

GREEN INNOVATIONS AND THEIR APPLICATION IN MODERN BUSINESS

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ABSTRACT

Rapid industrial and technological development has significantly impacted the natural environment. As a result, environmental protection has become an imperative. In response to growing ecological awareness and regulatory pressure, companies are adopting innovative practices across their operations. Green innovations now play a key role in reducing the environmental footprint of business activities. Green innovation involves implementing eco-friendly products and processes, improving resource efficiency, and minimizing environmental harm. These innovations often require new or improved business methods, technologies, and materials aimed at maximizing positive impact. In practice, this includes new production equipment, sustainable raw materials, and cleaner manufacturing techniques. Renewable energy is gaining ground, driven by innovations that lower costs and increase efficiency. As renewables begin to replace fossil fuels, they offer lower carbon emissions and reduced pollution, which are essential for addressing the climate crisis. Green innovation is therefore crucial for managing renewable energy sources and achieving sustainable business models. Industries with high environmental impact are more likely to adopt green innovations. The automotive industry, one of the major polluters both during production and through its products, has introduced green technologies to reduce its footprint. Companies like General Motors and Tesla are leading examples of this transformation, demonstrating how green innovation supports long-term environmental and economic sustainability.

Keywords: *green innovations, sustainable business, environmental protection, renewable energy sources, General Motors, Tesla*

1. INTRODUCTION

Green innovations refer to the adoption of business practices aimed at developing environmentally friendly products and processes, improving resource efficiency, and reducing environmental impact. They involve the development and social implementation of new technologies, production processes, and sustainable business models, ultimately enabling companies to reduce overall greenhouse gas emissions, control environmental pollution, and chart a path toward sustainable growth. Today, dozens of innovative projects and tools help reduce carbon emissions. Companies that often contribute to CO₂ emissions due to reliance on fossil fuels in their energy consumption and production processes see green technologies as an effective way to mitigate these impacts. For instance, many companies in the transportation sector, particularly in the U.S. and the European Union, are investing in electric vehicles (EVs) as a greener alternative to traditional internal combustion en-

gine vehicles. The paradigm in many industrial sectors has shifted toward energy efficiency and the use of renewable energy. Renewable energy production generates far lower emissions compared to burning fossil fuels (Nurgaliuly & Smagulova, 2025). Transitioning from fossil fuels, which currently account for the majority of emissions, to renewable energy is crucial for tackling the climate crisis. Solar panels, a well-known example of green innovation, have been widely adopted by businesses across sectors to harness solar energy. Solar-powered companies are an innovative way to apply green technology in urban areas, showing positive environmental impacts while adding economic value. This paper aims to provide a detailed analysis of green innovations and their application in modern business. Green innovations are seen as drivers of economic progress in recent years, as growing environmental challenges have led to increased interest and major shifts in business practices aligned with ecological standards. They play a key role in mitigating the environmental impacts of business operations and serve as a strategic accelerator for achieving sustainable development. In line with green innovation as a modern business concept, companies must evaluate their internal capacities, increasingly strict standards and regulations, as well as organizational, technological, and environmental challenges when applying green technologies. Environmental performance improves through the adoption of environmental management practices, adherence to ecological policies, pollution reduction, and the implementation of environmental standards across industries. The goal of this paper is to highlight the importance of adequately analyzing green innovations and their application in modern business. Green innovations, in line with ecological standards, imply new or improved methods of organizing and utilizing company resources. Therefore, this research aims to demonstrate the importance of integrating green innovation methods into business practices, which is positively correlated with raising environmental awareness. The significance of the research lies in expanding scientific knowledge in the field of green innovations and their application in modern business. Its scientific justification is reflected in enhancing the understanding of the specific role of green innovation in improving business performance. By formalizing their application, the success of green innovations in business can be evaluated. Describing trends and effects of their implementation enriches the scientific body of knowledge. The social relevance of this research stems from the fact that the knowledge gained through the analysis of green innovations is essential for companies operating in today's business environment. The insights from this study can serve as a fundamental tool for making informed decisions by all stakeholders involved in modern business.

