

Inspiring Technologies and Innovations

<https://dergipark.org.tr/tr/pub/inotech>**Research Article** **The Relationship of Energy Management and Environmental Innovation: A Conceptual Evaluation**Mustafa YÜCEL^{a*}, Erol TEKİN^b, Sevgi YÜCEL^c^aKastamonu Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, İşletme Bölümü, Kastamonu, Türkiye^bKastamonu Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, Uluslararası Ticaret ve Lojistik Bölümü, Kastamonu, Türkiye^cKastamonu Üniversitesi, Sosyal Bilimler Enstitüsü, İktisat Bölümü, Kastamonu, TürkiyeORCID^a: 0000-0003-1818-4189ORCID^b: 0000-0003-1166-7671ORCID^c: 0000-0003-4710-1864Corresponding Author e-mail: mustafayucel@kastamonu.edu.tr<https://doi.org/10.5281/zenodo.8099734>**Received** : 9.12.2022 **Accepted** : 24.06.2023 **Pages** : 1-7

ABSTRACT: Global warming and climate change are currently the most pressing challenges in the globe. Environmental pollution, greenhouse gas emissions, and wastes produced by the industrial sector at various stages of the production and consumption processes are the main contributors to this. As a result of additional harm to natural resources and the erosion of the balance, nations, corporations, and consumers face the possibility of not having a clean world where they can thrive and leave a legacy to future generations. It is necessary to develop R&D activities that support the recycling of natural resources, clean production and zero waste philosophy, technological advancement towards the use of renewable energy resources, and innovation in processes and operations in order to develop environmentally friendly production methods. This paper aims to analyze the connections between the ideas of energy management and eco-innovation and to explain their importance. The idea of energy management, the rise of environmental awareness concurrent with energy management, issues relating to energy use, and the connection between eco-innovation, energy management, and environment are all addressed within this framework.

KEYWORDS: Energy Efficiency, Energy Saving, Energy Management, Eco-Innovation**1. INTRODUCTION**

The increase in production activities with the industrial revolution caused rapid consumption of natural resources and an explosion in population. The increase in population causes an increase in economic activities to fulfill the needs, which increases energy demand and consumption in turn. Energy is accepted as one of the main inputs and driving forces of economic growth and development, and it poses a problem for most countries in terms of supply and consumption since the first industrial revolution. Due to its vital role in economic activities, most countries have turned to the use of fossil fuels such as coal and oil for energy production. However, this type of energy is not sustainable, as it is non-renewable and not environment-friendly. The fact that the increase in energy demand is higher than the energy produced from fossil sources jeopardizes sustainable development by causing both an increase in energy prices and the devastation of the environment.

In today's life, globalization is expanding throughout the world, and the energy market is undergoing significant changes in various aspects, such as cross investments, re-organization of local markets, restructuring processes associated with the old energy industry, depending on new global policies, as well as international trade. The transformation progress in the energy markets affects the relationship structures between producers and consumers; and rises issues related to energy supply security (Harris, 2001). In this parallel, the levels of development and welfare become more dependent on energy, as it is not possible to produce and deliver goods and services to consumers without using energy. Any disruption in energy input will likely put the economy in a bottleneck (Ghosh, 2002). Usually, developed countries have the necessary technological infrastructure to replace their energy resources or to use their resources more efficiently, which is one of the crucial factors that enable those countries to cope more successfully with the global crises that may occur related to energy supply. On the other hand, the lack of these opportunities in developing countries causes them to be more severely affected by crises related to energy supply. In this context, it is vital to pay attention to crises that may occur in the global energy supply, especially for developing countries (Karagöl, Özgür, & Görüş, 2020).

