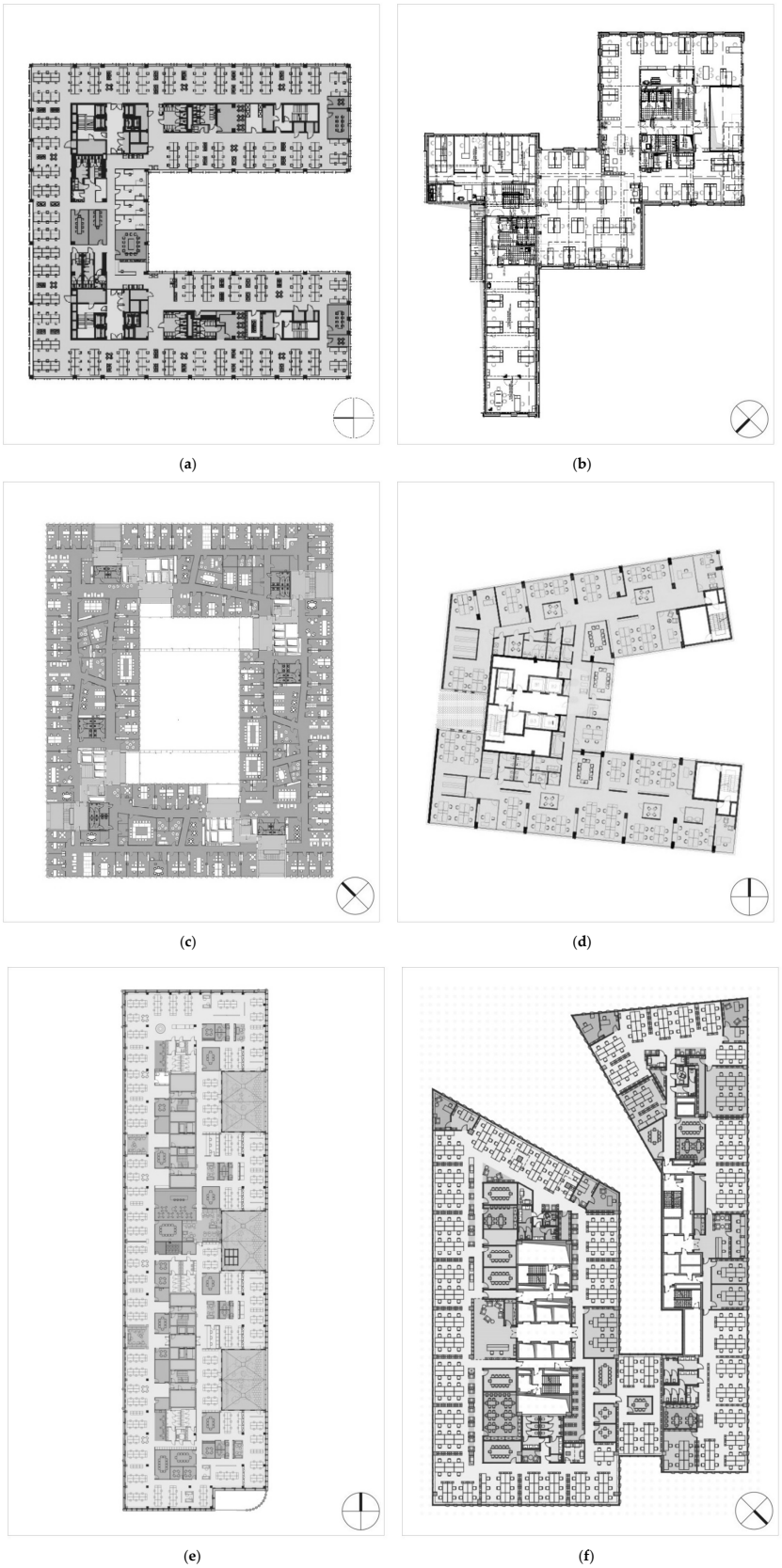


**Figure 15.** (**a**)Floor plan (typical office floor) of the surveyed buildings: B-01 (**a**), B-02 (**b**), B-03 (**c**), B-04 (**d**), B-05 (**e**), B-06 (**f**). [Source: Investor's advertising brochures and resources].

