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Green Innovation as a Driver of Sustainability in the Automotive Industry

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ABSTRACT

To contribute to sustainable development, companies must adopt sustainable business practices. Green innovations make a significant contribution to sustainable business, encompassing all forms of innovation that minimize environmental damage and ensure the most efficient use of natural resources. This paper presents the definition and various types of green innovation, as well as its importance. Crucial factors for the implementation of green innovation are also included. Moreover, this paper outlines the challenges and barriers to implementing green innovation. Finally, it provides examples of companies in the automotive industry that have adopted green innovation.

1. Introduction

Nowadays, we are facing environmental crisis, including climate changes, pollutions, biodiversity loss or overexploitation of resources. These problems result in threat to human health, ecosystem degradation and food and water insecurities. Such challenges demand urgent attention and actions, in order to effectively address the ongoing environmental threats.

Many companies choose green innovation, as a key mechanism to enhance environmental sustainability, along with gaining competitive advantage. They are significant considering nowadays companies' aims to reduce environmental impacts [1]. Although green innovation may seem as a great solution, there are several challenges for implementing greener technologies. Lack of financial resources has been shown as crucial limiting factor. Furthermore, absence of government support can be one of the significant obstacles. However, understanding challenges in implementing green innovation is essential for creating effective future policies.

Green innovation represents *condition sine qua non* for companies in manufacturing and energy intensive sector. This necessity comes from rising expectations from multiple stakeholders to use environmentally sustainable practices. Customers, public and regulators are demanding that companies implement sustainable business models. This highly affects automotive industry. As it can

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be seen, automotive manufacturers have been implementing green innovation, as a part of their long-term strategies.

2. Concept of Innovation

Innovation is a term often used in both everyday communication and scientific literature. It can be described as “entrepreneur’s instrument to utilize changes in the environment” [2], “the process of creating something new” [3], or as “idea transformed into practical reality” [4]. Earlier, innovation was seen as just technical solution. Nowadays, it represents new or improved product or a process – logistics, delivery, production, maintenance, or support processes as well as for marketing, organizational methods, or information processing [5]. Definitions of innovation vary, as different authors emphasizes different characteristic of innovation. Some of them see innovation as just an entrepreneurial act, other as the process of creation. However, it is widely acknowledged that innovation is essential not only for enterprises, but also for economies. No matter how defined, innovation is very important because it stimulates economic growth, new jobs, improves life quality and national competitiveness [6].

Beside their importance for business entities and national economies, innovations are the best instrument for solving contemporary social challenges, such as climate changes, lack of resources and energy, health protection and aging society [7]. It can be concluded that approach to innovation has been radically changed during time, especially in knowledge-based economy. This resulted in new paradigms such as open innovation and social innovation.

Open innovation has been defined in 2014 by Chesbrough and Bogers as “a distributed innovation process based on purposively managed knowledge flows across organizational boundaries” [8]. This concept highlights open boundaries of the enterprise and possibility of collecting ideas not only internally, but also from external sources. In that way, a company can maximize its innovation potential. Open innovation drastically changed innovation process [9]. It has great impact on performances of business entities, because they significantly increase competitive advantage of enterprises; output of open innovation process is more adjusted to the customers and has better quality [10].

On the other hand, social innovations are described as innovative activities and services motivated with satisfaction of social needs [11]. It can also be defined as development and implementation of new ideas for satisfaction of social needs and creation of new social relations [12]. Some authors highlight how green innovation fits into the broader framework of social innovation - green social innovation tends to combine sustainability issues with social issues, and more often than other fields find an economically viable solution [13]. Other supports the view that green innovation is a key component of social innovation by addressing environmental and social issues simultaneously [14].

