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Nowadays we can notice an increased interest in the phenomenon of sustainability in different areas of human activity. In general, manufacturing is one of such areas. All over the world production companies undertake a number of efforts to make their production activities to be more sustainable (Adamczyk 2012). Manufacturing companies are increasingly being conscious of their impact on environment and society as well as of their potential contribution to achieving sustainable development goals (Kleindorfer, P.K. et al., 2005; Jonek-Kowalska 2014; Bluszcz 2017).

Manufacturing companies pay more and more attention on not only the profit but also the way how the goods are produced (Kołodziej & Maruszewska 2015; Zasadzień 2014; Rosen & Kishawy, 2012). The idea of sustainable production begins to play a leading role in all major global production companies. The main message of the concept is that the production processes as well as the products do not adversely affect society, including employees, and the natural environment.

The sustainable production practices are usually identified with environmentally friendly initiatives. Therefore, there is a need to highlight the importance of the human factor in the production process, and the impact of the production processes on the local communities when considering sustainable production practices. The principles of the Lowell Center for Sustainable Production (LCSP) are used as a model in this paper to analyse the sustainable production practices because of its wider context in its approach which emphasises leadership, employee commitment, workplace safety, customer satisfaction as well as economic achievements.

The research question posed in the paper is: If and at what level sustainable production principles are fulfilled in the current practices of selected company from metal industry?

The rest of the paper is structured as follows. The next section provides an overview of sustainable production concept and discusses its main principles. This is followed by the methodology section which describes the research process and next the research findings. Finally, conclusions are presented with proposals of improvement.

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## SUSTAINABLE PRODUCTION

Production process undoubtedly plays a strategic role in the functioning of a production company, especially in terms of building a competitive advantage and improving efficiency. Very fast changes in technology and customer expectations, as well as functioning on global markets cause that production systems is changing constantly. Transformations in functioning of production systems, especially their evolution from systems that are oriented towards mass production and their gradual flexibilization and conversion into deferred systems, which allow to ensure the implementation of all individual customer expectations, are the main trends in production management. Initially, the main purpose of these systems was mainly to focus on low production costs, and over time, also to improve the quality of products (Czaplicka-Kolarz K., Kruczek M., Burchart-Korol D., 2013; Despeisse et al., 2012). The changes that are taking place on global markets are related to the constantly growing variety of product ranges, as well as the multivariability of manufactured products, but also the limited capacity of all production resources and legal regulations (Molenda M. & Ratman-Kłosińska 2018). These changes force producers to look for completely new solutions in the field of production management. In the design and use of existing production systems, a completely new trend appears again, the essence of which is the emphasis on the environmental aspect of processes and products and services, aimed directly at increasing the efficiency of production and services, as well as reducing the risk for people and the natural environment (Palka et al. 2017; Brzozowski 2014).

The production industry negatively influence environment and society and therefore must be reduced to sustain and support the development of global civilization (Garretson et al., 2016). The concept of sustainable production is directly linked to the broadly understood idea of sustainable development (Molamohamadi and Ismail, 2013; Ocampo and Clark, 2017; Midor, 2014). The purpose of this approach is primarily to increase the efficiency and effectiveness of production processes in such way that satisfying the current needs of the society does not interfere with the possibilities of realizing the needs of future generations. Sustainable production means the production of goods as well as services that (Adamczyk, 2012):

- uses processes and systems that do not pollute the environment or severely reduce environmental pollution,
- saves energy and raw materials,
- are realistic in economic terms,
- are fully safe and non-hazardous to people,
- are socially and creatively profitable for people.

We can talk about sustainable production in a situation when all, enterprises and employees, society as well as the natural environment benefit (Velva & Ellenbecker 2001). Sustainable production means activities that are aimed at the production of a good or service, so that the process does not adversely affect society and the natural environment, including the criteria of intra-generational and intergenerational justice. The Lowell Center for Sustainable Production (LCSP, 2018) defines the sustainable production as “*the creation of goods and services using processes and systems that are:*

- *non-polluting;*
- *conserving of energy and natural resources;*
- *economically viable;*
- *safe and healthful for employees, communities and consumers;*
- *and socially and creatively rewarding for all working people”.*

The principles of sustainable production established by the LCSP reflect the foundations of the concept (see Table 1).

