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Chapter

Circular Economy and Green Public Procurement in the European Union

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Abstract

Until now, construction was considered through the prism of technical possibilities of implementing investment plan supporting and, at the same time, urbanization processes. The development model, present in highly developed countries, is far from sustainable. The departure from natural technologies for erecting construction works must have resulted in excessive use of resources, mainly nonrenewable. The strong negative impact on the natural environment of the architecture, engineering, and construction (AEC) industry cannot go unnoticed. Therefore, a solution to the problem of excessive energy consumption in technological processes in construction, which are also generators of huge amounts of pollution, should be discovered. Circular economy (CE) is one of the concepts of response to the threat posed by these negative externalities. It is worth considering construction materials as reusable elements, e.g., after the demolition of a building. The implementation of the CE concept in AEC requires an identification of the next stage in the life cycle of buildings—the rebirth. The chapter focuses on the issues of green public procurement present in the orbit of interest of decision-makers from the European Union. It was associated with the idea of CE, which is significantly entering the construction sector in both managerial and technical terms.

Keywords: circular economy, green public procurement, construction, processes, investment

1. Introduction

The first, and probably one of the most important steps in construction projects, from which the organization of construction works starts, impacting the entire course of the project life, is to get all appropriate building materials.

Imagine the following situation. The basic raw materials used to erect buildings include stone, brick, lime, sand, and wood. Brick, as an innovative material, is becoming more and more popular. It begins to displace wood, which until now has been the main material used in constructions. Even though new ceramic technology is developing rapidly and successfully, not all investors use it. The poorer rural areas are still dotted here and there with thatched cottages. The use of stone remains wide, usually for the needs of foundations. Lime and sand are components of binders without which it would be impossible to permanently connect separated elements of the structure, called semifinished products. It is worth noting that feudalism effectively limits the development of quarries and brickyards. However, the effective transport of purchased goods depends mainly on the distance from the factory to the built-in location. Transportation of building materials is extremely expensive and requires the provision of a sufficiently high number of means of transport, i.e., horse-drawn or oxen-drawn wagons. Transport accounts for a significant percentage of construction costs and sometimes equals or even exceeds the value of transported materials. These reasons cause that the construction industry suffers from a permanent shortage of materials. Insufficient production capacity can be evidenced by the common recovery of demolition building materials [1]. This process is an alternative to the linear production model, in which the deficiencies described earlier effectively limit the development of societies.

This could be a perfect genesis of the idea of circular economy (CE) in the construction sector. The realities presented in the source texts dating back to the Middle Ages are close to those present in the twenty-first century. Unfortunately, in the meantime, there have been some twists and turns that on the one hand effectively limit thinking about construction as an eco-friendly industry and on the other hand that there is no turning back from radical moves and changes.

One of the turning points was the successful research on polymers carried out in the twentieth century. Since the 1950s, it is the moment when mass production of plastics began; over 8000 million metric tons (Mt) were produced in total [2]. The lion's share of this production goes to the construction industry [3] in the form of materials and packaging. Their advantages often overcome the disadvantages that are unacceptable from an ecological point of view. Synthetic materials disintegrate for a very long time, and from the point of view of even several consecutive generations, a majority of them are practically not degradable. Globally, the majority of plastic waste goes to landfills, not always legal ones, and from there to the seas and oceans. The increase in pollution caused by the presence of plastic in the water is frightening [4–6]. The augmented mortality of marine life (fish, marine mammals, flora), as well as the potential threat of the presence of microplastics in the food chain (of which human being is a part), caused that the problem really begins to be discussed. Political decisions are inevitable, but personal habits require a drastic, immediate change.

Households are subject to some consistent waste management policies in many countries. Unfortunately, construction sites are not restrictively treated as, e.g., individual properties, there are not so many fractions, and the garbage received is often mixed and unsuitable for reuse or further processing. But negative externalities of the construction industry are not just solid wastes. There are other pollutants and emissions generated throughout the entire life cycle of construction projects. The problem has been increasing step by step.

That is why the European Union bodies decide to significantly change its legal regulations or to create new guidelines which are focused on encouraging authorities and individual people to return to sustainable development. Since 2010, the European Commission has been sharing lessons learned on green public procurement (GPP) to show how public authorities in the European Union have successfully "greened" public tenders and procurement processes. GPP was defined in the Communication entitled "Public procurement for a better environment" as "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured" [7].

This chapter concentrates on the architecture, engineering, and construction (AEC) industry and its impacts on the environment. All issues related to the concept of circular economy and green public procurement were shown in the light of this sector which is treated as the most significant source of contaminants. The research covers a literature review on the CE concept and GPP. The results of the study on the ecological quality of construction processes were included too. Besides, a contribution of the chapter is to show a proposal of the eco-friendly vision of AEC supported by CE-based procedures implemented in GPP strategy in the European Union.

2. Circular economy concept

Many concepts limiting a negative impact on the environment are nowadays promoted all over the world. Circular economy has become a solution that theoretically provides significant relief to nature. To make this concept not just a substitute for a somewhat diminished "sustainable development," it is expected that radical changes in shaping natural resource management policies are created.

According to Ellen MacArthur Foundation, a famous worldwide trendsetter of the concept of a circular economy, a transition from a linear model of production to closed-loop variant helps to work effectively at all scales [8]. It does not cover only some adjustments aimed at reducing the negative externalities of the traditional economic paradigm. It simply represents a systemic transition that builds long-term resilience and provides environmental and social reliefs.

AEC, as a sector with high resource consumption, is a good example for explaining how far CE may be useful. It is one of the world's largest waste generators [9]. At the same time, it consumes 40% of the materials entering the global economy and generates 40–50% of the global output of greenhouse gas emissions [10]. Therefore, this sector cannot be considered as environmentally friendly. However, due to recent observations, even in the AEC sector, decision-makers are wondering how to implement some radical changes aiming to reverse the fate of the impending environmental disaster.