These events were impulses to improve and rethink certification priorities in terms of user safety and health, the protection and propagation of plants not only around buildings, but also in their interiors, and the use of solutions that decrease global warming and save energy. This mobilized organizations that certify green buildings to focus even more on creating a friendly work environment and formulate tools to support and motivate change. An excellent example of such a system is the WELL Health-Safety Rating system created for new and existing buildings by the International WELL Building Institute (IWBI), which is also the author and operator of the WELL Building Standard certification system.

This certificate was created in 2020 in a direct response to the pandemic, and its objective is to support building owners, both large and small companies, in taking the necessary steps to prioritize the health and safety of their employees, guests and stakeholders and to prepare a work environment for the post-COVID-19 era so as to build trust among employees and the community in general. The group that prepared the certificate's criteria consisted of nearly 600 public health experts, virologists, government officials, academics, business leaders, architects, designers, building scientists and real estate professionals. Their efforts resulted in a certificate that has over twenty features, including sanitation procedures, emergency preparedness programs, health service resources, air and water quality management, stakeholder engagement and communication and innovation [79].

## 4. Discussion

Certification systems are widely used in public buildings funded by the state or local governments, as well as in commercial office buildings, and to a much smaller degree in residential buildings. Our study showed significant change in the process of building certification in BREEAM, LEED and WELL systems, which considerably affect the design of 21st-century architecture. This applies both to building placement, massing, functional and spatial structure, the layout and zoning of workstations, as well as specialist utilities solutions. It also affects the design of interior spaces, their illumination, décor and furnishings.

Optimizing buildings in compliance with green building certification requirements brings the following benefits:

- It ensures the safety and wellbeing of staff, which results in a healthy and effective workforce;
- It aids in enhancing the program of office spaces and additional services in the building, which positively affects the functioning of the surroundings;
- It facilitates the creation of attractive, functional architecture, which is generally believed to enhance a company's prestige and signifies the vitality and innovation of a given city;
- The application of sustainable solutions in a design reduces a building's carbon footprint both during construction and occupancy, which contributes to lessening the pressure on the environment.

Executing the tasks presented above can inspire one to create innovative architectural solutions that allow for the creation of comfortable and safe workplaces, which is achieved by architectural means or organizational methods such as spreading them. To save energy, pro-environmental technical solutions also enhance the structure of flat roofs and triple and even quadruple-skin facades, which also reduces the carbon footprint associated with the structural systems of buildings, e.g., by applying reinforced concrete or wooden structures that are cost-efficient, prefabricated and can be disassembled. Technical infrastructure is likewise improved, e.g., in terms of heat recovery. To enhance indoor microclimate, greenery is used on a large scale.

In office buildings, the intent to ensure a maximum-performance and friendly workplace is typically realized in a way so that the effects required by certificates are obtained by meeting key guidelines specified in regulations on fire safety and evacuation, spatial layouts that facilitate open-space office work, floor-to-ceiling height, air quality and good daylighting. The dependency between optimizing these parameters and work efficiency

was indicated in numerous medical studies (MacNaughton), and commercial developers are well aware of this. In effect, for instance in relation to daylighting, this means that in certified office spaces, between 80 and 90% of workstations are in a zone where daylight intensity is at least 500 lx [80]. Temperature, air humidity and air exchange rates are optimized similarly, which is regulated by certification system criteria, and it is also recommended by local construction codes and sanitary standards. How certain factors are implemented is tuned to potential tenants. This means that with structurally uniform office spaces that meet key parameters for a given class and certificate for a given story, the décor and equipment standards can differ in areas leased by different tenants, and depend on the type of office work and a given company's specificity. Specifically, each office space will have different workstation density and ergonomics, finishes and interior aesthetics, as well as acoustics. Concerning the last of these parameters, it is crucial to ensure that partitions have proper acoustic insulation and prevent impact sound transmission by proprietary elevated floors and limiting reverberation time via sound-absorbing finishes on floors and suspended ceilings [81]. In the case of open-plan offices, distances between workstations will be crucial, while for group-office or combi-office spaces—the quality of partitions that separate workstations [82].

