Sustainable development is linked to balancing consumption with sustainable production. When considering its interrelations and cause-and-effect relationship, sustainable consumption and production should be expected. In practice, it is impossible and paradoxically, the existing discrepancy between mutual non-matching of production and consumption is deepened by the same factors that enhance sustainability individually within production and consumption spheres. Moreover, this discrepancy is deepened by such positively perceived factors as the process and product innovation being a motive power for launching new products on the market and increasing competitiveness. This is noticeable when considering an increasing quantity in product supply and developing new ranges of hitherto unknown products as well as accompanying global increase in consumption of raw materials, energy and waste. Production brings a strong stimulation of consumer needs and demands but it also puts pressure on consumers through marketing activity, advertising and promoting consumption lifestyle patterns. In this paper, the actions targeted at developing sustainable production and consumption in two areas are described. The factors of mutual unsustainability between production and consumption within the cycle: environment - resources – production – distribution – consumption – waste - environment.

**Keywords:** consumption, design, production, sustainable development, technology.
enhancing the company reputation and brand image through integration of sustainable development thinking into business practices. Also, capacity building for economic development in the communities, regions, and countries in which the company operates is to be expected.

Environmental actions comprise environmental impact reduction by minimizing and striving to eliminate the adverse environmental impacts associated with operations, products and services and natural resource protection by promoting the sustainable use of renewable natural resources and conservation, and sustainable use of non-renewable natural resources, including ecosystem services.

Social actions involve spheres covered by business ethics by supporting the protection of human rights within the company’s sphere of influence and promoting honesty, integrity and fairness in all aspects of doing business. They also significantly improve employee well-being as an effect of protecting and preserving the fundamental rights of employees, promoting positive employee treatment and contributing to employee health, safety, dignity and satisfaction (Clark 2007).

These also help increase the quality of life working with public and private institutions to improve educational, cultural and socio-economic well-being in the communities in which the company operates and in society at large (Rumpala 2011). Achieving these objectives require a comprehensive approach and compromise solutions necessary to reach a synergistic effect.

**Sustainable production and consumption and product design strategies**

The expected synergistic effects result primarily from actions in the areas of sustainable consumption and production based on the Life Cycle Thinking (LCT) paradigm of complex profiles in the triad of sustainable development.

1. Economic life cycle thinking:
   - total life cycle costs incurred by the enterprise, including capital and operating costs, and impact on long term profitability;
   - total cost of ownership to the customer, including purchase or leasing of equipment and ongoing supplies or services;
   - economic efficiency in terms of resource productivity and net energy production over the product life cycle;
   - economic growth or entrepreneurship opportunities enabled by the product introduction;
   - regional economic benefits of production due to sourcing of materials, suppliers and services;
   - new jobs created both directly and indirectly via the multiplier effect.
2. Ecological life cycle thinking:
   - energy consumption and energy efficiency of supply chain operations;
   - depletion of non-renewable resources, including materials and fuels, involved in transportation, production and distribution;
   - impacts upon local and regional ecosystems, including habitat integrity, biodiversity and distribution of natural cycles;
   - potential loss or degradation of agricultural lands, forests, water bodies, fisheries or other natural resources critical to human subsistence;
   - airborne emissions, including hazardous air pollutants, particulates, smog forming chemicals and greenhouse gases;
   - solid or liquid waste streams associated with supply chain operations, maintenance and disposable supplies;
   - potential risks associated with accidental spills, leakage, fire, explosion or other incidents that could threaten human safety or ecosystem integrity.

3. Social life cycle thinking:
   - benefits of product or service availability upon community quality of life, including improvements in health, nutrition, education, access to resources, sanitation, mobility and recreation;
   - impacts upon employees and families, including skill development, education, and personal health and safety;
   - potential adverse effects of new business operations and facilities upon existing cultural and community activities;
   - potential impacts upon aesthetics, including landscape changes, noise, odour or other effects of industrial activities.

It is easy to see that the production (product) side of sustainable manufacturing in LC convention consists in coexistence of physical and business cycles (KOM(2008)). In practice, LCT is accepted and completed by designers, constructors and technologists. The premise of LCT also comprises the sphere of consumption but according to studies, this more likely results from design assumption rather than conscious consumer’s choice. The natural consequence of LCT is Design for Environment (DfE). This design concept, being of crucial importance for sustainable consumption and production, is completed by four groups of strategies according to different industries and product systems. The aim of these strategies is to reduce resource consumption, while maintaining economic growth. (Fig. 1).
Fig. 1. General strategies of Design for Environment

Design for Dematerialization consists in minimizing consumption of raw materials, energy and other resources at each product life cycle stage that should lead to an extended product usability period, downsizing and simplified regeneration/recovery and recycling.

Design for Detoxification – serves to reduce adverse impacts on humans and the environment at each stage of product life cycle by eliminating toxic and hazardous materials, implementing cleaner production, reducing hazardous substance emissions and waste neutralization.

Design for Revalorization – is targeted at recovery residual value from materials and resources used, thus reducing consumption of primary raw materials. This can be achieved by making easier disassembly of used products and its components and separating materials for revitalization or extracting raw material groups for an economically efficient recycling. Similarly to Design for Revalorization, this design strategy is targeted at multiplying recirculation of primary raw materials, thus protecting natural resources.

