Circular Economy Maturity in Construction Companies

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Abstract. An idea of sustainable development is spread in many aspects of human activity. Recently, there has been a growing interest in it among entrepreneurs of various industries. Investigations of researchers in the field of ecology issues led to a formulation of the Ecodesign Maturity Model (EcoM2) supporting production companies in their pursuit of providing more sustainable products and services. The Circular Economy (CE), on the other hand, appears as a concept of reducing the ecological footprint by finding new concepts of the flow of matter in manufacturing processes, assuming its closed loop. In the literature, comparisons of production systems compatible with the idea of CE to ecosystems occurring in the natural environment, also known as closed ecological systems, can be found. CE in a building sector may be considered at different levels. At first, we can treat objects as ones that can be reused as a whole without any extra processing, for example: construction elements, pallets and multi-use wrapping of building materials. The second level includes reused parts of the construction that need to be remanufactured. The last stage requires a process of recycling, e.g. after a demolition of buildings, building materials are shredded and reprocessed into new elements. The EcoM2 model is used as a basis for an implementation of the Circular Economy in the construction industry. It is justified by its specificity because the construction of buildings is always associated with interference in the natural environment. The aim of the article is to indicate the role of construction enterprises in implementing the CE concept in the sector at the level of both processes and products, treated as an outcome of their activity. The article refers to the functioning of construction companies, including CE in their business strategy. The CE problem in a construction company should be recognised within the entire organizational structure. The concept of Circular Economy Maturity (CEM) of the enterprise is defined. The assumptions of the CEM model for construction enterprises is also described. The basic features that should characterise a company that is mature in terms of the application of the CE concept are specified. It is worth to note that the CE maturity is represented by enterprises that have a natural ability to reform and improve an ecological quality of their products and services. Moreover, these organizations are able to have unified processes and procedures that are identified, and knowledge about ecology is effectively communicated to employees. All organizations that have a CE maturity should plan all activities using processes that are designed and then improved by follow-up studies.

1. Introduction
Circular Economy (CE) Systems allow to preserve the added value of products for as long as possible and eliminate waste. They retain resources within the economy when the product life cycle ends, allowing them to be reused in a productive manner and thus creating another value. The transition to a more circular economy requires changes at every link in the chain of values, from product design to
new business and market models, from new ways of transforming waste into new consumer behaviour. It is connected with a complete systemic change and innovations not only in technologies, but also in organization, society, financing methods and politics [6].

Circular Economy creates opportunities to achieve benefits both in the economic (production processes, innovation, energy independence) as well as social and environmental field (shaping ecological safety) [10].

The construction industry has highly advanced relationships with environmental problems. The erection of buildings means direct interference with the natural environment.

The interaction of buildings and the natural environment continues throughout the life cycle of the facilities. They are influenced by decisions during the investment programming phase, planning of the completion of construction projects, in the implementation phase as well as in the scope of operating processes. Pro-ecological awareness of entities involved in tasks in the scope of subsequent phases of the life cycle of construction objects determines their correct coexistence with nature. Therefore, dissemination of the idea of CE among building contractors is of great importance.

Continuous improvement of the functioning of construction enterprises should take into account the CE concept as a determinant of their development. This would allow the company to achieve the maturity of the company in the CE perspective.

In creating the concept of company's maturity in the scope of CE, the problems of shaping the maturity of enterprises in various dimensions of their functioning must be taken into account. Attention can be paid to the experience in building design [5] or process [2] maturity.

These two types of company maturity complement each other and are interdependent, however, one must notice a few basic differences in the process and design approach, referring to the nature of processes (e.g. repeatability, routine) and projects (e.g. uniqueness, lack of routine) [3].

Enterprises, in search of success, introduce current market trends to their management philosophy. An example is the fact that the idea of CE has been identified as a challenge resulting from the growing environmental awareness of societies around the world. CE has been understood by entrepreneurs from various industries. Investigations of researchers in the field of ecological problems have led to the formulation of Eco-design Maturity Model (EcoM2) [8,9].

2. Idea of Circular Economy (CE) in the construction industry

The Idea of Circular Economy is spread in many areas of human activity. This concept draws attention in business of various industries. Its use is particularly important in the field of construction, which is characterized by close relations with the natural environment.

In the implementation of the CE philosophy, it is necessary to notice the life cycle of building materials used to erect building objects. It begins at the moment of obtaining raw materials, needed to produce a given material, through its production, building in the object, its operation, to the demolition of the facility. In order to protect the environment and natural resources, the construction materials used for the development of buildings must be fully or partially recycled and reused.

CE used in the construction sector may be considered at various levels both in terms of the subject (in relation to construction facilities) and in terms of the object (in the scope of the activity of construction companies).