The Ellen MacArthur Foundation underlines that the term of circularity has a deep historical and philosophical background. However, with current advances, information technology has the power to support the transition to a circular economy by radically increasing virtualization, transparency, and feedback-driven intelligence. CE model promotes the notion to make more sustainable production models, which are based on careful management of resources and the reduction of negative impacts. Its applications can foster significant improvements in the sustainability of the AEC sector.

There are different perspectives for analyzing the problem of circular economy in the construction sector: from technological issues, to the constructability of the solutions based on the zero-waste attitude and management perspective (only what gets measured gets done [11]), to system problems concerning the whole life cycle of the projects [12] and strategic perspective. In addition, it has to be said that planning the colonization of space requires solid rudiments. It seems that CE can be also applicable to such long-range plans of humanity.

Scientists are building the theoretical rudiments for the new concept [13]. New CE-related professions emerge. Therefore, proper preparation for such a revolution is needed. The methods of selecting suitable candidates for the position of circular economy manager were developed [14]. Systemic changes are also needed [15, 16].

The following concepts like biomimicry [17], industrial ecology [18], cradle to cradle [19], and design for deconstruction [20] are inseparably connected with the concept of CE in the AEC sector.

It turns out that CE is becoming an exemplary attitude for decision-makers when it comes to public procurement.

3. Green public procurement (GPP)

For almost 10 years, the European Commission has been promoting a voluntary instrument connected with good practice experiences on green public procurement. It helps to illustrate how public authorities all over Europe have successfully "greened" a public tender/procurement process. There are many ideas, methods, and tools to expand environmentally friendly attitudes towards business and public development. Among others, they are circular economy concept, sustainable innovations, life cycle costing, etc. Therefore, GPP can be treated as a strategy in which public institutions try to obtain goods, services, and works whose environmental impact during their whole life cycle is smaller than other variants of identical purpose that would be ordered otherwise. It tries to encourage market players to convert their ways of thinking into more sustainable. It attracts decision-makers' interest in the possible alternatives in terms of making the best offer selection more effective. As a part of the new solution, there are good practice cases published online [21], accessible to all interested parties, which provide some suggestions for replicating experiences. There are 22 sections, ordered alphabetically, where one can find different case studies described carefully and focused on making procurement processes less harmful to plants, animals, and other organisms that live on Earth.

According to the European Commission [22], green public procurement can provide public authorities with financial savings. Taking into account the cost of ordered products or services throughout their life cycle can reveal that a selection based only on the price of the purchase can mislead the decision-makers and encourage them to choose not the best offer. However, an awareness of public authorities is rather low. While GPP stays a voluntary procedure, it is important to educate people responsible for procurement processes and explain to them what really pays off. For example, buying products with low-energy or water consumption can lead to a significant reduction in utility bills. Lowering the share of hazardous substances in purchased products (goods or services) can limit the cost of disposal or recycling. Moreover, the bodies responsible for the GPP implementation will be prepared to meet changing environmental challenges as well as to achieve targets for reducing CO_2 emissions and increasing the energy efficiency of products manufactured in the European Union.

3.1 Legal regulations

Each EU member state has to follow some legal regulations. There are basically three areas in the field of legislation related to green public procurement: national law, EU law, and other laws. As for national law, the member states introduce laws together with a number of regulations as implementing acts to those legal acts that specify the nature of public procurement proceedings. Their content is adapted to promote GPP. Then, there is the EU law, which is conditioned by the Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC [23]. It addresses environmental issues in the following areas:

- Award criteria
- Contract performance conditions
- Environmental management standards

- Grounds for exclusion
- Labels
- Life cycle costing
- Qualification criteria
- Technical specifications

Other laws are formal records related to GPP but not necessarily connected with the core of procurement matter. These are:

- Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU
- Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC
- Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings
- Regulation (EC) No. 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU Ecolabel
- Regulation (EC) No. 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organizations in a community eco-management and audit scheme (EMAS), repealing Regulation (EC) No 761/2001 and Commission Decisions 2001/681/EC and 2006/193/EC
- Regulation (EC) No. 1222/2009 of the European Parliament and of the Council of 25 November 2009 on the labelling of tires with respect to fuel efficiency and other essential parameters
- Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles
- Regulation (EC) No. 106/2008 of the European Parliament and of the Council of 15 January 2008 on a Community energy efficiency labelling program for office equipment

3.2 Environmental criteria

The European Commission has taken some steps to create common criteria for GPP that can be used in all EU member states. They were developed for those product groups that were considered as the most suitable for GPP implementation. The criteria are the result of close cooperation between the services of the European Commission and other stakeholders. An application of the criteria is nonobligatory. They were formulated so that, after some minor changes, they could be included (partly or fully) in the procurement documentation by a body. In the AEC sector, the most relevant criteria are for:

- Sanitary tapware [24] (last update, 2013)
- Toilets and urinals [25] (last update, 2013)
- Waste water infrastructure [26] (last update, 2013)
- Water-based heaters [27] (last update, 2014)
- Road design, construction and maintenance [28] (last update, 2016)
- Office building design, construction and management [29] (last update, 2016)
- Paints, varnishes and road marking [30] (last update, 2018)
- Road lighting and traffic signals [31] (last update, 2018)
- Road transport [32] (last update, 2019)
- Public space maintenance [33] (last update, 2019)

All the above requirements generally aim to find a balance between environmental performance, economic effectiveness, market availability, and controlling accessibility.

In order to understand the European development model based on GPP and CE, theoretical considerations on ecology should be presented.

