Sustainable production projects – case studies in Turkey

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Abstract

Especially after the Industrial Revolution, the effects of humanity on the climate began to increase to a significant extent. Currently, these negative effects have reached the level that threatens the natural structure. Insensitive and excessive consumption of natural resources leads to an increase of environmental pollution. The concept of "sustainable production" has emerged to face the climate change and global warming. Modern businesses more frequently aim to conduct environmentally friendly projects and changing unsustainable production models. The implementation of sustainability concept into marketing strategy has had a positive impact on consumers and investors. The effective use of clean resources and green energy, the transition to ecological technologies, and the use of environmentally sensitive production principles are also important for compliance with difficult competitive conditions. Global economic and environmental crises in recent years have led to increased international efforts to transform to more sustainable industrial systems. In this study, the concept of sustainable production is discussed and the case studies of sustainable production projects realized in Turkey are examined.

Key words

sustainability, sustainable projects, sustainable production

Introduction

Nowadays, the concept of sustainability is often raised more by factors such as efficiency and resource saving requirements than sustainable use of resources and environmental protection. In the framework of "sustainable production" concept, while the concepts of clean production and eco-efficiency come to the fore, R&D and innovation activities that take into account the environmental factor are expected to increase for clean technologies and green products with high added value. In recent years, the determined role of environmental issues in economic and social policies has been increasing [Blok et al., 2018; Bouglet et al., 2012; Sarkis and Zhu, 2018]. An increase in efficiency in the provision, conversion and use of resources has become inevitable. The current economic and social problems around the world and the connections of these problems with environmental issues have made the sustainability approach indispensable in recent years [Broniewicz et al., 2019; Godlewska and Sidorczuk-Pietraszko, 2019; Sudolska et al., 2019]. Especially with the pressure to create new jobs and jobs in developing countries, the understanding of sustainability has gained a new dimension [Evin, 2020, p. 1-14].

The article presents various sustainable production parameters provided in twelve projects, the main effects of environmental technologies and energy efficiency projects.

1. Sustainability and sustainable production

In the report "Our Common Future", prepared by the United Nations Commission on Environment and Development, sustainability is defined as: "ensuring today's needs without compromising the ability of future generations to meet their own needs" [United Nations, 1987]. Sustainability is both active and proactive. It is defined as the ability of a society and ecosystem to continue their work without interruption, degradation, or damage to the main resources that the system needs [Muammer and Zişan, 2007, p. 222]. In the post-industrial revolution period, the trend of producing on a large scale and ensuring social well-being through increasing production led to excessive consumption of resources and environmental pollution. One of the most basic assumptions of economic science is that human needs are unlimited, but the natural resources to meet them are limited. Taken from this perspective, it turns out that concepts such as sustainability, sustainable development, and sustainable production, which have become more common since the end of the 20th century, are vital for the continuation of environment protection [Mert, 2005, p. 259-264].

Sustainable production means that businesses carry out their current production activities with less damage to the environment, in order not to endanger their future production. Sustainable production provides feedback, contributes to the discovery of new products. New opportunities can be achieved through sustainable production. Consequently, sustainable growth can be achieved in the long term. It is easier for the business to understand the risks associated with sustainability and to meet social expectations with good management of these risks [Süleyman and Emre, 2016, p. 63-101; Umit and Alpine, 2016; Timmermans et al., 2017].

However, in order to better understand sustainable production among businesses, nine basic principles have been prepared by the Lowell Center for Sustainable Production. These principles refer to issues such as product design and packaging, the destruction of waste and incompatible products, the reduction of work-related threats, and the continuous improvement of the well-being of workers and society. Businesses should also have goals consistent with these principles. These principles are shown below [Vesela and Michael, 2001, p.519-549]:

1. Products and services should be designed with confidence and ecological precision throughout their life cycles.
2. Waste and ecologically incompatible products must be continuously reduced, destroyed or recycled.
3. Energy and materials must be preserved, and energy forms and materials must be used optimally.
4. Chemicals, physical factors, technologies and business practices that threaten human health or the environment should be constantly reduced or eliminated.
5. Work areas should be designed to reduce or eliminate physical, chemical, biological and ergonomic hazards.
6. Management should commit to open, participatory processes for continuous development and focus on the long-term economic skills of the enterprise.
7. The work done must be organized in such a way as to protect and increase the productivity and creativity of the employees.
8. Like the continuous development of the capabilities and capacities of all employees, safety and well-being are a priority.
9. Communities near workplaces must be economically, socially, culturally and physically respected and developed; justice must be supported.