**Table 1**  
**The LCSP principles of sustainable production**

<b>The LCSP Principles of Sustainable Production</b>
<b>1. Products and packaging are designed to be safe and ecologically sound through their life cycles; services are designed to be safe and ecologically sound.</b>
<b>2. Wastes and ecologically incompatible by-products are reduced, eliminated or recycled.</b>
<b>3. Energy and materials are conserved, and the forms of energy and materials used are most appropriate for the desired ends.</b>
<b>4. Chemical substances or physical agents and conditions that present hazards to human health or the environment are eliminated</b>
<b>5. Work places and technologies are designed to minimize or eliminate chemical, ergonomic and physical hazards.</b>
<b>6. Management is committed to an open, participatory process of continuous evaluation and improvement, focused on the long-term economic performance of the firm.</b>
<b>7. Work is organized to conserve and enhance the efficiency and creativity of employees.</b>
<b>8. The security and wellbeing of all employees is a priority, as is the continuous development of their talents and capacities.</b>
<b>9. The communities around workplaces are respected and enhanced economically, socially, culturally and physically; equity and fairness are promoted.</b>

*Source: based on Alay C., Säfsten K., Johansson G.: Conceptual sustainable production principles in practice: Do they reflect what companies do? Journal of Cleaner Production 141 (2017), pp. 693-701*

The scope of issues covered under these principles clearly indicates that in order to make the manufacturing process more sustainable, improvements in the enterprise should concern not only products or technological processes but also the working conditions and well-being of the community, taking into account the product life-cycle perspective (Håbek & Lavios Villahoz, 2018). It is worth noting that the Lowell Center emphasizes in its approach also such issues as, for example, the leadership and commitment of employees, as well as job security, customer satisfaction, as well as economic achievements. These give the concept of sustainable production a much broader context, and also allows us to identify sustainable production with a holistic and new concept of management. The implementation of such a concept in an organization undoubtedly requires the construction of an appropriate management system. One of the possibilities is, for example, the implementation of formalized management system or integrated system, which can be based on international standards (ISO and/or others), with the possibility of external, independent verification

and certification (e.g. quality management system, consistent with the requirements described in ISO 9001 standard, environmental management system that is fully compliant with the requirements of ISO 14001 or EMAS regulation, occupational health and safety (OHS) management system compliant with the ISO 45001 standard) (Rogala 2011).

## **METHODOLOGY**

The purpose of the study was to assess implementation of the principles of sustainable production in the company from metal industry and to indicate areas that need to be improved. The nine sustainable production principles formulated by the Lowell Center for Sustainable Production were adopted as a reference point. To achieve the aim of the study, it was necessary to address the following research questions:

- Are products and packaging designed to be safe and ecologically sound through their life cycles?
- What actions have been taken to reduce wastes and by-products?
- Are energy and materials conserved, and are the forms of energy and materials used most appropriate for the desired ends?
- How are the chemical and physical factors eliminated that pose a potential threat to employees or the environment?
- Are the work places designed to minimize or eliminate chemical, ergonomic and physical hazards?
- What is the position of the company's management to continuous improvement focused on the long-term economic performance?
- What actions are taken to enhance the efficiency and creativity of employees?
- What actions are taken to assure security and wellbeing of all employees?
- How does the organization's cooperation with the local community manifest?