4. Ecological engineering vs. theory of ecology

Practical applications of the theory of ecology are connected with a scope of ecological engineering. This phenomenon can be understood as a field of applied sciences, which is the basis for rational use and protection of the environment as well as natural and anthropogenic resources. It can be described as a design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both [34]. Being the nexus of ecology and engineering design, ecological engineering is a distinct engineering discipline [35]. It is used for the ecological development of societies. Ecological engineering deals with the development of new procedures in case where the classical ones are based on assumptions that cannot be real. At the same time, it is based on theoretical knowledge in the field of the general theory of ecology. Ecological engineering solutions also generate issues for general considerations, developing the theory of ecology covering life and technical science, economy, and social science. A complementarity of engineering and ecology theory is presented in **Figure 1**.

On the other hand, according to Allen et al. [36], environmental engineering is an extension of the engineering process that considers the environment in as many aspects as are thought to be relevant. Environmental engineering, as opposed to ecological engineering, works only with the structure; it lists its components and evaluates the effects of the ecosystem on the components. As a result, environmental engineering then remains a part of engineering, although having an awareness of ecology.

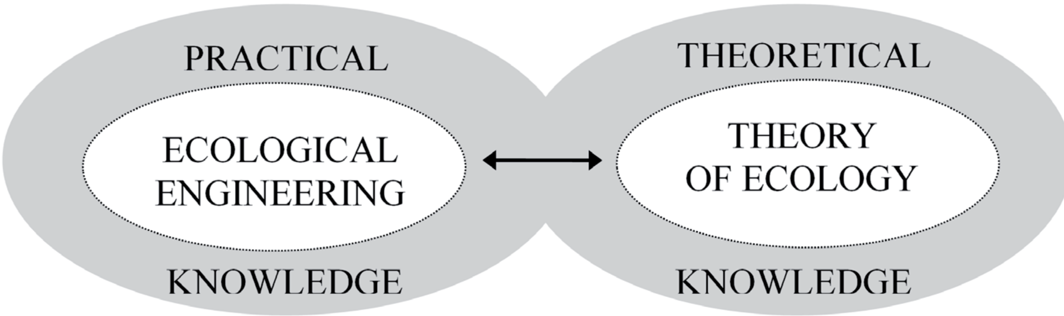

Figure 1.
Ecological engineering and its connections with the theory of ecology as well as practice and general theory.

Odum and Odum [37] maintain that environmental engineering develops the technology for connecting society to the environment. However, technology is only one part of interference with the environment. The other part is provided by the ecosystems as they organize themselves to adapt to the special conditions. Ecological engineering takes advantage of the ecosystems as they link natural resources and outputs from the economy to generate useful work.

The theory and practice, despite dialectical unity, can be distinguished by a number of specific features, among which are a degree of generalization of problems, assumptions, a subject of analysis, etc.

A goal of knowledge management is, in general, to inform and influence decision-making in the organization. Knowledge is recognized as the most important resource of the organization. In fact, maps of knowledge are helpful tools in knowledge management. They are usually created on the basis of audits [38].

The management of an organization's environmental programs in a holistic and documented manner is often called the environmental management system (EMS). In 1996, the International Organization for Standardization adopted a new international standard for EMS-ISO 14001 [39]. The actual language of the standard is that the information should be communicated to facilitate effective environmental management [40]. According to Kacsmerk [41], there are several subjects of environmental management:

- Creation of biological infrastructure, which contains all components of environment conditioning life forms on Earth
- Creation of ecological and technical infrastructure, in which all components of the natural environment dominate, as a set of conditions accompanying production and determining its proper processes
- Resources conditioning the continuity of economic processes
- Production functions, including individual components of the natural environment
- Culture-forming and civilization functions related to the impact of the natural environment on the non-economic sphere of human activity, influencing the creation of the value system of a given society

Hamdoun et al. [42] maintain that there are clear relationships between quality management, environmental management, knowledge transfer, and innovation. It can be noted that quality management has a positive effect on environmental management. Then, quality management and environmental management positively influence innovation, and what is interesting is that both quality management and environmental management positively influence knowledge transfer. It was also revealed that there is a positive effect of knowledge transfer on innovation.

A combination of "management" and "civil engineering" disciplines delivers foundations of knowledge management in construction companies. The knowledge must relate to problems connected with the nature of construction processes, whose implementation is embedded in closer and further economic environment. The management staff of construction companies must be able to use market opportunities to get involved in the implementation of construction projects in a way that ensures achieving the organization's strategic goals. They should also be able to create the operational prospects for anticipated forms and ranges of participation of the company in construction projects. Experience accumulates organizational knowledge and, along with the ability to predict economic principles, also at the global level, allows to transform construction enterprises into learning organizations. Seeing that the construction industry is increasingly competitive, and demanding improved inter-organizational relations, construction companies cannot use out-of-date business philosophies, if they want to remain in business [43]. Practical knowledge about construction projects starts with choosing the right place for buildings or nonbuilding structures. A building plot should have the right size and shape. It is also worth to check out if the location is near wetlands or floodplains and whether the plot has access to a public road. Formal issues also include a verification of the local development plan documents and other statements.

The next part of this chapter will be devoted to the relationship between ecological quality and construction processes.

5. Ecological quality of construction process ecosystem

Raising the level of environmental sensitivity leads to the implementation of environmental management principles at various levels of human activity. This applies, in particular, to the AEC industry. Construction processes consume substantial amounts of resources, (raw) materials and energy, and leave their products (buildings, roads, etc.) with many years of life, what requires special consideration of complex relationships between construction production processes and environment.

In recent times, in many countries, there is an increased interest and progress both in the theory of environmental quality management and in the practical application of new environmental management concepts in entities operating in the business environment. Practical effects are brought by the national environmental protection plans and other specific institutional measures. These effects are observed in the form of reducing pollution from various sources. An example of systemic management of environmental protection can be found in many countries. A clear pro-ecological activity, at the level of environmental quality management, is the creation of global standard regulations. The International Organization for Standardization introduced environmental standards of the ISO 14000 family. These documents, despite a lack of their mandatory character, have been widely used so far. Production systems are an essential source of ecological risk, due to the multifaceted connections with the natural environment. The progress, in which advances in technology, science, and social organization produce an improvement in entire societies, carries a number of potential environmental threats. The emerging production plants operating in the natural environment benefit from environmental goods, but unfortunately, on the other hand, are the source of emissions and waste. The outcomes of production processes are also a question mark for the environment. Relations between particular elements of production systems are presented in **Figure 2**.