Source: own research.
Design for Capital Protection and Renewal – is aimed at securing access to various forms of capital (human, economic, natural) enhancing well-being. Capital protection assumes continuity and effective use of existing capital, whereas capital renewal requires capital to be reinvested or newly generated. An example of capital renewal is acquiring talented employees, creating new jobs and ecological revitalization.

The product design process realization is based on design dichotomy, assuming consistency between these two design forms as a necessary condition for success. This consistency relates both to the selection of means for achieving the goal, i.e. the transition from quality of design and manufacturing to product quality. At each of these stages ecological issues understood not only as a direct environmental impact but also its indirect consequences remote in time and space. At this point it is necessary to refer to the important role of LCT, especially life cycle design, assessment and analysis (LCA), modeling methods and scenario techniques that together with Environmental Management Systems and ISO/TR 14062 general guidelines (2002) create another system, influencing both sustainable production and consumption (Bostrom & Klintman 2008).

Achieving the DfE strategy may be seen as troublesome and costly undertaking, however its effect is not only an idealistic desire for sustainable production and consumption (Keane 2011). DfE initiates a complex process that finally creates value for the enterprise and shareholders (Fig. 2).

![Diagram of DfE Practices, Performance Improvement, Economic Value, and Shareholder Value]

**Source:** own research on: Fiksel J., Low J., Thomas J., (2004), Linking Sustainability to Shareholder Value, Environmental Management (6).

**Fig. 2. Process from design for environment to shareholder value creation**
Achieving DfE requires various tools accompanying preparation and the design process. These are mostly concepts and tools used in realization of the concept of sustainable development in many sectors (Table 1).

The concepts that integrate production and consumption such as QFD (quality function deployment) integrate consumer preferences with the process preparation activities so that the required level of product quality, in particular eco-labeling and its inspiring manufacturers and consumers take an important role.

Table 1

<table>
<thead>
<tr>
<th>Concept</th>
<th>Tool</th>
<th>Sector</th>
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<td>Chemicals</td>
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<tr>
<td>Clean technology - cleaner production</td>
<td>Analysis of consumer preferences and attitudes</td>
<td>Construction and buildings</td>
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<td>Climate change mitigation</td>
<td>Economic instruments</td>
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<td>Consumer engagement and communication</td>
<td>Integrated product policies</td>
<td>Financial</td>
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<td>Corporate social responsibility</td>
<td>Internalization of environmental and social costs</td>
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<td>Eco-efficiency</td>
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<td>Eco labeling</td>
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<td>Ecosystem services</td>
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<td>Life cycle management</td>
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<td>Producer responsibility</td>
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<td>Rebound effect</td>
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<td>Supply chain management</td>
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<td>Sustainable products and services</td>
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Source: own research.
The role of eco-labeling in achieving sustainable production and consumption

Across the EU there are numerous solutions enhancing sustainable production and consumption recommended by the Commission of the European Communities (KOM 2011). In addition to eco-design, it is also recommended to use ecological product marking, green public procurements and an encouraging system supported by member states and creating the global market for ecological products (Vollmer 2010).

Eco-labeling is an activity initiated in the area of sustainable production, but also functioning in the target area of consumption. An integrated eco-labeling consists in generating effects targeted at sustainable production by meeting product environmental requirements, and then at influencing consumer preferences under market conditions, while supporting sustainable consumption.

Within this scope, eco-labeling supports decision making on:
- individual purchase, individual and green public procurements
- analyses related, inter alia, to economic growth and competitiveness
- raw material recovery and waste management.

Through eco-labeling the manufacturers communicate to consumers and other stakeholders the message that the product meets certain ecological criteria. In order to gain the right to use eco-signs some activities are deemed necessary pertaining to design and manufacturing processes as well as product features. Life Cycle Thinking (LCT) and use of LCA computer aided techniques is an essential paradigm. The rules of ecological marking were established in the EU with Regulation No. 66/2010 of the European Parliament and of the Council of 25 November 2006 (EC/ 66(2010).

The popularity of European eco-labeling is confirmed by the number of licenses and products/services awarded with the EU Ecolabel (Fig. 3 - 6).

During the reporting period (March 2016), the largest number of EU Ecolabel licenses were awarded in France (28%), Italy (18%) and Germany (12%). Iceland and Croatia have not been awarded any EU Ecolabel licenses.

Out of the total number of licenses during the reporting period (March 2016), the majority of products/services comprised within this total are from Italy (46%), France (10%) and Spain (9%). Iceland and Croatia have not been awarded any EU Ecolabel products or services.

Over the decade, a number of studies on label functioning were carried out taking into account not only organizations and procedure performance but also the attitude of stakeholders. The group of respondents included manufacturers, consumers, traders and representatives of governmental and non-governmental organizations.