The benefits of sustainability to businesses means not only effective management of resource use, but also venture capital and costs reduction. As a result, positivity in environmental values is observed [Nurdan, 2012, p. 227-242].

A variety of tools are needed to identify the problem with existing production systems and then measure progress towards sustainable production and set specific

goals towards sustainability. These tools are indicators of sustainable production developed by the Lowell Center for Sustainable Production and put forward by some authors. These indicators are numerical measurements that provide information about the economic, physical, environmental/ecological and social systems of enterprises. But the specific structure of sustainable production systems varies according to the sector of the production industry. Therefore, the characteristics of sustainable production vary on a sector-by-sector basis. However, sustainable production indicators of enterprises are more related to the environment [Figen, 2004, p. 5].

Indicators of sustainable production defined by the Lowell Sustainable Production Center can be defined within the framework of five steps. This five-level representation creates a more evolving five-step structure of indicators of sustainable production. This five-step structure is shown in the Figure 1 [Vesela and Michael, 2001, p. 519-549].

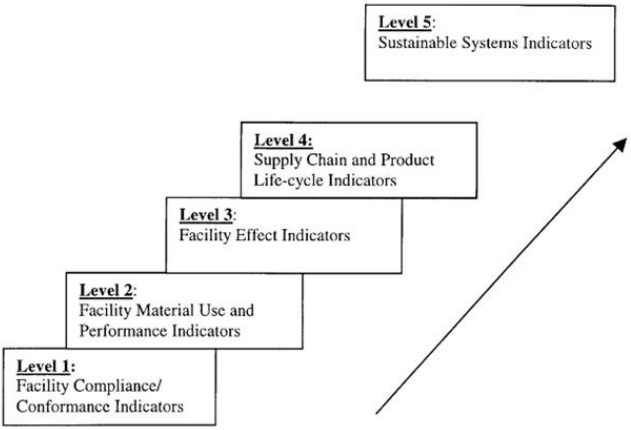

Fig. 1. Sustainable production indicator framework

Source: [Vesela and Michael, 2001].

2. Literature review

From the industrial revolution to the present day, the paradigms in the field of production or operations management has changed towards sustainable orientation. The concept of sustainable production and its sub-elements have been processed in

detail and indicators of sustainable production have been addressed [Burcu, 2010, p. 141-156].

In Alpagut's study, the concept of sustainability was first discussed considering various dimensions. The dimension of development within the framework of economic science and then the evaluation of sustainability was examined [Alpagut, 2010, p. 63-68]. The concepts of sustainability are strongly likened to their environment, compared to the economic and social direction [Glavič and Kovačič Lukman, 2007, p. 1876-1885]. The concept of sustainability includes all stages of production, from product design to material recovery to product life cycle concept and stages. In order to measure the level of sustainability of enterprises, the topic of sustainability indicators is discussed [Figen, 2004, p. 4-5]. In enterprises that incorporate sustainability policies into their business processes, corporate identity and performance in enterprises increase with the new technology used. It reduces costs and increases profitability, the reputation of the enterprise and finally a competitive advantage [Ümit and Alpine, 2016, p. 51-66; Evren et al., 2014].

3. Sustainable production projects in Turkey

In the following section, the success story of case studies of twelve sustainable projects carried on in different companies is presented in chronological order. Projects concern environmental technologies and energy efficiency. These projects, which were implemented in the period 2007-2012, are given in accordance with the same chronology, along with brief notes on important developments in Turkey in related areas and other supporting activities and work of the Technology Development Foundation of Turkey [Evren et al., 2014].

3.1. Gas Turbine Inlet Air Cooling Project (2007)

- Problem: Loss of production that occurs during periods when the weather is hot.
- Solution: Reducing fuel consumption and lowering inlet air temperature.
- Goal: Reducing fuel consumption and increasing production capacity.