The implementation of environmental management strategies is possible provided that the information about the environmental system is adequately processed. This applies to both modelling or creating mappings of elements of production systems, as well as the quality of input information, including mainly the specification of places where environmental risks are created. The methods of presenting processed information and interpreting results are also important. In particular, one can mention a way of constructing the model of the environmental impact of production, completeness of threat specifications, variability of threats, significance of the impact of threats on individual features of ecosystems, a method of estimating critical values, and data accuracy (accuracy of measurements, accuracy of readings, distortion). It must be remembered that insignificant changes slowly accumulate in tendencies, and therefore models of environmentally friendly decision-making should be dynamic. From the point of view of places of occurrence of threats that cause ecological risk, it is possible to classify environmental risk factors (externalities) of production systems, as in **Table 1**.

The ecological quality of construction production must be considered in an initial (conceptual planning) phase: e.g., by adjusting the management of the production processes to the ISO 14000 standards. These standards are a set of guidelines, which is in some descriptive documents helpful in the implementation of the so-called cleaner production. A systemic approach to managing the ecological quality of construction production is a prerequisite for obtaining positive environmental effects. A condition of effective environmental management is the systematic collection of information about a state of the environment, as well as the sources of potential hazards in production systems.

Geographic information systems (GIS) can be treated as a tool for creating a comprehensive model of these phenomena. Digital maps can be an excellent source of information for making strategic decisions in the spatial management on the regional, macro-regional, country, or international level. Such complementary data can be very useful in making decisions in environmentally managed production systems (with a significant impact on environmental protection). Modelling the ecological quality of construction production, with particular emphasis on ecological risk identification, aims to show the directions of preventive activities

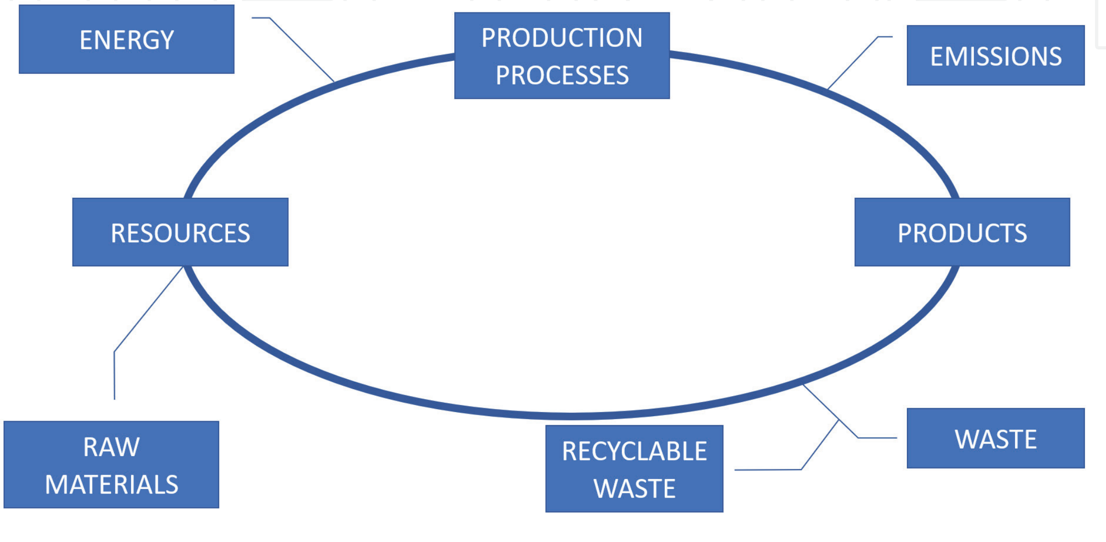

Figure 2.
Production processes ecosystem.

Type of impact factor	**Place of occurrence and source of threat**						
	Exterior of production system				**Interior of production system**		
x	Natural processes	Processes stimulated by human activity	Ecological disasters	Forces of nature	Increased consumption of natural resources	Failures of the system components	Mistakes of decision-makers
Systematic factors	Changes in the environment cumulating in trends (e.g., greenhouse effect)	Increase in emission of solid pollutants, dust, gases, radiation, noise (on input to the system)	x	Incapacity of the forces of nature to absorb waste	Depletion of resources, increase of waste	Damage to elements of technical systems	Ecological policy
Non-systematic factors	Incorrect estimation of input data to the system	Development of new techniques and technologies generating new threats	Sudden damage to technical systems in the environment (e.g., explosion at a nuclear power plant)	Anomalies of nature (e.g., floods)	Cumulative effects of resource consumption (including water, energy)	Failures of technical systems	Errors in modelling phenomena and estimating data

Table 1.
Characteristics of sources of environmental threats.

in relation to the predicted threats to ecosystems. The discovery of nature, and the place of occurrence of threats, as well as the level of risk in ecosystem modelling, is conducive to making accurate decisions in the field of environmentally friendly actions.

The implementation of environmental management principles, including ecological risk, may bring a number of effects, i.e., more efficient use of (raw) materials, and energy leading to the reduction of consumption. Improvements in manufacturing processes lead to a minimization of waste and reduction of costs and enable for the creation of new products and technologies based on environmentally friendly processes ("cleaner production" modes). Also avoiding high costs related to environmental damage (insurance premiums, costs of actions to remove damages) is another effect of intelligent environmental management. Environmental management in construction production, with particular emphasis on the identification of environmental risks, aims to show the directions of preventive actions in relation to the anticipated threats to ecosystems. In the following part of this chapter, the results of our own research on the vision of AEC as an environmentally friendly sector will be presented.