Similar precepts must be followed in matters of reducing carbon footprint of office building construction and use. This is achieved by designing buildings with compact masses and the use of high-quality partitions, which in Poland is regulated by restrictive codes. To increase the efficiency of erecting buildings and to lower the energy consumption of construction itself, prefabricated reinforced-concrete structural systems are used, which also have the added benefit of being reusable should a building be dismantled. Renewable energy installations include the common use of heat pumps and recovery systems. Wind turbines are also installed, yet they require costly technical solutions that absorb vibrations and dampen noise. Photovoltaic panels are more efficient in energy generation, yet their use is limited by usable rooftop space and attempts at installing them on facades are typically architecturally unsuccessful. Progress in this field can be seen in the new generation of photovoltaic facades covered with super-thin transparent cells called perovskite sun blinds, patented by Saule Technologies from Wrocław [83]. Such globally prototypical solutions were installed in 2021 in the Aliplast office building in Lublin [84].

Studies showed that most office buildings come with stormwater collection systems, which in the center of Wrocław is an obligation regulated by Local Spatial Development Plans. Meanwhile, complicated grey-water installations are chosen by few developers. Whether a given beneficial pro-environmental solution is installed depends on its contribution to minimizing negative environmental impacts, which is always evaluated based on the amount of potential certification points to be gained versus the cost of a given innovation.

Furthermore, the referential samples of buildings discussed in this paper excellently depict the phenomenon of the complete centralization of humanity in the perspective of development project planning, building certification and assessment systems, and therefore, directly affects the form and type of solutions applied. This phenomenon receives invaluable support from certification system creators, especially the authors of the WELL certification, who pursue the improvement of environmental quality and its direct impact on our health through their knowledge and experience. In the period between March 2021 and September 2021, the number of WELL-certified buildings increased from 16 to 29 (including 21 certified and 8 pre-certified), with 60 buildings pending certification, which provides grounds for expecting that a growth trend will persist and will exceed 100% in 2021.

By analyzing the criteria focused on in this study and examining them in terms of the time period when a building's design and construction took place, we can observe a steadily growing number of pro-environmental solutions, and especially pro-health solutions. Executing the tasks mentioned will lead to the construction of architecturally excellent, yet complicated and costly buildings. This raises serious doubts as to the feasibility of building such structures in the future, in which, in all probability, between 30 and 50% of

office employees will be working remotely. This can lead to a situation in which classical corporate offices, as well as coworking offices that were seen as innovative only two years ago, will become mostly obsolete. This opens up a new field for pursuing optimal solutions for the functional and spatial structures of office buildings, especially those which keep employee wellbeing at the core of their decision-making process.

The presented investigation of the impact of certification systems on architectural solutions featured in office buildings built in Poland in the years 2014–2019 indicated a rapid increase in the number of buildings whose structures were constantly being enhanced and adapted in compliance with the requirements of two leading certificates: BREEAM and LEED. In 2020, this positive trend was disrupted as a result of the crisis and successive lockdowns caused by the COVID-19 pandemic. This situation further added to the weight of comfort and employee health factors in designs, which, following global trends, meant a change of office work systems and a greater share of buildings that were entered into WELL certification procedures, especially the WELL Health-Safety Rating.

The disruption of the office space market that has been unveiling for two years now, combined with the multiple aspects of the investigation, means that the findings presented here are mostly based on historical data, as it was not possible to examine the current situation through interdisciplinary academic study. Introducing new guidelines and criteria requires considerable effort and is time-consuming, and as such, solutions developed over the course of the latest research that would also account for problems that emerged in over the last few months are just starting to be introduced to architectural designs, for which the real estate development process could take up to two years or longer. For this reason, the findings presented have certain limitations. Based on the presented sample, while also accounting for analyses of another 60 office buildings (which is the target representative sample for this investigation), it was observed that the pursuit of attaining a specific certificate had the greatest impact on a building's program, technology, furnishings and office interior décor. The differences in massing composition and the internal function-spatial structure of the building were affected the most by location (shape and size of the site), applicable zoning regulations and the type of office work planned in the building. This is also visible in the structural systems of buildings, which fulfils tasks given to it by architects and ensures safety following local building codes.

The investigation presented indicated that in the years 2014–2019, there was a rapid increase in the number of class A and B buildings, in prestigious locations and offering a high standard, whose structures were adapted following the requirements of constantly enhanced leading certificates: BREEAM, LEED and WELL. In 2020, the environment instability caused by successive waves of the pandemic forced a reevaluation of the weight of several factors, a change in the balance between in-office and remote work and the enhancement of tools that facilitate various forms of hybrid work. The COVID-19 pandemic has had several phases already. The lockdowns which in many European countries led to constraints on in-office work down to 10–20% of staff present at a given time, impacted the long-term decisions on workstation spacing and the trend to normalize hybrid work. In Poland, in the spring and summer of 2021, after the end of the third wave of the pandemic, employees returned to their offices. Initially, 40% did so, and later, this increased to 80%. During the fourth wave (autumn 2021), another shift to hybrid work is being made, with a proposed 50/50 split.