3. Green Innovation

Green innovations have become necessity, considering alarming environmental conditions. In light of challenges like climate change, resource scarcity, and environmental pollution, they play a crucial role in reducing harmful effects and promoting sustainable ecosystems. Some authors see it as innovation that focus on preventing pollution, reducing waste, and implementing environmental management systems in organizations [15]. Implementing green innovation is significant considering nowadays companies’ aims to reduce environmental impacts. It is also defined as a crucial component of sustaining the protection of the environment [16]. Others emphasize importance of technology, and define it as the development and implementation of new processes, systems, or technologies that are designed to promote environmental sustainability and reduce the environmental impact of industrial processes [17]. Certain authors point out that green innovation has an impact on organizational performances – implementation can improve position at the market, attract customers and gain competitive advantage [18]. Authors Frare and Beuven point out a broader perspective of green innovation. They highlight importance of green innovation, as a critical aspect of sustainable development, which supports economic growth while minimizing environmental consequences [19]. Authors Chen, Lai *et al*. [20] define green innovation as "hardware or software innovation that is related to green products or processes, including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs, or corporate environmental management". Despite differences in defining this concept, it can be concluded that green innovation has great potential to reduce the environmental harm and also optimizes the usage of available resources [21].

In nowadays literature, there are several concepts of innovation with subtle variations. Eco-innovation is any form of innovation aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment or achieving a more efficient and responsible use of natural resources, including energy [22]. On the other hand, environmental innovation a specific form of innovation aiming at reducing the impact of products and production processes on the natural environment [23]. Sustainable innovation means innovation that balances the long-term influences of the process and the output with the needs of people, societies, the economy and the environment [24]. However, many authors use these terms interchangeably with green innovation.

4. Types of Green Innovation

Green innovation can be classified into several typologies, each offering a unique perspective on its various forms and applications. Understanding these taxonomies help enterprise in implementing green innovation. Furthermore, it facilitates act of creating green strategies and policies.

First taxonomy use differentiation to product and process. Green product innovation means implementing innovative ideas that enable the design, production, and marketing of new green products that perform significantly better than traditional or competing products [25]. Green process innovation refers to any change or regulation that contributes to reducing the environmental damage that may occur at any production stage, such as material purchase, manufacturing, or delivery in the production process [26]. Green process practices consist of lean manufacturing, agile manufacturing, and quality-control procedures that prevent or at least reduce faulty parts -these components reduce negative environmental impacts, resulting in more efficient raw materials and a lesser waste and byproduct generation [27].

Pisano [28] gave framework which provides understanding of how companies can strategically approach green innovation, balancing technological change with business model adaptation. Pisano identifies four categories of innovation, each corresponding to a different approach in integrating technology and business models:

i. *Routine green innovation* – This type of innovation leverages a company's existing technical capabilities and aligns with its current business model. It is an incremental innovation that enhances existing products or processes, catering to the established market base without disrupting the status quo.
ii. *Disruptive green innovation* – Unlike routine innovation, disruptive green innovation necessitates a new business model but does not necessarily involve a technological breakthrough. It has the potential to challenge and disrupt the business models of competitors, posing significant challenges to companies within the same industry.

iii. *Radical innovation* – The focus here is purely on technological advancement. Radical innovations introduce new technical competencies while maintaining the existing business model. These innovations often lead to significant performance improvements or entirely new product categories.

iv. *Architectural green innovation* – This type is the most transformative, combining both technological breakthroughs and business model disruptions. Architectural green innovations require companies to rethink both their technical capabilities and market strategies, leading to a comprehensive overhaul of their existing practices.

The map is built on the assumption that companies must choose how much of effort to focus and invest in technological and business model innovation [28].

5. Crucial Innovation Factors

Green innovations are vital for fostering a sustainable future, as they ensure a harmonious balance between environmental health, economic growth, and social well-being. Identifying the key factors for their successful implementation is crucial, as it not only aids current innovators in developing effective and impactful solutions but also guides future innovators in advancing sustainability efforts. By understanding these factors, we can accelerate the adoption of green innovations, driving systemic change and creating a resilient, eco-friendly economy for generations to come.

Zhang *et al*. [29] conducted research, based on the technology - organization - environment framework. In their study, it is examined how prepared enterprises are prepared for implementation of green innovation in terms of technology, organization and environment readiness.

Technology readiness encompasses the attributes of the technology that an enterprise aims to adopt as a key asset for green innovation. The effectiveness of implementing new technological resource is primarily determined by its compatibility with existing technologies. As the factors that push and pull green innovation forward, technology compatibility and relative advantage form the technology readiness for green innovation [29].

Organizational readiness refers to the essential characteristics an enterprise needs for the successful implementation of green innovation. This readiness encompasses two key components: innovation capability and environmental concern. Innovation capability reflects the organization's ability to develop and adopt new technologies or processes, while environmental concern demonstrates the commitment to sustainability and eco-friendly practices. Empirical studies confirmed the effects of absorptive capacity and sustainable capabilities on green innovation adoption [30].