The total budget of the project was 1.1 million USD and the duration of the project was 3 months. The most important benefit of the project was the reduction in fossil fuel consumption and the increase in energy production. At full capacity, CO_2 emissions decreased by approximately 9800 tons/year, while in addition, nitrogen oxide (NOx) emissions were reduced. With the project, there was an average decrease of 2% and a maximum decrease of 3% in fuel consumption

required for the same amount of energy production, in other words, 2% more energy production was realized with the same amount of natural gas. The project repaid itself in 1,5 years.

Expert staff constantly follow innovations and techniques that increase productivity. It sends waste on site to recovery and disposal facilities, waste heat from furnaces and chimneys in our cement factory is evaluated in a steam turbine and generates energy, drainage water is evaluated in cooling towers, saving 4000 tons of water per year.

3.2. The Project of Reducing Raw Material Consumption by the Method of Recovering the Waste Created in Aerated Concrete Production in the Production Process (2007)

- Problem: Aerated concrete waste that appeared to be lost in the production process.
- Solution: Development of processes for recycling waste into production.
- Goal: Increase in product quality as a result of returning waste to the production process and renewing prescriptions accordingly.

The total budget of the project was 242 000 USD, and the duration of the project was 12 months. The project paid itself back in about 2,5 years. Within the scope of the project, the process of restoring the firm to production was developed, methods that can also save raw materials were investigated, and methods of application were studied. One of the most important achievements of the project was the return of waste to the production process and, accordingly, the increase in product quality as a result of the renewal of prescriptions. On the other hand, the fact that the material saved was cement also indirectly reduced the use of energy and greenhouse gas emissions caused by cement production, which was an energy-intensive sector. The project achieved a decrease in production costs and a cost advantage. The firm competitiveness and profitability also increased. Applications in the project were realized with 100% domestic resources. The project is an example of eco-innovation that includes both national and company-level.

3.3. Ram Machine Flue Gas Energy Recovery System Project (2008)

- Problem: Energy loss by waste heat from dryers.
- Solution: Heating fresh cold air and process water by evaluating waste heat with Energy Recovery System.
- Goal: Increase in natural gas saving and CO_2 emission reduction.

The budget of the project was 240 000 USD, and the duration of the project was 5 months. The socpe of project indcluded the discovery of chemicals and dust from the fabric in the content of waste gas coming out of the machines. It was envisaged that these substances would be automatically cleaned by water spraying of heat transfer surfaces, taking into account the risk of causing pitch on heat transfer surfaces. The energy recovery system, which was developed in this way, became one of the newest technologies applied in the textile sector. The new generation of RAM machines were supplied with such heat recovery systems. The project repaid itself in 1,2 years. Therefore, the effectiveness of the project is high when economic and environmental gains are taken into account. It is worth noting the direct impact of the project on the increase in profitability of the firm.

3.4. Energy Efficiency Project (2008-2009)

- Problem: High energy costs.
- Solution: Recovery of waste heat with chiller and compressor.
- Goal: Saving electricity and natural gas; heating the inside of the factory with waste heat.

The budget of the project was 756 000 USD and the project lasted 12 months. Within the scope of the project, studies such as the development of mold cooling system and the installation of cooling tower, recovery and evaluation of waste heat from "chiller" and air compressor, improvement of electrical and pump systems were carried out. In particular, the recovery of waste heat from the "chiller" and compressor contains an innovative perspective and is considered an example of good practice. Applications related to lighting, insulation and roofing, which are not directly related to production processes, were carried out with the company's own resources.

The energy savings provided by the project resulted in a reduction in fossil fuel consumption and CO_2 emissions. The energy saving rate provided from the project was about 10%. About 600 tons of CO_2 reduction per year was achieved in the project, other combustion gases from fossil fuels were also reduced.

3.5. Energy Efficiency Project (2008-2009)

- Problem: High energy consumption and waste heat energy loss, especially tunnel furnaces.
- Solution: An integrated system that will increase efficiency after a detailed energy study.

- Goal: Reduced costs of natural gas and electricity used for heating.

The budget of the project was 430 000 USD and the duration of the project was 12 months. The project repaid itself in less than 2 years. Within the scope of the project, in line with the forecasts, there was a decrease in the consumption of both electricity and natural gas. By ensuring that the recovered waste heat works in coordination with the existing heating system on very cold days, the consumption of natural gas used in the factory for heating purposes has also decreased.