**Fig. 3. Total ecolabel licenses by products and services group**
The execution of activities related to eco-labeling has been confirmed by the results of a survey ordered by the EU in 2014 (EU Ecolabel Survey, 2014). The results indicated that up to 79% of respondents considered EU labeling an important sales tool, while 66% of respondents recognize the ecolabel as the most important factor in taking a purchasing decision. In fact, individual EU member states assign different degree of significance to ecological labeling when making purchasing decisions.


Fig. 4. Total ecolabel products and services
The results of our survey, carried out on a representative random sample in Poland show that only a small group of consumers actually pay attention to eco-labeling when making their purchasing decisions (3%). More than half of the respondents (52%) declare that they use an eco-mark when making decisions, while the rest of them pay no attention to eco marking.


Fig. 5. Total EU Ecolabel Licenses per Country
The EU surveys indicate that small and medium sized enterprises (87%) pay more attention to eco-labeling as compared to large companies (74%). In addition, the concept of common market requirements for EU labeled products was highly appreciated (87%), although individual interest groups present a relatively differentiated opinion. The highest consistency was shown by representatives of governmental organizations (100%) as well as consumers (92%); however, the concept gained little appreciation by those who held no ecolabel certificates (75%). Responses to eco-labeling by prospects brought some interesting information too. More than half of the respondents (54%) point out the necessity to improve the Ecolabel system, (41%) to leave it unchanged, while the remaining (5%) propose to liquidate it.

**Controversy about the effect of activities related to sustainable production and consumption**

Already by the turn of the last century, some authors (Dowell et.al 2000) expressed skepticism about the effects of sustainable production and consumption. Still,
the pre-production and production activities that remain in the domain of manufacturers cause not only favorable but also adverse environmental impacts. This paradox has occurred with the development of innovation and design under conditions of strong competition. The implementation of technical innovations, e.g. innovative design or products, even with the occasional face lifting applied to them, increases a stream of products entering the market, shaping new product groups. As a result, a more intensive use of raw materials and power resources is observed, all the more this is not accompanied by removal of old products. Thus, the imbalance between production and consumption becomes even greater.

Evidence of unethical cost cutting practices in order to achieve microeconomic objectives together with manipulations in Lean Production to improve productivity have also caused negative effects. Such practices often entail replacement of high quality materials (that are basically more expensive), with their cheaper substitutes, while increasing performance characteristics to indicate product innovation. This leads to the cutting down on the service life of parts and sub-assemblies, limiting it to the warranty period only. The situation is further aggravated by the so-called “Design for Service” consisting in introducing irreparable sub-assemblies or making repairs more complicated by using designs and connections that require specialized tools and equipment, which makes the whole process more labor-consuming. As a result, the repair itself becomes unprofitable, stimulating a demand for new complete sub-assemblies or even new products. This is witnessed both in food production and non-food products.

An example of such practice, which is easy to show due inherent product features such as intended use of relatively long service life and the possibility of product assessment after use, is the automotive industry. The public has long been aware of recurring problems with cars, e.g. faulty TSI engines, gearboxes, valve timing gears or DPF filters. A peculiar design “achievement” was placing the valve timing gear between the engine block and the gearbox in BMW N47 engines. Such practices make servicing more difficult and expensive and shorten service life, although they could create a short-term driving force for sales growth in the automotive market. What is more, solutions targeted at mitigation of harmful environmental effects of transportation are of end-of-pipe technologies (e.g. soot after-burning). One can see no activities whatsoever aimed at improving combustion processes and emission reduction by eliminating some diesel oil components, while at the same time bio-fuels

1 To reduce friction between the piston and cylinder, piston rings of reduced friction area, thus less resistant and tight were introduced.
that are being introduced, have their ecological features originating in plant raw materials; it is true however that their potential to replace oil is rather limited. (Smith 2009). Not to mention that some counter-innovation activities such as hydrogen powered engines or the development of hydrogen fuel cell technologies are thought provoking.

Among activities that only seemingly lead to sustainable production are practices used by highly developed countries which eliminate use of raw material technologies and are based on importing pre-processed raw materials from countries where costs of labour and raw materials are low. These practices have negative impacts on the environment due to an increase in consumption of raw materials and energy and harmful emissions, and related costs beyond their boundaries, usually outside the EU territory. This too results in technological stagnation in some countries, which in order to increase profits, intensify extraction and sales of raw materials, while suffering losses from emission costs.

**Conclusion**

Despite common interest in sustainable development and supporting strategies covering specified areas of activities, their current performance cannot be considered satisfactory. The pursuit of sustainability is never-ending. The positive effects of sustainable development are primarily brought about by the involvement in the design and manufacturing areas, i.e. production, and to a smaller degree by consumers who attach insufficient significance to environmental issues when making buying decisions. Distributors and retailers play an important supporting role by shaping supply chains and consumer behaviors. Moreover, manufacturers and retailers often agree that sustainable production and consumption offer a chance to develop innovations and improve competitiveness. It is also necessary to perform informative and educational activities among consumers to make sustainable consumption their lifestyle. Long-range activities should bring in a positive effect in the form of sustainable consumption, even though this is a long-lasting process. Low environmental awareness, lack of understanding of the concept of sustainable production and consumption and a growing consumerism induced by a wide market can postpone sustainable development.

**References**