Environmental readiness refers to the external pressures that drive an enterprise to implement green innovation. This readiness is shaped by both policy orientation and market orientation. Policy orientation involves regulatory frameworks and government incentives that encourage sustainable practices, while market orientation reflects the demand for eco-friendly products and services, influencing companies to adopt greener approaches.

Additionally, authors Medeiros *et al*. [31] selected several factors, based on previous research. Factors are classified into four groups:

i. *Market and legislation knowledge* – Most important variables of this group are customer expectation fulfillment and compliance with laws and regulations.

ii. *Cross-functional collaboration* – Integration inside the different departments in the company (R&D, marketing, and production) is essential. Also, integration with stakeholders (suppliers, universities, environment specialists, etc.) has great impact.
iii. *Innovation-oriented learning* – This includes elimination of cultural barriers, development of a set of green competences (leader proactivity, creativity, and experimentation) and development of critical reflective analysis capability.
iv. *R&D investments* – Core variables for innovating are investment in methods for sustainable product and investment in qualified personnel.

Authors emphasize that companies may organize their green innovation practices based on investments related to people, labs, equipment, and technological research [30]. Additionally, the leaders' vision and dynamism are essential to trigger important interrelations between the market and legislation knowledge, cross-functional collaboration, and innovation-oriented learning factors.

6. Challenges and Barriers

Today, green innovation has become an important tool for businesses to increase their market share and stay alive in the long run [18]. Moreover, despite its potential, the implementation of green innovation is obstructed by several challenges and barriers. Regardless of some differences in their findings, most authors agree on several key obstacles.

Financial barriers have been identified as the most frequent mentioned by several authors [32-34]. Empirical analyses confirm financial barriers as an obstacle for the innovative capacity of EU firms [32]. Companies are discouraged by high initial cost of investment in greener products. Government funding is necessity for advocating green innovation.

One of the biggest obstacles for implementing green innovations is lack of technical expertise and knowledge in companies, needed for creating greener products and processes. This problem mostly affects SME's. Addressing this issue requires better collaboration with academic institutions.

Government subsidies and public support are very crucial for sustainable development and green communities [34]. According to some authors, better and tougher environmental requirements from governmental agencies, may be an effective way of sparking green innovation initiatives [35]. Strict regulative in this area, followed by clear policies and strategies, motivates companies to conduct their business in more ecologic way.

Other authors also mentioned various barriers – market barriers, organizational or managerial. However, barriers mentioned above are crucial for implementing green innovation [36]. In order to promote green innovation, governments should design their future politics and legislative considering these challenges. Green innovation support can be accomplished by creating dedicated funds for financing green innovations, followed by financial incentives and changes in fiscal policies.

7. Implemented Green Innovation

While many industries contribute significantly to pollution, this paper will focus on examples from the automotive sector due to space limitations. The transportation industry, encompassing road, air, and marine transport, is a significant contributor to air pollution and CO2 emissions, playing a major role in driving climate change. According to EU Report, ground transportation produces 71 % of all greenhouse gas emissions from transport in the EU [37]. The greening of the automotive industry is part of an eco-mobility scenario, which requires a complex transition to sustainable transport solutions, habits and policies to become a reality [38]. All automobile manufacturers are exploring ways to reduce the CO2 emissions of their vehicles and increase fuel efficiency, motivated by higher oil prices, increasing concerns of energy security and stringent government regulations [39]. Thus, green innovation has become a strategic tool for achieving the sustainable development of industry, resulting in the improvement of the environmental situation [40]. The forcing power of regulatory interventions has been highlighted by Berggren and Magnusson [41], revealing to be decisive in helping car manufactures meeting higher environmental standards, by encouraging the expansion of their technological repertoire with a "long-term oriented, technology-neutral, innovation and competition driving policy, built around stepwise tightening of emissions and incentive levels".