In addition to the analysis of the current status of sustainable production practices in a selected enterprise (analysis of documentation, participant observation), the level of implementation of sustainable production principles was also assessed by using interview technique with mid-level managers. In order to assess the company in terms of the application of the nine principles of sustainable production, the respondents were asked to assess the use of each of the LCSP principles with a five-point scale (the score "1" means that the principle is implemented to a very low level and "5", that it is carried out at the very high level). The interview technique is classified as a diagnostic survey method. The selection of mid-level managers as respondents was intentional due to the fact that these managers in a company X have a broad knowledge and experience within the subject of the study. The interviews were individual. The questions answered by the respondents concerned, among others:

- product design,
- dealing with wastes and ecologically incompatible products,
- use of energy, materials and other resources at the input of the production process,
- applying the recycling in the company,
- elimination of chemical substances and physical factors posing a threat to human health or the environment,

- solutions and procedures used in the company, aimed at minimizing chemical, ergonomic and physical hazards,
- commitment of the company's management in implementing the principles of sustainable development,
- cooperation of the company with internal and external stakeholders.

The research material collected using the methods described above was then analyzed. As a result, a radar chart was developed to illustrate which aspects of sustainability production still need to be improved.

The research allowed for the development of suggestions for improvements that may be implemented as part of the sustainable management program in the company X, in particular in the area of aluminium profile production.

## RESULTS

The company chosen for the study has more than 25 years of experience in the production of aluminum structures, produced in an environmentally friendly and energy-saving way. These constructions are used, among others, during the construction of windows, doors, facades, winter gardens, skylights, balustrades and sunshades. The company manufactures both standardized products as well as those created to individual customer's order and used in commercial, industrial and residential construction. From the perspective of introducing and maintaining the principles of sustainable production, important is that the company X has implemented integrated management system composed of quality, environment and occupational health and safety management systems.

The data collected during the analysis of the current state of implementation of the principles of sustainable production in the company X is presented in Table 2.

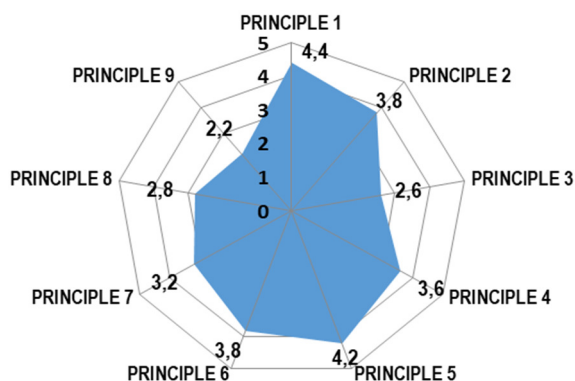
In order to determine the level of implementation of nine principles of sustainable production, the surveyed mid-level managers were asked to evaluate the practices in the company X. The assessment was carried out with a five-point scale, according to which the score "1" means that the principle is implemented to a very low degree, and "5" to a large degree. The results are presented at a radar plot (see Figure 1).

The study indicates that in the examined enterprise, the best implemented principles are: principle 1 (products and packaging are designed to be safe and ecologically sound through their life cycles; services are designed to be safe and ecologically sound) and principle 5 (work places and technologies are designed to minimize or eliminate chemical, ergonomic and physical hazards) and the improvement actions should be focused especially on principle 3 (energy and materials are conserved, and the forms of energy and materials used are most appropriate for the desired ends), 8 (the security and wellbeing of all employees is a priority, as is the continuous development of their talents and capacities) and 9 (the communities around workplaces are respected and enhanced economically, socially, culturally and physically; equity and fairness are promoted).

The aspect of product and packaging design with regard to environmental factors should be considered as well developed in the company X. This process takes into account requirements resulting from standards, including ISO 14001, which has been implemented in the company and constitutes one of the pillars of the IMS.