The increase in fossil fuel-based energy demand causes global warming and climate change due to the continuous release of greenhouse gas emissions into the atmosphere. This situation endangers the sustainability and security of energy on a global scale (Akintande et al., 2020, p.1). The continuous use of non-renewable energy and the depletion of natural resources have increased the awareness of international organizations and country groups on global warming, and many countries have shifted their focus to renewable energy production methods. These production methods have lesser negative effects on the atmosphere and environmental quality compared to fossil fuels and non-renewable sources. In addition, global health problems, economic losses, climate change, and sustainability problems are the factors that contribute to encouraging the use of renewable energy (Wang and Wang, 2020, p.1). From this point of view, it is known that the concept of energy efficiency is at the center of national, economic, energy, and environmental issues, especially in developed countries. Moreover, the energy crises experienced in the past periods have been important encouraging factors that have played a role in focusing on energy-saving measures (Kurbatov and Naumenko, 2014). Because, in an environment where there is rapidly increasing competition with globalization both in the dimension of nations and companies, it is inevitable in a sensible mindset to use energy efficiently and to show interest in saving measures.

The purpose of this paper is to explain the vitality of energy management and eco-innovation, and examine the relationship between these two concepts. Thus, the development of environmental awareness in parallel with the issues related to energy consumption was reviewed before the evaluation of the relationship between eco-innovation and energy management.

2. MATERIALS

2.1. Environmental Awareness in Parallel with Energy Consumption-Related Problems

Since the first industrial revolution, took place in the eighteenth and nineteenth centuries, energy demand has increased, especially in Western countries, depending on the increase in industrialization movements. The spread of these movements in many other countries, especially in China, has gradually increased the global dependence on the use of energy resources, making it an indispensable factor in economies. Even today, non-renewable and high carbon-emitting fossil fuels, led by oil, natural gas, and coal, continue to be the most used energy sources. In this current situation, countries that take the ever-increasing energy demand into account have increased their interest and sensitivity in energy efficiency and obtaining alternative energy sources, and have carried out various studies (Karadaş, Koşaroglu, and Salihoğlu, 2017).

The first significant formations of today's contemporary, systematic environmental awareness approach gained momentum in the second half of the twentieth century. Profound studies were initiated in the 1960s, a period when the development race, economic concerns, and the search for power overshadowed the significance of human health and natural balance for a long time (Tıraş, 2012; Korotenko, 2018; Lin and Niu, 2018). In this period, the worldwide production rate increased several times more compared to previous periods, and in this direction, the balance between nature and humankind's economic concerns began to deteriorate rapidly, and nature's self-renewal rate fell behind. With the realization of this situation, noteworthy studies that advocate environmental awareness and human health have started. For example, in 1962, in his work titled "Silent Spring", Rochel Carson drew attention to the damage done to human health and nature by explaining the harmful effects of pesticides used in agriculture. By the 1970s, environmental destruction had reached a global dimension, leading to an increase in sensitivities on this issue. One of the first important steps was the report called "Limits to Growth", which the Club of Rome asked some of the leading intellectuals of the time to prepare in 1972. In the prepared report, attention was drawn to the dependence between economic development and the natural environment (Shave, 2012).

2.2. Energy Management

The concept of energy management refers to all the measurements and activities that include managerial and technical processes, which are implemented in a planned manner in order to minimize energy consumption in any structure (Fiedler and Mircea, 2012). Energy management (Lee, Teng, Fan, Yang, and Horng, 2011), which concerns different disciplines such as engineering, finance, management, and architecture, contains two important concepts, Energy Saving and Energy Efficiency, which are often confused with each other. When it comes to energy saving, it means that energy-consuming tools and equipment are turned off when they are not actively used, or that energy is consumed less in a way that affects living conditions. Solutions such as preventing electrical resistance losses and reducing the ambient temperature in heating can be given as examples of savings. On

the other hand, Energy Efficiency is the same quality and level of output with lower energy input. Thermal insulation applications in buildings, the use of efficient machines in the industry, and the preference for energy-efficient light bulbs for lighting are some examples of ensuring energy efficiency (Topal and Özoğlu, 2018). The implementation process of Energy Management is a dynamic process that contributes to the production of new knowledge and ideas and is beneficial in almost every field due to economic, social, and environmental factors (Kannan and Boie, 2003). Figure 1 summarizes the process of energy management:

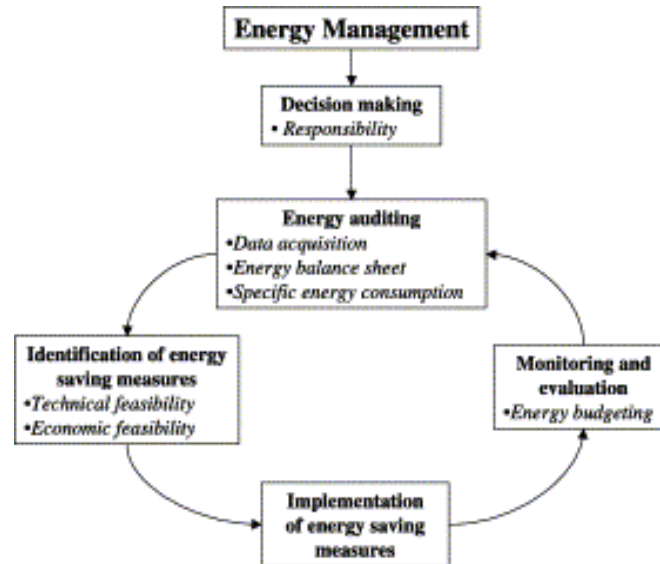


Figure 1. Energy Management Process (Kannan, R. & Boie W. (2003). Energy management practices in SME – case study of a bakery in Germany)

As it is clear in Figure 3.1, it is crucial that the decision-maker managers take responsibility in this regard and be determined to take the necessary steps as the first step in energy management practices. The lack of senior management in energy management, which should be continuous, can lead to inadequate or unsustainable practices. In this context, based on the willingness and determination of the top management of the organization in energy management practices, first of all, the existing energy map of the organization should be created. It is important to collect data on energy consumption, to reveal the area covered by the expense item, and to determine the most energy consumer units in the building. As a result of these determinations, ways to use energy more efficiently and economically without any reduction in work efficiency are investigated, and it is determined whether there is any waste. At this point, the feasibility of the planned solutions in terms of technical and economic suitability should be made. A decision should be made on whether to make a new investment, and it should be clarified in which areas and to what extent the improvements will be made. In the next stage, it is vital to determine energy-saving measurements in order to record the effect of energy-saving solutions to be implemented. After the implementation of the planned solutions, it is crucial to monitor the results to understand the realization of expectations. According to the results obtained, energy budgeting should be done for the next period, and then it should be returned to the examination of energy consumption items. In a sustainable and effective energy management strategy, this phased cycle should be carried out continuously, and the detected problems should be resolved as quickly as possible.

In a study conducted by Introna, Cesarotti, Benedetti, Biagiotti, and Rotunno (2014), it has been suggested that Energy Management was only applied in a few sectors where energy was used intensively before 1973, and it was an unheard concept by the majority. In addition, businesses developed more comprehensive approaches to combat increasing energy costs, entering a period in which awareness of greenhouse gas emissions increased significantly, as a result, the Kyoto Protocol was negotiated and, as a result, the measurement criteria and incentives of member countries on energy efficiency in the European Union. It has been stated that the popularity of Energy Management applications has increased rapidly, with the enactment of the 2006/32/CE regulation, which is required to clearly state the energy performance and targets, and also emphasizes the development and dissemination of goods and services that increase energy performance.

2.3. Eco-Innovation

3.3 Eco-Innovation

While innovation activities increase the welfare level of people with socio-economic benefits, they also contribute to sustainability by creating new resources. Eco-innovation, one of the typologies of innovation, is essential in terms of contribution to sustainability. According to Hemmelskamp (1997), eco-innovation is defined as innovation made to reduce the environmental impact of production methods (Hemmelskamp, 1997). While eco-innovations are classified in managerial, process, product, or marketing areas (OECD, 2009), they are also classified as pollution control and clean technologies (Rennings, 2000). However, the determinants and motivation sources of eco-innovation may be different compared to other innovation types. OECD (1997) emphasized the socio-economic benefit of innovation (TUBITAK, 1997).