6. Eco-friendly vision of AEC: study results

6.1 Method

This research was carried out in the form of interviewing technique in which the respondent used an electronic device to answer the questions (computer-assisted personal interviewing). A pilot survey was launched on www.surveymonkey.com platform in January 2019. Thirty participants of construction processes employed by construction companies were asked to complete the questionnaire. They were supported by the researcher. A leading role of respondents is illustrated in **Figure 3**, and their experience is illustrated in **Figure 4**.

The questionnaire consisted of the two questions about a sample description, and the rest were focused on obtaining an answer consistent with the respondent's own conviction regarding the particular areas surveyed, with a degree of

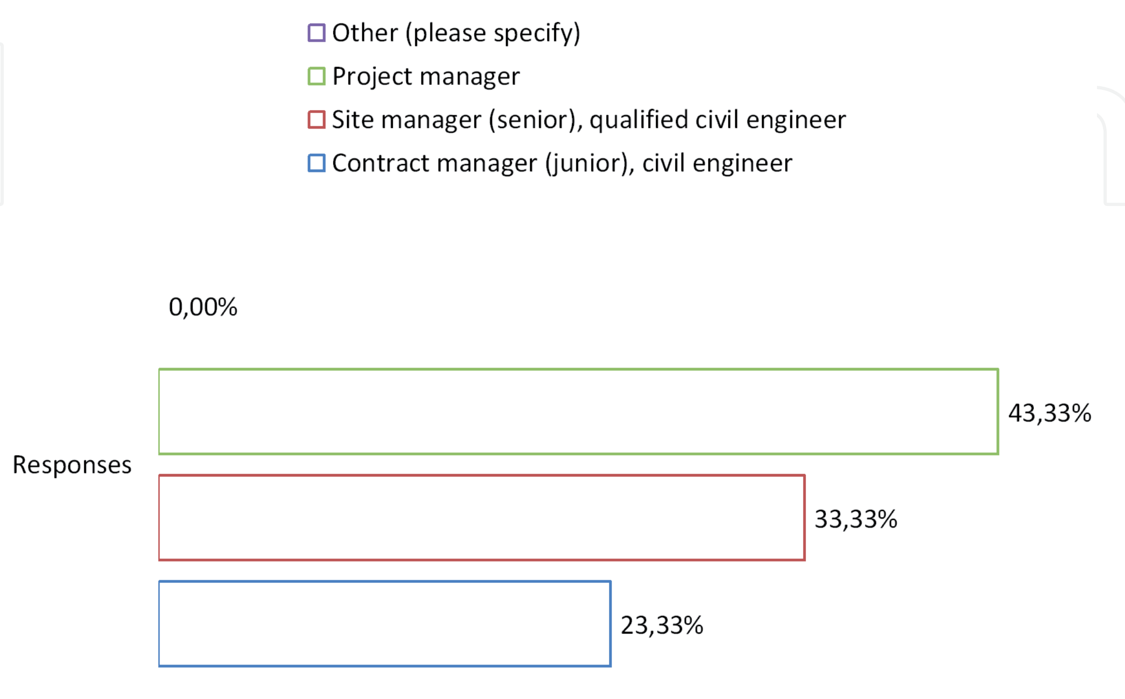

Figure 3.
Leading role of respondents.

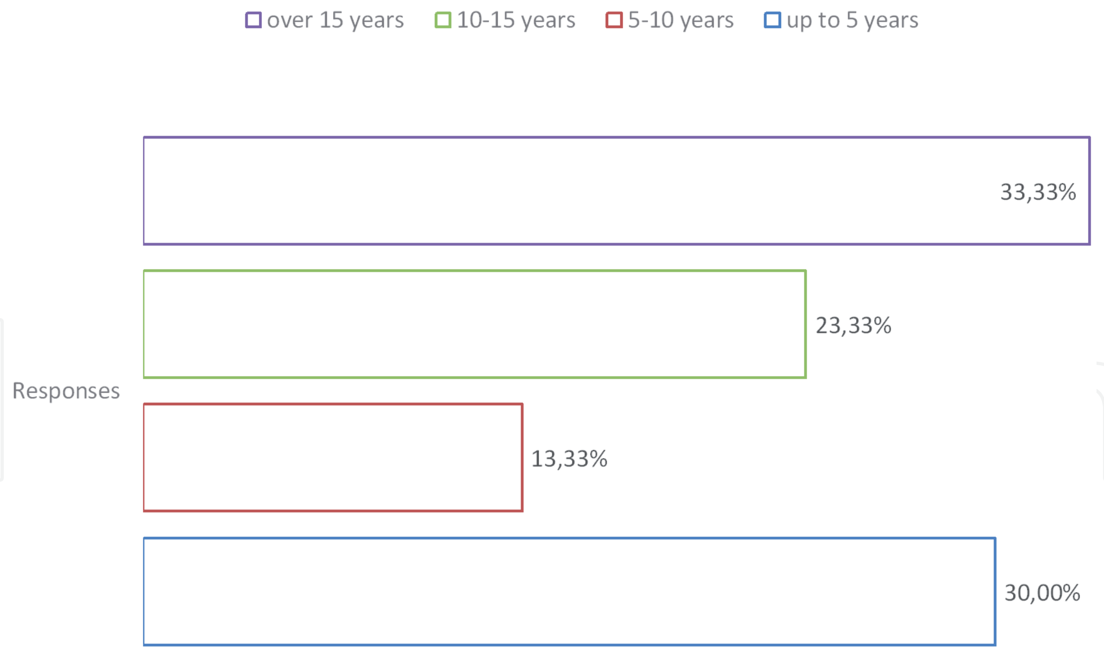

Figure 4.
Experience of respondents.

compliance on a five-point Likert scale, where "1" means "strongly disagree" and "5" "strongly agree."