2. LITERATURE REVIEW AND RESEARCH QUESTION SPECIFICATION

The rapid industrial and technological development, particularly characteristic of the second half of the 20th century, has left—and continues to leave—a significant impact on the natural environment. Most modern civilizational activities imply global changes that are either currently occurring or will occur in the future. In the era of globalization, changes in people's lifestyles, accompanied by the emergence of new industries competing in product innovation, have increased production to meet consumer demands, leading to uncontrolled exploitation of natural resources, which negatively affects the environment. Emissions from industrial waste by-products harm both the environment and human health. The excessive use of fossil fuels also contributes to the greenhouse effect, resulting in global warming. As such, the protection of nature and its values is now seen as imperative. This concern has led to the establishment of legal and institutional frameworks for environmental protection in many countries. These frameworks regulate the sustainable use of natural resources and environmental conservation, depending on the level of development and overall societal progress.

Rising environmental awareness and global health concerns are causing businesses to shift from traditional models to more sustainable and eco-friendly approaches. This has led to the emergence of sustainable business practices, which reveal environmental issues to the public while raising awareness about the importance of green corporate behavior.

Sustainability refers to both the sustainability of development itself and the practices or policies that can lead to a better, more stable quality of life. To achieve long-term sustainability, it is necessary to pursue a green economy and seek solutions to resource limitations (Idris & Rahman Razak, 2025). While there are various definitions of sustainable development, there is broad consensus that it

meets the needs of the present without compromising the ability of future generations to meet their own (Streimikiene & Kacerauskas, 2020).

In the business context, sustainability extends beyond environmental protection. It refers to conducting business in a way that does not negatively impact the environment, community, or society as a whole. Business sustainability encompasses company strategies and actions aimed at reducing the environmental and social impacts of operations in a specific market. Environmental, social, and economic requirements are considered the three pillars of sustainable business. In the corporate world, this is often referred to as the “triple bottom line,” a framework for assessing a company’s environmental, social, and economic impact. These three categories are commonly represented by the acronym ESG—Environmental, Social, and Governance. ESG is another framework that helps companies document their sustainable practices, progress, and the associated risks and opportunities as part of their sustainability efforts. Companies can measure success in these areas using various ESG metrics and report the results publicly. ESG rating agencies use disclosures and other data to assign companies ESG scores, which investors and other stakeholders consider when evaluating organizations (Blowfield & Murray, 2014).

Business sustainability refers to a company’s strategy and actions aimed at reducing the negative environmental and societal impacts that result from its operations. Sustainable business covers a wide range of practices such as reducing emissions, lowering energy consumption, ensuring proper disposal of physical waste, and minimizing the company’s carbon footprint. Examples of sustainable business practices include improving energy management efficiency by using alternative energy sources and carbon accounting, introducing infrastructure that reduces greenhouse gas (GHG) emissions, conserves water resources, and eliminates waste, managing dynamic and efficient supply chains to support a circular economy, encouraging reuse, designing out waste, promoting sustainable consumption, and protecting natural resources. Sustainability also involves assessing risks and improving resilience while complying with external regulations and development goals (Antonioli et al., 2013).

Green innovations (GIs) are seen as a driver of economic progress in recent years, especially as growing environmental challenges have increased interest in and significantly influenced business transformations in favor of environmental priorities. Green innovations are a key strategic accelerator for achieving sustainable development, particularly through technological innovations in energy conservation, pollution prevention, and waste recycling. These approaches improve resource efficiency, reduce costs, and protect the environment. Green product innovations involve the use of materials that have a lower environmental impact, require less energy and fewer resources, and result in environmentally friendly products that can be easily recycled, reused, or biodegraded. Green process innovation enhances efficiency by reducing raw material usage and the generation of hazardous substances and waste, as well as minimizing electricity, water, and oil consumption. Green organizational innovation includes the creation of new and valuable ideas for green products, processes, services, and behaviors that can strengthen business models and shift managerial attitudes toward establishing a green organizational identity (Abbas & Sagsan, 2019). Green innovations, therefore, refer to the adoption of business practices aimed at developing environmentally friendly products and processes, improving resource efficiency, and reducing environmental impact.