The implementation of the idea of CE in the shaping of buildings requires, first of all, construction objects that can be reused in their entirety. For example: back office facilities or devices that support logistics processes. The second level of consideration of the object-oriented idea of CE is reuse of parts of a building object - the same or use in a different way. For example, the use of wooden frames for building joinery in shaping the façade of the EU headquarters building in Brussels. The third level of CE application relates to items or parts thereof that need to be processed. Examples are demolitions of building objects, during which building materials are usually crushed and intended for reuse. This approach is widely used in the repair of road facilities. With regard to CE in the activities of construction companies, it is possible to distinguish their pro-ecological activity at the level of:
workgroup, process and organization. Literature review in the field of the implementation of the CE concept in construction companies allowed for specification of CE indicators at individual levels.

The selected group of indicators has been classified according to the life cycle model. Selected indicators and their desirable values are shown in tables 1, 2 and 3.

Table 1. Circular economy indicators in the construction sector: Workgroup level, [7]

| Level | Perspective | Indicators (Measures)                                      | Desired value of the indicator (Target) | Justification                      |
|-------|-------------|------------------------------------------------------------|----------------------------------------|------------------------------------|
| DE    | MM          | ‘Close loop’ instructions for designers - percentage       | 70%                                    | Majority of experts pointed it out  |
|       | CP          | More sustainable sources (reused components, recycled and controlled virgin feedstock) - percentage | 100%                                   | Majority of experts pointed it out  |
|       | MA          | Waste collected for reuse and recycle - percentage        | 40%                                    | Majority of experts pointed it out  |
|       | EL          | CE / BMS instructions based on BIM - percentage            | 90%                                    | Majority of experts pointed it out  |
|       |             | Decision accuracy of demolition techniques - percentage   | 90%                                    | Majority of experts pointed it out  |

DE – design phase, MM – manufacture of materials phase, CP – construction process phase, MA – maintenance phase, EL – end-of-life phase, BIM – Building Information Modelling, CE – circular economy, BMS – Building management system

Table 2. Circular economy indicators in the construction sector: Process level, [7]

| Level | Perspective | Indicators (Measures)                                      | Desired value of the indicator (Target) | Justification                      |
|-------|-------------|------------------------------------------------------------|----------------------------------------|------------------------------------|
| DE    | MM          | Designs prepared in full BIM standard - percentage         | 100%                                   | Majority of experts pointed it out  |
|       | CP          | Continual improvement in CE (management control system) - percentage | 90%                                    | Majority of experts pointed it out  |
|       | MA          | Construction site waste sorting - percentage              | 100%                                   | Majority of experts pointed it out  |
|       | EL          | Processes based on BMS - percentage                       | 80%                                    | Majority of experts pointed it out  |
|       |             | Decision accuracy of demolition methods - percentage      | 90%                                    | Majority of experts pointed it out  |

DE – design phase, MM – manufacture of materials phase, CP – construction process phase, MA – maintenance phase, EL – end-of-life phase, BIM – Building Information Modelling, CE – circular economy, BMS – Building management system

Table 3. Circular economy indicators in the construction sector: Organizational level, [7]
The LCA - Life Cycle Assessment may be the method of assessing the life cycle of a building. It consists in analysing all possible and potential risks and hazards from the design phase, through construction and operation, to demolition of the facility, so that the design solution is as environmentally friendly as possible, and thus the building was the most energy-efficient. The most important parts of the LCA method are [4]:

- identifying negative burdens and risks and determining their impact,
- estimation of potential impacts of burdens and risks,
- defining available actions to minimize or eliminate risks.

As the results of implementing the idea of CE, it is possible to expect [10]:

- increasing savings in production processes due to the reduction of waste of raw materials and materials used,
- increasing the efficiency of manufacturing processes,
- eco-innovation development,
- using environmentally friendly technologies,
- independence from energy supplies,
- reduction of greenhouse gas emissions,
- shaping ecological safety.

3. Modelling Circular Economy Maturity (CEM) in a construction company

Maturity of a construction company in the scope of CE, described as CEM (Circular Economy Maturity), manifests itself in understanding the close interdependence of its success and respect for the natural environment through the implementation of the idea of CE. At the same time, the idea of CE in the organization cannot be narrowed down to individual, developed buildings, because it would be short-term thinking and would ignore the strategic view of the success factors of the enterprise.

The increase in CEM level, through the development of rational ecological thinking and good CE practices at the level of production positions, processes and the entire enterprise means greater...
efficiency of its functioning. It provides a clear division of rights and responsibilities of employees, in particular, a clear specification of their roles at different levels of the organization.

High CEM level means achieving economic goals, meeting environmental and social expectations. It significantly contributes to achieving investors' satisfaction, which creates a good image of building contractors. In a construction company, CE maturity means equal treatment of business and technological and organizational problems at the level of positions, processes as well as the entire organization. It is an important determinant of the success of a construction company involved in shaping the natural environment.

A construction company should perceive its important innovative tasks, both at the strategic and operational level, as those which need to take into account CE.

It should be noted that shaping the company's CEM level is multidimensional.