6.2 Basic attributes of eco-friendly construction

The respondents commented on the basic attributes of eco-friendly construction. According to their conviction the most important are:

- Use of low-energy technologies for the construction of buildings and non-building structures (weighted average = 3,63)
- Limiting labor intensity (weighted average = 3,57)
- Ecological quality of design variants for buildings and nonbuilding structures (weighted average = 3,53)
- Use of low-cost technologies for maintenance of buildings and nonbuilding structures (weighted average = 3,53)

However, the rest are also significant (weighted average over 3,0):

- Use of renewable energy in the whole life cycle of buildings (weighted average = 3,30)
- Limiting water consumption during the entire life cycle of buildings (weighted average = 3,27)
- Use of recyclable building materials (weighted average = 3,13)
- Application of just-in-time (JIT) method in construction works (weighted average = 3,10)

In the scope of the research was also to extract knowledge about the desired individual skills expected from employees working in eco-friendly construction. The most important, according to the respondents, are:

- Ability of decision-making under risk
- Experience in project management
- Interpersonal skills
- Knowledge about building materials used in eco-friendly construction
- Knowledge about decision-making process
- Knowledge about the ecological quality of construction technology
- Knowledge about the natural environment
- Openness to innovation
- Systems thinking skills

The set of skills with their significance is shown in **Figure 5**.

According to the respondents, the most important skill demanded from employees of eco-friendly construction is the openness to innovations. However, the rest eight qualities present a similar level of significance (3,6–3,9).

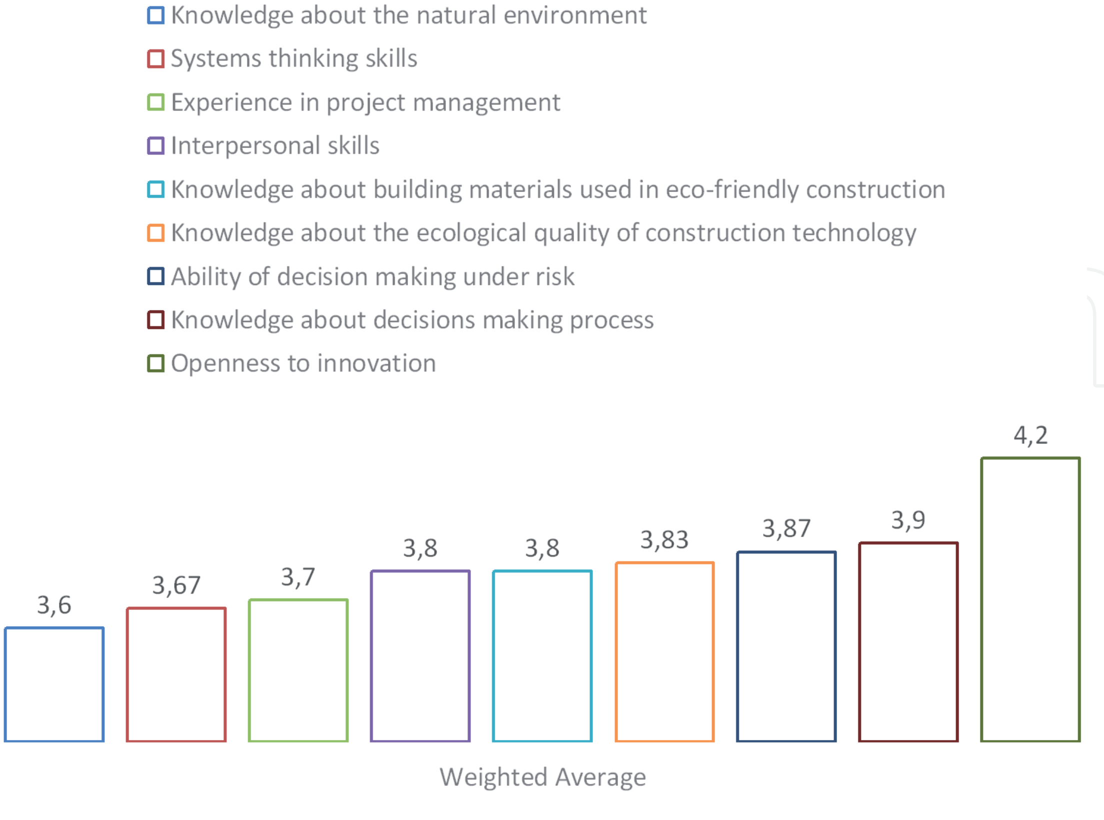

Figure 5.
Desired individual skills of employees working in eco-friendly construction.

6.3 Ecological quality factors in the opinion of participants of the construction process

6.3.1 Ecological quality in the design and construction phase

As the main factors of the ecological quality of construction processes in the design and construction phase, there are:

- Designing and accounting for water consumption
- Designing buildings according to BIM standards
- Designing low-energy houses
- Low-energy building techniques
- Organization of logistic processes according to just-in-time (JIT) criterion
- Reduction in waste of building materials
- Taking into account the idea of circular economy in the design phase
- Use of energy-saving construction machinery and equipment
- Use of recyclable building materials
- Use of reusable building materials

These results are collected in **Figure 6**.

The respondents maintain that two first phases of construction projects (design and construction) bring some difficulties in judging which factors are the most important for assessing ecological quality in projects.