The realization of the savings rate in production cost as 2% with the project was an important competitive element. This has strengthened the firm's position in the market, maintained its competitiveness in the national and international markets, and has had a direct impact on profitability growth. In addition, the decrease in production costs had increased production by providing cost support in the acquisition of some large auctions with very low profits. The company also contributed to the "image of a company that respects nature" to its customers in developed countries. This has had positive effects on exports.

3.6. Energy Saving and Efficiency Project (2009-2010)

- The problem: High energy costs.
- Solution: Improvement of steam and fire transport systems by various methods.
- Goal: Savings in natural gas use and reduction in greenhouse gas emissions.

The budget of the project was 272 000 USD and the duration of the project was 10 months. The project repaid itself in 2 years. Applications carried out within the scope of the project: providing steam at the rate of need by making the existing steam system more flexible, reducing pressure levels; condensate recovery (baveria) and switching from an open-channel system to a closed-pipe system used for transporting clippings.

3.7. Project to improve the compressed air system used in the aluminum tube manufacturing plant and increase energy efficiency (2011-2012)

- Problem: Inefficient air compressors
- Solution: Supply of domestic production, high quality compressors.
- Goal: Prevention of energy losses in the compressor system.

The budget of the project was 273 000 USD, and the project lasted 12 months. The project repaid itself in 13 months. Within the scope of the project, two new generation compressors of higher capacity, more efficient and continuous, domestic

production were commissioned, replacing the existing four compressors, which were first inefficient and worked at continuous load. The existing compressor room has been brought to suitable conditions in terms of volume, fresh air, filtration and insulation. In addition, a common compressed air line was established within the enterprise for compressors. By creating a turnstile system in the enterprise, equal compressed air was obtained in all compressed air workstations. Each machine was given as much air as it needed with the installation project, which is the company's own design. Air outlet models of the installation in accordance with the standards prevented the flow of water and humid air to the machines.

3.8. Improving Efficiency in Heat Recovery and Energy Use Project (2010)

- Problem: Energy losses and leaks in the production process.
- Solution: Insulation of Heat center and heat lines.
- Goal: Energy saving and greenhouse gas emission reduction.

The budget of the project was 296 000 USD and the duration of the project was 9 months. The project repaid itself in 20 months. Within the scope of the project, condensed balls located on the steam line and detected leaks were replaced, the clean air entering the RAM machines with the economizer application was again heated by gas released from the chimney of the RAM machines. Another application performed was to recover the heat of the water used in paint shops and released as hot as a result of the process and reused.

3.9. Luleburgaz Brewery Evaluation Of Waste Beer Yeast As Feed Material By Drying Project (2010-2011)

- Opportunity: Establishment of a second facility for the production of animal feed raw materials from Brewer's yeast waste in the Lüleburgaz region.
- Action: Creating a second plant that is more efficient than the previous one, thus ensuring that waste is converted on site and the waste gas coming out of the beer production plant is also considered fuel for drying.
- Goal: Production by evaluating waste, with more effective processes and ensuring an increase in product diversity and quality.

The budget of the project was 330 000 USD and the duration of the project was 8 months. The project repaid itself in 2,5 years. The most important return of the project was 1800 tons of waste yeast produced as a result of beer production are converted into products by replacing raw materials in a way that creates added value. The costs of disposal of waste were also eliminated. As there was no use of steam in

the new system, an annual water saving of 600 m^3 was achieved. With the establishment of the plant next to the brewery, the cost of transportation disappeared. Due to the automatic system, it had a positive effect on labor productivity.

3.10. Generation of Electricity from End of Life Tires (2011 - 2012)

- Problem/opportunity: Tires that have completed their life, which are an important place in the waste sector.
- Solution / action: Waste disposal using pyrolysis method and obtaining new products.
- Goal: Generation, use and sale of electricity using pyrolytic oil and gas.

The budget of the project was 2,5 million USD and the duration of the project was 7 months. The project repaid itself in 9 months. With this project, the acquisition of new products with economic value from the tires that have completed their life and the production of energy have been realized with innovative applications and in a way that creates high added value. By signing a first in this sense, he also created a very positive image in his regions. They believe that this practice, which has a high level of innovation on a national scale, will serve as an example for many applications in a similar field.