**Table 2**  
**Sustainable production principles and practices of company X**

The LCSP principles	Solutions used in the company X
1. Products and packaging are designed to be safe and ecologically sound through their life cycles; services are designed to be safe and ecologically sound.	<ul style="list-style-type: none"> <li>- Company X uses materials from certified suppliers,</li> <li>- at the product design stage, the requirements of environmental standards are taken into account, as well as safety requirements, also during the exploitation and disposal phase of the product,</li> <li>- an analysis of feasibility conditions is carried out during the design process, the aim of which is to find solutions in the field of production that will ensure the best results in economic terms, but also environmental ones,</li> <li>- the impact of the finished product on the environment is not assessed,</li> <li>- the company uses ecological packaging, produced from natural raw materials, biodegradable,</li> <li>- a re-use program of waste and incoming materials was implemented in the company,</li> <li>- the company has adopted a program aimed at minimizing the used packaging.</li> </ul>
2. Wastes and ecologically incompatible by-products are reduced, eliminated or recycled.	<ul style="list-style-type: none"> <li>- new products are designed in such a way that it is possible to reduce the amount of solid waste. The design of a new product is often modified to reduce the amount of waste,</li> <li>- programs have been implemented to reuse and recycle waste,</li> <li>- the company uses closed-loop systems, for example when cooling profiles,</li> <li>- the company has a biological wastewater treatment plant,</li> <li>- scrap is sent to suppliers for its processing and reuse,</li> <li>- the company has introduced a procedure for dealing with non-compliant products, including those that do not meet the requirements of safety standards and environmental standards,</li> <li>- training for employees regarding sorting and waste reduction is not carried out,</li> </ul>
3. Energy and materials are conserved, and the forms of energy and materials used are most appropriate for the desired ends	<ul style="list-style-type: none"> <li>- training for employees in the field of energy saving is not carried out,</li> <li>- renewable energy is used in the company to a very low extent,</li> <li>- the company has not implemented an energy management system compliant with ISO 5001,</li> <li>- work is in progress in the company aimed at adapting processes to the requirements of the directive on industrial emissions,</li> <li>- investments aimed at substituting conventional fuels by alternative fuels are also planned,</li> <li>- energy-efficient systems have been implemented in the plant, eg in the field of building automation,</li> <li>- no energy audits are carried out in the company,</li> <li>- the construction department and research and development department carry out work aimed at optimizing the use of production materials and energy,</li> <li>- the profile cooling water is in a closed circuit, thanks to which it is possible to recirculate it.</li> </ul>
4. Chemical substances or physical agents and conditions that present hazards to human health or the environment are eliminated	<ul style="list-style-type: none"> <li>- the company reduces the level of use of hazardous substances during the implementation of production processes, it is not possible to completely eliminate the use of such substances due to the fact that they do not have their "safe counterparts",</li> <li>- employees receive training on occupational risk and the use of hazardous substances while hiring,</li> <li>- all hazardous events with the use of toxic substances are registered on an ongoing basis, and improvement works are carried out at the plant, aimed at reducing accidents at work with the use of such substances,</li> <li>- the plant uses air filtration and purification systems, as well as biological treatment of wastewater,</li> <li>- the procedure for dealing with hazardous substances has been adopted,</li> <li>- workstations are designed in accordance with the principles of ergonomics, the plant uses solutions that limit the impact of physical factors on human health.</li> </ul>
5. Work places and technologies are designed to minimize or eliminate chemical, ergonomic and physical hazards.	<ul style="list-style-type: none"> <li>- in the plant, along with the implementation of the 5S and visual management system, redesign of the workstations has been made so that they meet the requirements of safety and ergonomics,</li> <li>- standardization of work has been introduced,</li> <li>- automation solutions have been introduced (e.g. using industrial robots), especially in the case of technological operations, the implementation of which could be particularly dangerous for employees,</li> <li>- 5S audits and internal security inspections are carried out at the facility. A register of potentially accidental events is also kept,</li> <li>- the technology department conducts work aimed at modifying processes to reduce noise and vibrations,</li> <li>- each employee undergoes training in the subject of work safety.</li> </ul>
6. Management is committed to an open, participatory process of continuous evaluation and improvement, focused on the long-term economic performance of the firm.	<ul style="list-style-type: none"> <li>- the company has implemented an integrated system (quality management, environmental management and occupational health and safety), which is supervised by an employee directly subordinated to the company's management board,</li> <li>- in the company pro-ecological investments have a priority, contributing to increasing work safety as well as product quality, investments focused only on economic benefits are less important,</li> <li>- regular audits are conducted at the company to continuously improve the company's operations</li> </ul>
7. Work is organized to conserve and enhance the efficiency and creativity of employees	<ul style="list-style-type: none"> <li>- in order to increase work efficiency, process mappings were made, which allowed to optimize them by removing non-value operations,</li> <li>- procedures in the field of work standardization have been implemented, which not only increases the efficiency, but also the safety of employees,</li> <li>- employees participate in kaizen teams whose aim is to improve the processes carried out in the company,</li> <li>- employees are rewarded for ideas that are accepted for implementation,</li> <li>- the company promotes team work and solving problems together,</li> <li>- employees take part in job training aimed at improving the quality and efficiency of their work.</li> </ul>
8. The security and wellbeing of all employees is a priority, as is the continuous development of their talents and capacities.	<ul style="list-style-type: none"> <li>- the company has implemented a health and safety management system,</li> <li>- employees who submit ideas that are implemented are rewarded,</li> <li>- there are no career development programs in the company,</li> <li>- employees are assigned to specific job positions, no rotation, in the case of employee absence, there is often a lack of replacement</li> <li>- there are no scholarship programs in the company,</li> <li>- employees are entitled to private health care packages,</li> <li>- the employee satisfaction assessment is not carried out in the company.</li> </ul>
9. The communities around workplaces are respected and enhanced economically, socially, culturally and physically; equity and fairness are promoted.	<ul style="list-style-type: none"> <li>- the company is a place of work for many people living in the place where the production activity is carried out, as well as from the surrounding area,</li> <li>- the company does not cooperate with educational institutions; sometimes apprenticeships and internships are organized, but they are irregular in nature,</li> <li>- meetings with local authorities are occasional,</li> <li>- the company sometimes sponsors local initiatives and cultural events, it also supports local public benefit organizations,</li> <li>- the company does not use volunteering for local communities.</li> </ul>