They play a crucial role in mitigating the negative environmental effects associated with business activities. These issues range from carbon emissions to resource consumption, encouraging companies worldwide to focus on innovation as the key to improving environmental performance, reducing their carbon footprint, and boosting competitiveness in rapidly changing markets. There are several definitions of green innovation in the literature. Some suggest that innovation is the sum of “design + product.” Accordingly, GIs can be defined as the sum of “eco-design + eco-production,” as they involve developing ecological products or processes and applying innovations in technologies that include energy saving, pollution prevention, and green product design. Similarly, some authors define GIs as innovations that focus on achieving sustainable development and preserving natural resources by developing more environmentally friendly products and services (Song & Yu, 2018). Many also define green innovation as the development of sustainable products and processes through the use or adoption of eco-friendly raw materials during the production or design phase.

This process includes applying eco-design or eco-production principles—where the environment is considered from the moment a product or process idea is conceived, not just at the end of its life cycle. Accordingly, although GIs have mainly focused on manufacturing processes, some companies have extended this trend by redesigning not only production but also their entire processes, including distribution channels and after-sales services. Thus, GIs are innovations embedded throughout the business cycle—in design, production, supply, and end use of commercial products—which significantly contribute to environmental sustainability (Weng et al., 2019).

Green innovation is a form of innovation that focuses on reducing environmental impact and maximizing sustainability. This can include the development of new technologies, processes, products, services, or business models that have a positive impact on the environment. Green innovation is the use of creative solutions to reduce negative environmental impacts and maximize sustainability. This includes the development of new technologies, processes, products, services, or business models that are more environmentally friendly than those they replace. Green innovations can also improve resource efficiency by reducing waste or enhancing energy efficiency. By finding innovative ways to reduce environmental impact, natural resources can be used responsibly and remain available for future generations. Green innovation refers to the adoption of business practices aimed at developing environmentally friendly products and processes, increasing the efficiency of resource use, and reducing environmental impact. Green innovations involve the development and social implementation of new net-zero technologies, production processes, and sustainable business models, which ultimately enable enterprises to reduce overall greenhouse gas emissions, control environmental pollution, and set a path toward sustainable growth (Tang et al., 2018).

The terms “sustainable innovation” and “green innovation” are often used interchangeably, but the two are not entirely the same. Green innovations, although they deal with societal well-being as a whole, primarily focus on the environment, while sustainable innovations place more emphasis on ethical and social aspects. Some examples of green innovations include: geothermal energy – a method of collecting renewable energy through dry steam power; solar energy – a way of generating electricity using solar panels and UV rays; wind energy – a form of renewable energy production using wind turbines; hydropower – a method of generating renewable energy through water power and the use of hydroelectric plants; green infrastructure – not only is green infrastructure beneficial for economic growth, but it can help reduce environmental impact; smart farms – new technologies used within sustainable agriculture help reduce greenhouse gas emissions; sustainable packaging – efforts to find new ways to package products in materials that do not contribute to landfill waste are a great example of ecological innovation; smart grids – these electrical grids help maximize the use of electricity to preserve limited resources; carbon capture and storage systems – specifically designed to remove excess carbon dioxide emissions from the atmosphere, carbon capture and storage systems (also known as CCS) are perhaps a defining example of ecological innovation (Schiederig et al., 2020). Green innovation can be classified as green product innovation, green process innovation, or green organizational innovation. The first, green product innovation, includes environmental improvements such as recycling. The second, green process innovation, aims to minimize energy consumption and maximize efficiency in the use of resources. Finally, green organizational innovation reflects the development of new ideas, behaviors, processes, and innovative management systems that contribute to reducing environmental harm (Hottenrott et al., 2016). Companies can better utilize their resources while reducing costs, which can increase their recognition of the potential for green product innovation, all of which fosters ecological organizational innovations.