3.11. Obtaining Feed Raw Materials From Turkey Slaughterhouse Residues (2011-2012)

- Problem: Large amounts of waste resulting from processing.
- Solution: On-site processing of production residue by cooking and drying methods.
- Goal: Production of flour and oil from the resulting waste and energy saving.

The budget of the project is 1,3 million USD. The project repaid itself in 1,3 years. The company's Waste Recovery System includes a number of processes, including cooking and drying. Thanks to the plant, which obtained animal fats and protein flours of various properties as a result of successive processes, it was possible to convert the residue into value-added products at an annual rate of 5300 tons. On the other hand, with the implementation of the project, the health risks that may arise due to the storage and transportation of these residues, which require attention from a sanitary point of view, have also disappeared. With the disappearance of the need for storage and transportation, materials were prevented from deteriorating and depreciating over time due to bacteriological activity.

3.12. Natural and Mineral Based New Generation Thermal Insulation Board Production with Environmentally Compatible Production Processes (2012)

- Problem: Existing insulation materials are harmful to the ozone layer and the environment, production costs are high.
- Solution: Production of a new product with a lower cost by making it low density and high heat insulated by the process of expanding perlite.
- Goal: Saving cost in thermal insulation and reducing environmental damage.

The budget of the project was 1,2 million USD and the duration of the project was 9 months. The project repaid itself in 2,5 years. Applications covered by the project include expanding perlite, which makes up 98% of the product, resting expanded perlite in silos by mixing with binders, turning the product into block panels and sheets, then drying or cooking. The process consists of stages such as crushing, screening and drying of perlite brought from the mine as tuvenan and making it ready for expansion and use as raw material.

Conclusions

The development of the sustainable projects, the approach of the companies, as well as the impact of the projects on the enterprises, relevant stakeholders and natural environment were evaluated and discussed. As a result of twelve projects, the important effects have been stated both economic and environmental.

The main effects of the projects implementation concerned the following aspects: the improvement of work environment, the increase in production capacity of the companies and their export potential, improvement of the production quality and finally increase of companies competitiveness. The following main environmental effects were achieved: saving natural gas and electricity consumption, carbon dioxide emission and reduction in the amount of waste were observed. As far as the economic benefits are concerned, these projects contributed to annual savings of about 15 million USD. The financial effects of the project were achieved through the increase of waste water purification and the reduction of water consumption, air pollutant emissions, solid waste, carbon dioxide emissions, power and natural gas consumption.

Finally, transformation into an economy based on sustainable production is possible thanks to not only technology supply, but the relevant process can be effective with the introduction of innovative business models, consistent implementation of strategies and encouragement by public policies.

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Projekty dotyczące zrównoważonej produkcji – studia przypadków w Turcji

Streszczenie

Wpływ ludzkości na klimat zaczął się w znacznym stopniu nasilać szczególnie po rewolucji przemysłowej. W konsekwencji, negatywne efekty rewolucji osiągnęły poziom, który obecnie zagraża równowadze środowiska naturalnego. Nieumiejętne i nadmierne wykorzystywanie zasobów naturalnych prowadzi do wzrostu zanieczyszczenia środowiska. W obliczu zmian klimatycznych i globalnego ocieplenia pojawiła się koncepcja zrównoważonej produkcji. Coraz częściej celem działalności przedsiębiorstw jest realizowanie projektów przyjaznych dla środowiska i zmiana niezrównoważonych modeli produkcji. Wykorzystanie zrównoważonego rozwoju jako strategii marketingowej ma pozytywny wpływ na konsumentów i inwestorów. Efektywne wykorzystanie czystych zasobów i zielonej energii, przejście na ekologiczne technologie oraz stosowanie przyjaznych dla środowiska zasad produkcji są również istotne w celu sprostania rosnącej konkurencji rynkowej. Globalne kryzysy gospodarcze i środowiskowe w ostatnich latach doprowadziły do zwiększenia międzynarodowych wysiłków na rzecz transformacji w kierunku bardziej zrównoważonych systemów

przemysłowych. W niniejszym opracowaniu omówiono koncepcję zrównoważonej produkcji i przeanalizowano studia przypadków projektów zrównoważonej produkcji realizowanych w Turcji.

Słowa kluczowe

zrównoważony rozwój, zrównoważone projekty, zrównoważona produkcja