6.3.2 Ecological quality in the maintenance and end-of-life phase

At the end of the research, the respondents were asked to respond to ecological quality in the maintenance and end-of-life phase. The following have been indicated as the most important:

- Complying with recommendations of building management
- Demolition of buildings with respect for circular economy requirements
- Demolition of buildings with respect for ecosystem
- Monitoring the consumption of raw materials
- Noise regulation
- Reduced energy consumption
- Reduced water consumption

- Regular building management
- Use of renewable energy

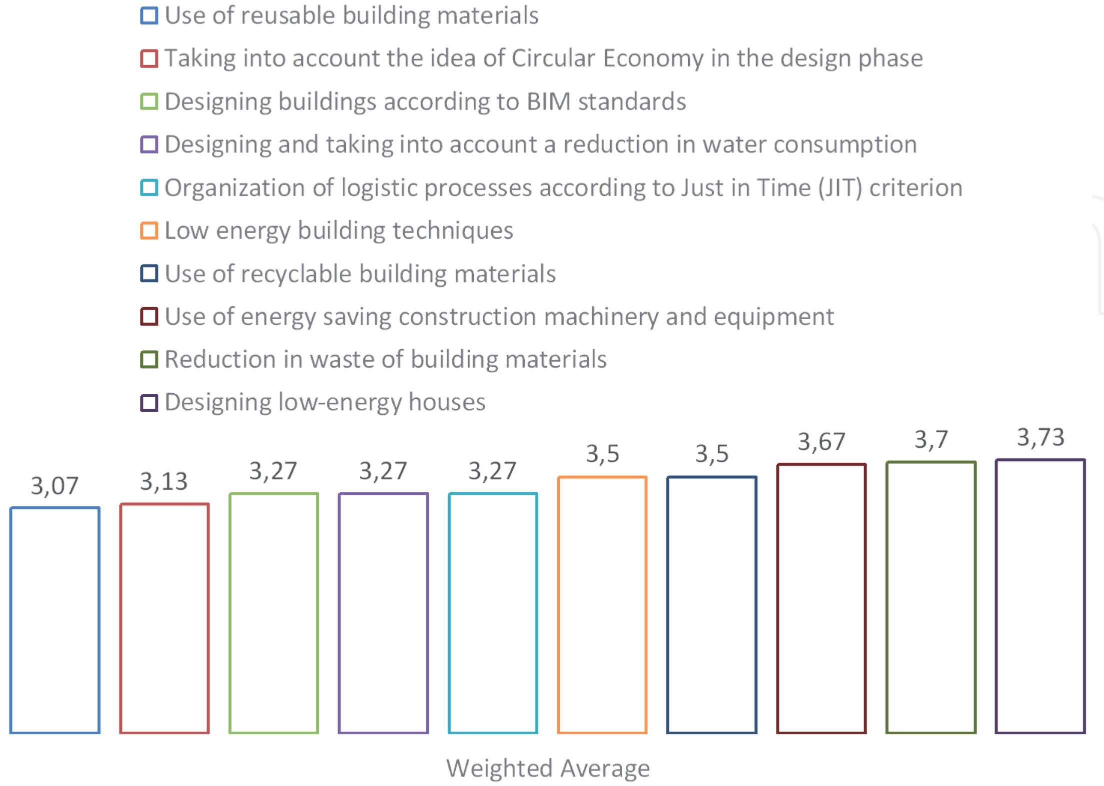

Figure 6.
Factors for assessing ecological quality in the design and construction phase.

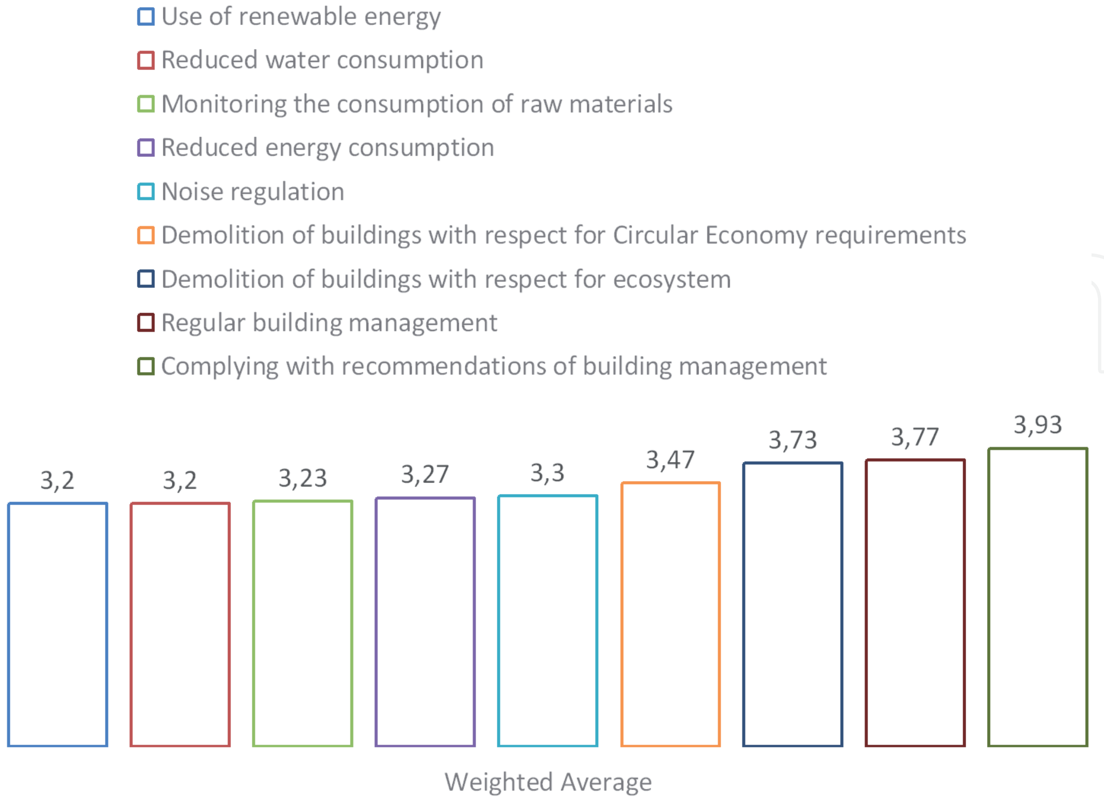

Figure 7.
Factors for assessing ecological quality in the maintenance and end-of-life phase.