In such a changing environment, it is difficult to formulate architectural conclusions based on up-to-date and thoroughly verified academic research findings. The most reliable sources of information are now direct interviews with designers and users, as well as ongoing analyses presented on websites and in trade journals. In summary, it can be stated that the current consensus appears to be that home offices appear less efficient than in-office work, but they are cheaper and offer a satisfactory degree of performance when work that requires a quiet environment and concentration is being performed, or when the tasks are repetitive.

Home office work also reduces employee stress levels, as they can spend more time with their family, and limits energy consumption and cuts down on commuting time, which, accounting for the scale of the phenomenon (hundreds of millions of office workers) is a significant component in preventing global warming. Over the long term, it is becoming visible how a lack of direct contact makes it harder for companies to generate innovative solutions, hinders personnel training and gradually reduces service quality. This means that individual office sectors see a need to find a balance between in-office and remote work, and to further improve tools for both forms of work. At present, it is believed that the majority of companies will employ rotational schemes, which means a reduction in office workspaces by around 20–30%.

Thus far, corporations from the Business Service Center sector do not appear to be abandoning the renting of office spaces in Poland, and thus, they have surplus office spaces and they increased distances between workstations to 2 m, which is seen as a safe distance provided effective ventilation. Over the past year, there has also been a visible tendency to reduce the number of open-space offices, which amounted to 70% of all offices only two years ago. Currently, this is down to 30–40%, with the remainder consisting of optically and acoustically sectioned spaces intended for individual or group work. Such spaces are used for discussions, training courses and making phone calls (phone boxes). Such spaces are equipped with audiovisual devices and custom furniture, such as tables with changing heights that allow having a standing or sitting conversation. For safety reasons, enclosed spaces are equipped with high-performance mechanical ventilation that guarantees air filtering at a level of 13 or 14 Minimum Efficiency Reporting Value (MERV) [85]. The increased distances between workstations can also reduce stress and the negative consequences of irrelevant speech noise in open-plan offices [86].

Soft furniture and green walls enhance acoustic comfort. New offices also contain constantly improved and extended break rooms and chillout rooms, as well as thanks to additional functions installed in office buildings, such as small grocery stores or delicatessen, freely accessible gastronomic service (as an amenity and integrative meeting space) and a nursery or kindergarten. In addition, the option to open windows is provided, and recreational areas are extended via enclaves with greenery and recreational terraces, which leads to a feeling of a friendly and homely atmosphere and increases work effectiveness.

In Poland, companies from various sectors continue to develop, including IT, life science, e-commerce, business services and manufacturing, and their offices evolve following the tendencies outlined. At the same time, following in the footsteps of other European Union countries and the US, access to class-A office buildings is made more accessible to smaller companies, sometimes with short-, medium-, and long-term lease, along with the option to rent space on the spot without a contract in the renting system. This is happening due to the development of numerous mobile apps [87].

The ongoing improvement of existing office buildings can be treated as stress tests of their structure [88]. This testing concerns both financial effectiveness (a key aspect for building commercial offices) and is also an experimental field for investigating the function-spatial potential of such offices. The most typically encountered five-bay office buildings appear to have high potential due to 17–20 m bays that are insulated from two sides and have elevated floors, which offers flexible workstation layout options.

Simple technical means can be used to increase the share of acoustically and sanitarily sectioned spaces for group work. However, it is difficult to evaluate the degree to which such "loosening" is effective in terms of organization and cost in the light of competition from offices in countries where there is less significance attached to employee work comfort (and the pandemic's consequences are prevented by strict adherence to sanitary regulations and mass quarantines). It is also possible that mixed-use buildings, in which office work using a co-working scheme is combined with freely available retail, gastronomy, leisure and entertainment uses, with each component replaceable as needed, will start to play a much bigger role. It is also possible to mix office spaces with residential floors, which, in

the case of buildings in city centers, increases attractiveness by the complementation of the activity times of these two uses.