Observing the functioning of the organization, seeing its success in the smooth course of implementation of the undertaken projects with regard to CE, it is possible to formulate the basic dimensions of CEM, which can be called as:

- CEM of human resources,
- CEM of technical infrastructure,
- CEM of organizational culture,
- CEM of organizational structure,
- CEM in management of construction projects,
- CEM in organization management.

Circular Economy Maturity of human resources is an important dimension of the pro-ecological potential of the company. Qualifications of employees, i.e. their knowledge, skills and experience, position the organization on the path of CE development. This perspective of the CEM of the company is expressed mainly in the employees' mental readiness to take on innovative challenges in the scope of CE. Also important are the ability to accept changes and the ability to collaborate in a team.

Circular Economy Maturity of technical infrastructure can be considered in the area of the entire organization process map, i.e. both basic processes (creating added value), as well as supporting processes and management processes. It means readiness to support innovative tasks, as well as technical service capability of various projects and preparation of an IT system for management by CE.

Circular Economy Maturity of organizational culture is the willingness of an enterprise to accept modern trends in shaping the "spirit of organization". Therefore, it is necessary to open the organizational culture, operate universal artifacts of this culture and tolerate different organizational cultures.

Circular Economy Maturity of the organizational structure is associated with the flexibility of the organizational structure, visualization of the CE projects in this structure.

Circular Economy Maturity in management of construction projects is reflected in the competences of project team members - including the project manager. It is also necessary to create an environmental risk management plan in the project and risk capital to cover potential losses related to CE implementation.

Circular Economy Maturity in organization management refers to the readiness to undertake innovative projects, the ability to interact with other entities, and above all, the possibilities of introducing a management philosophy by CE.

4. Results of innovation research of enterprises
Boosting innovativeness of enterprises should have an extensive perspective, as according to a system-oriented innovation model they are the result of complex interactions between individuals, organizations and the environment in which they operate. The increase in innovativeness of construction enterprises is an important premise for implementing the idea of CE.
The directions of pro-innovative activities in a construction company can be classified as follows:
- systemic innovations at the enterprise level, aimed at improving the functioning of the entire organization, e.g. implementation of the Strategic Scorecard, quality management system, risk management system, etc.;
- systemic innovations of individual projects, supporting the achievement of the project's goal, e.g. introducing the idea of project management (Project Management), etc.;
- process innovations, supporting the achievement of the purpose of particular processes implemented in the enterprise, e.g. in the field of improving the production process (including the introduction of new technologies), increasing the security of the IT process, etc.;
- product innovations, which bring about positive changes in the products offered, or are aimed at the development of new products - material products and services.

The results of the study of the factors inspiring the implementation of innovations in the enterprise and the reasons for reluctance in this respect are presented in Figures 1 and 2.

![Figure 1. Inspirations to implement innovations in the enterprise (source: [1])](image1)

![Figure 2. Reasons why innovations are not implemented in the enterprise (source: [1])](image2)

In the course of research, the following theses have been put forward: innovations that determine the organization's success, both exogenous and endogenous, are a challenge for the organization.
Implementation of innovations requires restructuring of all organizational management processes. The success of implementing innovations in an organization is conditioned by its adaptation to changes resulting from the occasion of technological and organizational changes in processes.

Attention was paid to a number of conditions for the success of such cooperation. They are, among others, determined by the openness to innovations, the degree of maturity in the scope of CE of the company, as well as the flexibility of the organizational culture, allowing to adapt to the endo- and exogenous conditions of functioning on the construction market including the CE.

The development of enterprises in the construction industry and their competitive position depend on the innovative potential. Technological innovations, i.e. innovative products and original processes, accompanying their creation, implemented in a construction company, create opportunities to gain a competitive advantage on the domestic and international construction market. However, effective implementation of technological innovations, as well as market success, requires attention to the need to implement organizational and marketing innovations in the enterprise.

Initiating projects that take into account the idea of CE is part of undertaking innovative activities and is associated with changes in the organization, because each project affects many elements of the organizational space. However, organizations, in order to meet the requirements of recipients of their goods and services, are forced to take on such challenges. Thus, managing by CE as an organizational innovation.

5. Conclusions
Summarizing the above considerations, one can express the opinion that the market demand for innovative products is the suction power for pro-innovation activity in the enterprise. However, centrifugal forces that push innovative processes towards meeting market requirements are indispensable in the company. Those are systemic and process changes, among which technological innovations that use the idea of CE deserve to be emphasized.

Product innovations can be seen as an important factor in the restructuring of the company. It results from the necessity to create conditions that enable the production of new or improved products suitable for the application of the idea of CE.

It should be noted that "innovative" enterprises are more likely to incur high expenditures and take risks related to the implementation of innovations, and experimenting with new ideas has a high priority for such companies. They will also be willing to implement CE as an innovative activity aimed at leading the organization to the path of sustainable development.

CEM of construction companies may constitute a significant differentiator in the competitive construction market, determining their success.

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