These results are presented in **Figure 7**. Opinions of the respondents about the two last phases of construction projects (maintenance and end-of-life) also bring some difficulties in judging which factors are the most important to assess ecological quality in construction projects. Their weighted averages vary between 3 and 4.

One of the most important challenges for authorities and policymakers is to convince the construction market that being environmentally friendly, and becoming an eco-friendly company pays off. This requires learning innovative ecological technologies, which is to start implementing innovative processes for the cleaner production of ecological products.

Although the research is still in its embryonic stage, it gives an insight into some crucial problems connected with a hierarchy of attributes of eco-friendly construction and ecological quality factors in particular phases of construction projects.

The conducted research enabled to create the eco-friendly vision of AEC sector. In the next part of this chapter, the relationship between GPP model and CE policy in the European Union will be presented.

7. GPP model as part of European CE policy

Described before, good practice cases available online, accessible to all interested bodies responsible for public procurement were divided into 22 sections. Among them, there are eight areas directly connected with the AEC sector. These are:

- Buildings (30 cases, accessed January 2020)
- Furniture (12 cases, accessed January 2020)
- Gardening products and services (3 cases, accessed January 2020)
- Indoor lighting (4 cases, accessed January 2020)
- Office building design, construction, and management (3 cases, accessed January 2020)
- Street lighting and traffic signals (6 cases, accessed January 2020)
- Road design, construction, and maintenance (2 cases, accessed January 2020)
- Water-based heaters (2 cases, accessed January 2020)

The rest can be treated as areas indirectly connected with the AEC sector.

Thanks to the publication of information on the course of the selection process of the best offer under procurement procedures and detailed descriptions of the background of the contract, the adopted objectives, selection criteria used in tenders, obtained results, as well as the achieved environmental impacts, the European Union disseminates information on good practices that may be replicated in the future by other public institutions. The authorities may use lessons learned that are given in the reports.

More and more suggestions promoted by the European Commission are connected with circular economy. In the eight areas, mentioned before, there are five pure examples of applying CE principles to procurement procedures [21]. Two of them are coming from the Netherlands ("Circular Procurement of Furniture for the City Hall of Venlo," "Circular Procurement of Furniture for the City of

Wageningen") and one from Denmark ("Circular procurement for a sustainable learning environment," Aalborg), Sweden ("Furniture framework applying circular economy principles," Malmö), and Switzerland ("A low carbon, circular economy approach to concrete procurement," Zurich).

According to the repeating conclusions from the sustainable procurement processes, there is a need to carry out a thorough analysis of the whole process before starting the procedure. Moreover, it is necessary to collaborate closely with all stakeholders involved in the process, whereas sometimes some extra training sessions are needed to increase awareness of the business partners. However, all case studies testify to the rightness of the chosen pattern of conduct in relation to public procurement. The European Union wants to promote its own, improved over the years, economic development model among all its member states.

Nevertheless, there are different models of development seen all over the world. The key players try to adapt a need for sustainable development to local circumstances. For instance, an interesting comparison of urban planning models from Sweden and China has been published so far [44]. It seems that the European Union's model is like the Swedish one which prefers slower but more resilient development of urban areas, rather than a vertical mode, which produces fast results along with all negative consequences, including the environmental pollution and the negligence of sustainability.

The European Union, by promoting GPP, raises awareness of environmental issues among public authorities, as well as sets an example to private consumers.

The rich experience of European countries in the implementation of green public procurement, numerous examples of good practices, and the multitude of educated public clerks mean that the example of the European Union can be set as a role model for others. By promoting GPP, the European Union is developing its policy based on circular economy principles.

8. Conclusions

AEC is a sector of the economy with a significant influence on the environment. Buildings and other structures shape our surroundings and "consume" many resources throughout their life cycle. Contractors have to be sensitive to environmental issues.

In the chapter, based on considerations taken from the literature review as well as direct interviews with experts of the construction sector, it was revealed that knowledge management system in every construction company should cover also, and maybe primarily, the environmental knowledge. In order to indicate significant contents of such knowledge, a survey was conducted among construction engineering experts. The respondents pointed out the subjective role of companies and described it as crucial, indicating a number of individual skills required in eco-friendly construction. The study allowed to discover the buildings' life cycle approach to the creation of environmental knowledge of construction companies.

The chapter identifies the circular economy as an element of the strategic policy of the European Union. Treated as an effective mechanism for sustainable development, CE has become a pillar of GPP.

Despite the nonobligatory nature of the rules related to GPP, the European Union focuses on educating decision-makers, directly public and indirectly private ones. It is worth noting that the GPP model includes not only CE but a number of other solutions supporting sustainable development. The European Union policy results from the need to respond to the deteriorating condition of the natural environment. The growing environmental threats from industry and services require an immediate response. However, changes in improving production conditions take time.

On the other hand, there are often numerous restrictions affecting the risk of such activities. The most serious threats include the low adaptability of other players, limited knowledge of sustainable development, GPP and CE, as well as reluctance to change. It seems that one of the most serious risk factors—apart from those mentioned earlier—is the routine of public authorities and the lack of willingness to go beyond the usual framework of existing legal procedures related to public procurement.

Sometimes safety, provided by well-established patterns of conduct, can be illusory. It is worth taking a risk and turning towards GPP, which give the opportunity to achieve even better results than before.

To use the full potential of GPP, along with many environmentally friendly mechanisms (including CE), one should use the model promoted in the European Union and presented in this chapter. Some decision-makers can share their experience with others. In addition, a crucial remark is that the cooperation of all participants of investment and construction projects and all players from the AEC sector is necessary.

It is worth remembering that contemporary economic activity has an impact on these and future generations. Sometimes it is worth considering how we can stop the processes that have a negative impact on the natural environment. Maybe it is worth thinking about GPP, maybe CE is not an odd idea, especially when the temperature outside is positive, although it is usually frost and snow.

Conflict of interest

The authors declare no conflict of interest.

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