Eco-innovation studies emerge as a developing field by benefiting from many different disciplines. These fields are evolutionary economics, theories of technological change, industrial economics, systems analysis, sociology, political science, business management, etc. It is a concept that can encompass many areas such as (Carrillo, Gonzalez & Könnöla, 2010). From a managerial point of view, the first definition of eco-innovation was given in the study of Fussler and James (1996). He stated that eco-innovation creates important contributions both for the consumer and for the business; that these contributions can be presented to all stakeholders through products, services, and processes by minimizing the effects on the environment (Bartlett & Trifilova, 2010). The concept of eco-innovation also appears in the literature as green innovation and eco-innovation (Schiederig, Tietze & Herstatt, 2012). The advanced version of the concept of eco-innovation, including the protection of future generations and the protection of our planet, also appears as sustainable innovation (Ruzzier, 2016). Therefore, it is possible to come across these concepts as concepts used interchangeably in the literature.

According to Rennings (2000), eco-innovations have three different features compared to other innovations. First, eco-innovations can take place in the technological, managerial, social, or institutional realm. Eco-innovations can be realized by both businesses and non-profit organizations and do not have to be sold on the market. Although eco-innovation is a multidisciplinary field, it encompasses both environmental economics and innovation economics. While environmental economics evaluates environmental policies, innovation economics tries to explain the factors affecting innovation decisions. While eco-innovations produce positive externalities, they create negative external costs from an environmental economics perspective. The third feature of eco-innovation, "double externality", can be solved by harmonizing both disciplines.

While Andersen (2002) stated that eco-innovation activities opened a new chapter in the markets and had high potential, OECD (2009) mentioned two important and privileged features of eco-innovation. Firstly, the impact of eco-innovation on the environment was evaluated. The second feature emphasized that eco-innovations will cause changes in socio-cultural norms and businesses (OECD, 2009). According to Helström, evaluating eco-innovation only with its reducing effect on environmental effects is a view that narrows the importance of this concept. Eco-innovations also have aspects that affect the quality of human life (Hellström, 2007). Therefore, the definitions related to eco-innovation, doesn't provide a full scope with solid lines, but it is clear that six different dimensions of eco-innovation emerge. The dimensions are listed as follows (OECD, 2009):

1. The innovation object is product, process, service, and method,
2. Market orientation to meet the needs and to be more competitive in the market,
3. Reducing negative environmental impacts (optimal = zero impact),
4. Paying attention to the entire life cycle of products (reducing raw material consumption),
5. Willingness to reduce cost and environmental impacts,
6. Establishment of a unique environmental standard.

The eco-innovation typology created by OECD based on eco-innovation definitions can be analyzed as the target, the mechanism, and the effect of innovation. Accordingly, it is possible to describe the target of eco-innovation as products, processes, marketing methods, businesses, and institutions. However, while processes and products need technological development, eco-innovations in areas such as managerial and marketing come with change and are not dependent on

technological development. The eco-innovation mechanism is again about whether it requires technological progress or not. These are minor or incremental modifications, redesign, development of alternatives, or the creation of new processes and products. Finally, the innovation effect is the last link of the typology. Accordingly, the impact of eco-innovations on the life cycle or other environmental areas and the target of eco-innovation have been determined as the effect created by the interaction arising from its mechanism in the socio-technical field (OECD, 2009). Eco-innovations are of strategic importance for sustainable production. Figure 2 summarizes the typology of eco-innovation.

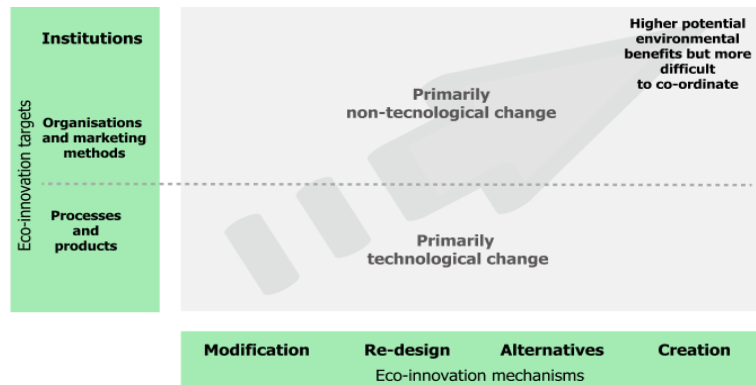


Figure 2. Summary of the typology of eco-innovation.