**Fig. 1** The level of implementation of the LCSP principles in company X

Some of the products manufactured in the company are also suitable for recycling, just like the packaging used. The company X also organized a reverse logistics system in which aluminium waste from production processes is returned to suppliers for processing and reuse.

In turn, while designing new products, a feasibility study is conducted, oriented on finding the most effective production solutions, both from an economic and environmental perspective. The company also undertook activities aimed at reducing the amount of wastes and ecologically incompatible products. The amount of production wastes is already taken into account at the design and production stage of the prototype. Systems with closed water circulation are used to cool the profiles. The plant also operates a sewage treatment plant. However, the issue of limiting the emission of industrial gases is still a problem. The adaptation works currently carried out in the company are time- and cost-intensive.

When it comes to designing a workplace in company X, activities are carried out aimed at reducing the consumption of chemical substances that pose a threat to the health and lives of employees. However, their complete elimination is not possible. In order to reduce the risks for employees in the company, solutions in the field of production automation were implemented, along with part of the processes being carried out by computer controlled industrial robots. The company also registers all events with the use of hazardous substances on an ongoing basis, and based on the analysis of their causes, improvement actions are developed. During the implementation of the 5S practice in the plant, the production hall and workstations were redesigned to reduce physical and chemical hazards for the employees. The work safety is also ensured by work standardization, which is one of the essential elements of the lean manufacturing system implemented in the company. The company also conducts 5S audits and occupational safety inspections on a regular basis. On the other hand, OHS service employees are responsible for keeping a register of potentially accidental events, developing and implementing solutions that reduce the risks for employees of the company X.

An area requiring improvement is undoubtedly the one related to the efficient use of energy and materials. Employees should also be motivated to propose their own solutions aimed at reducing wastage in the company, also in the area of energy use. Improvement activities should be developed, for example, through the kaizen teams, in which all employees of the company can participate.

Improvement is required in the area which is covered by the principle eighth – securing wellbeing of employees as well as talent management in the company. This is the more important issue because in the opinion of the respondents, there are more and more problems related to the recruitment of qualified and motivated employees. For this reason, it is important to maintain existing employees and systematically invest in their development. The conducted research indicates in particular the need to develop training programs for employees, as well as to provide people employed in the company with development opportunities. It is also necessary to support team cooperation, which is one of the most important tools for the exchange of knowledge. Management, in turn, should motivate employees to submit their own ideas, and if justified implement them.