## 5. Conclusions

Currently built office buildings have varying spatial forms depending on the size, location and planned main work system (Cellular office, Group office, Combi office, Open-Plan Office). The planned office space layout is a significant factor in user comfort. In the plans of the buildings presented we can find a diverse range of space designs. The predominant types of design are group-office and open-plan office designs, yet in each building, one can observe additional, sectioned-off spaces for individual work (including properly acoustically adapted spaces) [81] or meetings for smaller and larger groups. The need to separate such spaces is related to the noise generated from conversations between colleagues, telephone calls and laughter [86,89,90].

The vast majority of the investigated office buildings are A- and B-class, following recommendations by BREEAM and LEED certification systems. Both these systems account for the human factor. The current precepts require revision, which has been stressed when office users were forced to adopt protective measures to counter the effects of the COVID-19 pandemic. These globally most popular certification systems evolve to account for the greatest possible number of factors with significance to improving and enhancing the safety of office work spaces and that have a positive impact on user health and comfort. It is expected that a key role in this process will be played by the WELL Building Standard certificate, which can, over time, also become a leading certification system that defines Polish work environment quality in office spaces. Its growing popularity is reflected in the growing number of applications for certification (60 buildings in Poland).

A study from 2016 by WGBC found that individuals who worked in buildings with a LEED certificate scored 26% higher in cognitive tests than persons who worked in high-parameter buildings (e.g., with improved ventilation or a lower number of airborne organic compounds in the air, but that were not certified) [75]. It is to be expected that in the case of the WELL certificate, whose objective is to be human-focused, these results could significantly improve, a hypothesis that will be verified over the course of future investigations.

The analyses presented are a stage of research on architectural solutions employed at the design and construction stages of workplaces in over four hundred office buildings built in Poland in the years 2014–2021. The results of these analyses shall be presented in further papers and in a dissertation [91].

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## Appendix A

The LEED multi-criteria building assessment system (Leadership in Energy and Environmental Design) was first applied in 1998 by USGBC (US Green Building Council) in its pilot form, LEED 1.0, tested on 19 projects. Due to its success, a widely available version, LEED 2.0, appeared in 2000. Over the past decade, several successive variants of it have appeared, with the latest being from 2019—LEED v4.1, which is primarily distinguished by the ability to score LEED points by monitoring building effectiveness. The system is currently available in six versions (building design + construction, interior design + construction, operations + maintenance, residential, cities and communities, recertification). Version 4.1 of the program assigns a maximum of 110 points in eight categories: location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation and regional priority. LEED is characterized by four certification levels: Certified (40–49 points), Silver (50–59 points), Gold (60–79 points) and Platinum (80 + points). In Poland, the first building received its LEED certificate in 2009 [63,92–94].

## Appendix B

The BREEAM assessment system (Building Research Establishment Environmental Assessment Method) was introduced in 1990 in a pilot version for office building in Great Britain by BRE Global. Over the past thirty years, several variants of the system have been developed, with the most recent one being from 2018—BREEAM UK New Construction. The system is currently available in five versions (communities, infrastructure, new construction, in-use and refurbishment and fit-out). The current version of the program can assign a maximum score of 100—in the form of percentage scores in ten categories: energy, health and wellbeing, innovation, land use, materials, management, pollution, transport, waste and water. BREEAM is characterized by five certification levels: Pass (30–44% score), Good (45–54% score), Very Good (55–69% score), Excellent (70–84% score) and Outstanding (85% + score). In Poland, the first time a BREEAM certificate was awarded to a building was in 2010. It is the most popular certificate used in Poland [95,96].

## Appendix C

The WELL Building Standard multi-criteria assessment system was first applied in 2014 by the International WELL Building Institute. Since the certificate's inception, two variants of it have appeared, with the latest dated to 2018 (the year of the release of the pilot version)—WELL v2. The system is currently available in two variations: WELL Certification and WELL Core Certification. The WELL v2 version can assign a maximum of 110 points in ten categories: air, water, nourishment, light, movement, thermal comfort, sound, materials, mind and community. WELL is characterized by four certification levels: Bronze (40–49 points), Silver (50–59 points), Gold (60–79 points) and Platinum (80 + points). In Poland, the first building was certified using this system in 2017. In 2020, WELL began certifying using an additional system, designed in response to the outbreak of the COVID-19 global pandemic—WELL Health-Safety Rating [97].

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