According to International Council on Clean Transportation Report for 2023, Tesla is the leader of global manufacturers in the Zero Emission Vehicle. This company, originally Tesla Motors, was founded in 2003. Tesla's goal is to develop "zero-emission electric vehicles" which performs better than the fueled vehicles while pacing the adoption of sustainable transportation by creating attractive mass-market electric cars. Tesla's purpose is to accelerate the world's transition to sustainable energy and to eliminate fossil fuels. In their Annual report for 2021, Tesla estimates that its vehicles saved 6.8 million metric tons of CO_2 emissions compared to internal combustion engine (ICE) vehicles with an average fuel economy of around 24 mpg. Additionally, Tesla's solar and storage solutions contributed to a 1.6 million metric ton reduction in CO_2 emissions by generating zero-emission electricity.

The Centre of Automotive Management (CAM) has presented its new ranking of global automakers, based on around 1,000 innovations of the annual analysis period 2023/2024. In their latest innovation study, the BMW Group achieved the highest level of innovation among 30 automotive groups on the basis of 70 series innovations. Furthermore, BMW group is one of the biggest green innovators in automotive industry. In the words of their CEO, sustainability and economic success go hand in hand at the BMW Group. BMW group has the ambition to lead the way in the area of sustainability. Their primary goal is CO_2 reduction. BMW Group has restructured supply chain – from the supply chain, through production, to the use phase. According to their plan, CO_2 emissions across the entire lifecycle of BMW Group products will fall 40% by 2030 compared with 2019. The BMW Group aims to ensure compliance with environmental and social standards in particular already at the extraction and processing stages of the raw materials. Since 1994, the BMW Group has operated its own Recycling and Dismantling Centre (RDZ), where several thousand vehicles are processed annually. This initiative allows for the recovery and reintegration of materials into the production cycle as secondary raw materials. Additionally, components that continue to meet BMW's quality standards are reconditioned for reuse, supporting a more circular economy. One of the visions of BMW Group is completely recyclable vehicle, as a car of the future.

Hyundai Motor Company represents one of the significant green innovators in automotive industry, considering the fact that they've produced their first electric vehicle in 2010. They recognize the environment as a core element of their business. In 2022, this company declared the commitment to the global initiative RE100 (Renewable Energy 100 percent). Hyundai now aims to achieve 100% renewable energy transition by 2045, ahead of the RE100's target year, 2050. These actions are taken in all of company's business sites - in North and Central America, Europe, and India. Hyundai has established the Hyundai Motor Company Environmental Management Policy to conduct environmental management in a proactive manner. In order to accomplish environmental goals, company is transitioning business structure from internal combustion engine vehicles to an electrification- focused approach. Hyundai is continuously developing and producing not only hybrid and PHEVs but also EVs and FCEVs that have zero carbon emissions during operation. Company launched the dedicated eco-friendly model named IONIQ in 2016, the IONIQ brand was created based on the E-GMP platform. Besides that, Hyundai's global sales of electric vehicles in 2023 increased by 27.8% from the previous year. Hyundai is aiming for a long-term transition to EVs while also making efforts to minimize greenhouse gas emissions from ICEVs which take large portion of our total sales volume as of current.

As shown earlier, companies in the automotive sector have already implemented green innovation. They are also adjusting their strategies in to align with sustainable principles. Companies that implement green innovations stand to gain significant advantages, including the creation of new market opportunities and revenue streams. By responding to the growing demand for sustainable products and services, these companies expended their offer and attracted customers with can expand their offerings and attract customers that are environmentally responsible.

8. Conclusion

Green innovation can be described as implementation of new processes, systems, or technologies designed to promote environmental sustainability and to reduce the environmental impact of industrial processes. It represents significant tool for adjusting to challenging environment conditions. Besides that, it improves business performances of the companies - by creating better offer, loyal customers and competitive advantage. Also, green innovation has great impact to national economies. Implementing green innovation benefit the environment and so contribute to sustainability of ecosystem.

Nowadays, this innovation has great importance - it will play an even greater role in the future, considering climate changes and overall state of environment. Every responsible company should decrease its environmental impact and optimizes the usage of available resources, despite several challenges in implementation. Future strategies and initiatives must consider these issues in order to promote green innovation. Automotive industry, as one of the significant pollutants, has to implement green practices and green innovation resulting in the improvement of the environmental situation. This paper shows good examples of companies from non-green industry transitioning to green practice.

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Conflicts of Interest

The authors declare no conflicts of interest.

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