3. RESULTS and DISCUSSION

Environmental pollution and damage caused by the intense use of fossil fuels underline the need for businesses to redesign their raw material, supply chain, and production strategies. Industrial enterprises should increase their R&D investments in order to make their operations environmentally friendly with energy management and Eco-Innovation practices. The establishment of green supply chains at both national and global levels has become a necessity today in order to ensure sustainability on a global scale. Businesses need to establish sustainable supply chains by establishing an ecosystem cycle from producer to consumer and from consumer to producer through green operations. If it is; The cooperation of country administrations at the global level necessitates more planned and regular progress with state subsidies and legal regulations, encouraging businesses, and taking faster and healthier measures. Although making R&D investments to develop applications for eco-innovation and energy management may seem costly at first to businesses, it is obvious that the return on investment will provide high benefits in both financial, social, and environmental dimensions in the future. For this reason, country governments have an important role in encouraging R&D investments in order to improve the Eco-Innovation and technology infrastructure of enterprises.

Studies show that energy management, which encompasses saving and efficiency applications, is an inherent part of Eco-Innovation. For instance, Kuo and Smith (2018) mentioned that companies in various sectors, from footwear to automotive, usually focus on energy management practices in their innovative improvements, as energy is one of their primary inputs. Furthermore, Janahi, Durugbo, and Al-Jayyousi (2021) assert that "energy intensity and efficiency" is one of the major research topics within eco-innovation literature. They also claim that energy pricing and costing strategy, green knowledge sharing and sourcing strategy, and energy structures and systems strategy are some of the essential components that firms can formulate applicable targets for eco-innovation strategies to improve their sustainability.

Eco-Innovation is of great importance for ensuring the sustainability of our world and improving its livability. For this reason, each study from micro to macro is valuable. In order to carry out these studies, civil society and governments should consider eco-innovative steps as an agenda item. Although the various global economic crises negatively affected Eco-Innovation studies, it is expected that research and development (R&D) budgets to increase in the following periods as the focus turns to responsible investment for the economy. It is noteworthy that the countries at the forefront of Eco-Innovation are also those that value R&D both intellectually and materially, and they are at the forefront of the human development index, have large economies, and have well-established legal infrastructure. It is vital to establish a system that will produce solutions by re-evaluating the processes that ensure the minimization of environmental damage by efficient use of resources (input) and the final product (output); within the framework of optimum resource use to ensure sustainable development.

4. CONCLUSIONS

One of the most essential and urgent issues in the world today is global warming and climate change. The leading factors that cause this are environmental pollution, greenhouse gas emissions, and wastes that occur at the stage from the production process to consumption caused by the industrial sector. Countries, businesses, and consumers are faced with the threat of not having a clean world where they can survive and leave a legacy to future generations as a result of further damage to natural resources and the deterioration of the balance. Developing environmentally friendly production methods requires the development of R&D activities that contribute to the recycling of natural resources, clean production and zero waste philosophy, technological progress towards the use of renewable energy resources, and innovation in processes and operations.

It is of great importance for the future of all countries that the concept of energy management, which has other benefits such as saving energy, preventing environmental pollution, and providing quality and comfort, is popularized and brought to life in practice. Ensuring the continuity of the studies and enacting the law on this subject as soon as possible will provide great convenience. Subsequently, energy management covers efficiency and saving measures, and it is one of the main components of eco-innovation. The implementation of eco-innovation is impossible without taking energy management into account.

The examination of the linkage between energy management and eco-innovation concepts is becoming one of the promising areas. Future research could focus on the attitudes and decision-making processes of firms regarding eco-innovation, and how to influence them to invest in eco-innovative initiatives, as it is clear that the primary tendency of businesses is increasing profitability; but not protecting nature.

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