The area of sustainable production that has been assessed as being implemented at the lowest level in the enterprise X was the one concerning cooperation with the local

community, as well as educational institutions, research and scientific centers or other business institutions. Undoubtedly, good communication not only with clients and employees, but also with business partners and the local community is an important factor shaping the relationship with the environment, based on the principle of partnership and trust.

The conducted research drew attention also to the fact that the analyzed company does not undertake activities related to employee satisfaction survey, its internal clients. This situation is the more surprising because of the implemented in the company integrated management system. The employee satisfaction survey should be part of this system. In addition, the results of such survey would be also useful when identifying areas that need improvement from the perspective of the people employed in the company.

## CONCLUSIONS

The aim of the paper was to analyze the state of implementation of the principles of sustainable production in enterprise X, and to identify areas for improvement. The research indicates that many solutions oriented to sustainable production have been implemented in enterprise X, both in terms of environmental as well as social and economic aspects. Analysis of the organization in terms of LCSP principles of sustainable production showed that in each of the analyzed areas some practices have been implemented, however there were identified some deficit areas.

The best assessed principles in company X were those related with product and packaging design, workplace design, waste management and monitoring and improvement of the company's economic performance. The implementation of the principle 3, 8 and 9 was assessed as the worst. For these deficit areas, improvements were proposed that could be implemented as part of the sustainable management program in the company, in particular in the area of aluminium profile production.

Taking into consideration the principle 3, concerning the efficient use of energy and materials it is proposed to implement the following actions:

- implementation of the ISO 5001 standard for helping organization to manage its energy performance,
- training of employees in the field of efficient use of energy and materials,
- investments in renewable, environment-friendly energy sources,
- gradual reduction of the use of solid fuels during production processes.

Employees should also be motivated to propose their own solutions aimed at reducing wastage in the company, also in the area of energy use. The company can also carry out energy audits, during which it would be possible to identify in which areas the greatest energy losses occur.

The worst assessed areas were those covered by principle 8 and 9, which are basically related to each other, concerning the wellbeing of employees and cooperation with the local community, as well as educational institutions, research centers, and other business institutions. Undoubtedly, good communication not only with clients and employees, but also with business partners and the local community is an important factor shaping the relationship with the company's stakeholders, based on the principle of partnership and trust. The conducted research indicates the need to implement actions oriented at:



- supporting the development of the local community,
- development of dialogue with each of the key stakeholder groups in order to build effective communication regarding the company's sustainable development,
- shaping an organizational culture that is focused on innovativeness, environment friendly solutions as well as safety of employees.
- establishing cooperation with educational centers and universities, which should encourage attracting young, qualified employees,
- undertaking internal marketing activities addressed to employees in order to increase the sense of their identification with the company and its goals to prevent excessive rotation of personnel.

In addition to the above proposals, it is also recommended to introduce a regular assessment of employees satisfaction as the long-term and sustainable success of the organization depends on their level of satisfaction.

## ACKNOWLEDGEMENT

*The research was conducted with the support of the statutory work titled "Methods and tools supporting development of priority research areas", project number 13/030/BK-19/0052.*

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**Abstract.** Production activities of companies significantly impact society and environment. It is high time to re-think many of industry's practices and to change manufacturing processes in a way that allow the company to increase its competitiveness, while at the same time help to achieve sustainable growth. The sustainable production is a concept that is able to strengthen such transformation. The aim of this paper is to present empirical evidence of implementation of the sustainable production practices in the selected company from metal industry. The principles of the Lowell Center for Sustainable Production (LCSP) are used as a model to assess the main aspects of sustainable production in practices of the company. Empirical evidence shows that in each of the analysed issue some practices have been implemented, however there were identified some deficit areas. Therefore, at the end of the paper the improvements actions were proposed that could be implemented in the analysed company as part of the sustainable management programme.

**Keywords:** sustainable development, sustainable production, manufacturing of aluminium profiles, Lowell Center for Sustainable Production principles