According to some studies, green organizational innovation reflects compliance with management norms and environmental regulations, so investing in green innovations can foster ecological organizational identity, environmental commitments, and legitimacy. At the same time, eco-innovative actions improve and support environmental actions by introducing new production processes, products, and services that reduce or prevent ecological risks such as pollution and any other negative impacts during resource use in the implementation of these actions (Gurlek & Tuna, 2018). In business, this translates into new equipment, new ideas integrated into the production line, and of course, new raw materials for maximum positive impact.

Green innovations play a crucial role in mitigating the negative environmental impacts associated with business activities. These environmental issues range from carbon emissions to resource consumption, prompting companies globally to focus on innovation as the key to improving their environmental performance, reducing carbon footprints, and strengthening competitiveness in rapidly changing markets. Green innovations involve the development and social application of new net-zero technologies, production processes, and sustainable business models, which ultimately enable companies to reduce overall greenhouse gas emissions, control environmental pollution, and chart a path toward sustainable growth.

In recent years, the global trend of introducing renewable energy sources has been increasing, aiming to achieve sustainability and protect the environment. The pathways toward a 100% renewable energy (RE) sector are also emerging. This is a significant challenge, as industry increasingly contributes to climate change and must reduce fossil fuel usage. On a global level, energy challenges vary depending on the stage of development. Developing countries often face greater energy limitations due to limited infrastructure, inadequate access to modern technologies, and similar factors. In contrast, developed countries are focused on optimizing energy use, reducing emissions, and integrating renewable energy solutions. To achieve reliable and environmentally acceptable renewable energy alternatives, the energy sector requires a comprehensive transformation by adopting renewable sources.

Today, with innovative and more affordable ways to capture and store wind and solar energy, renewables are becoming a more significant energy source. Renewable energy is on the rise, as innovations lower costs and begin to fulfill the promise of a clean energy future. This means renewables are increasingly displacing “dirty” fossil fuels in the energy sector, offering the advantage of lower carbon emissions and other types of pollution. Sustainable energy production requires low-carbon energy systems that do not cause negative social and environmental impacts.

Renewable energy has gained importance and plays a crucial role in the decarbonization of the energy sector, as it is produced using natural resources that are constantly replenished and cannot be depleted. Renewable energy sources include biomass, hydropower, tidal and wave energy, solar photovoltaic energy, wind, and geothermal energy. Renewable energy, often called clean energy, comes from natural sources or processes that are continually replenished. The definition of renewable energy is energy that is sustainable—something that cannot run out or is infinite, like sunlight (Twidell, 2021). The term “alternative energy” is also commonly used to refer to renewable energy sources, although other energy types may also be considered alternative. Renewable energy refers to energy that differs from the most commonly used unsustainable sources, such as coal.

Renewable energy is energy derived from natural sources that replenish themselves more quickly than they are consumed (Twidell, 2021). Sunlight and wind, for example, are such sources that are continuously renewed. Renewable energy sources are abundant and all around us. Fossil fuels like coal, oil, and gas, on the other hand, are non-renewable resources that take hundreds of millions of years to form. When burned for energy production, fossil fuels cause harmful greenhouse gas emissions, such as carbon dioxide. Renewable energy production generates far lower emissions compared to burning fossil fuels. The transition from fossil fuels, which currently account for the majority of emissions, to renewable energy is essential for addressing the climate crisis. Renewable energy sources are now cheaper in most countries and generate three times more jobs. Solar energy is the most abundant of all energy resources and can even be harnessed on cloudy days. The rate at which the Earth intercepts solar energy is approximately 10,000 times greater than the rate at which humanity consumes energy. Solar technologies can deliver heat, cooling, natural lighting, electricity, and fuels. These technologies convert sunlight into electricity either through photovoltaic (PV) panels or by using mirrors that concentrate solar radiation (Ehsanul & Pawan, 2018). The cost of producing solar panels has dropped over the last decade, making them not only affordable but often the cheapest form of electricity.

Wind energy harnesses the kinetic energy of moving air using large wind turbines located on land or offshore in seas or freshwater. Wind energy has been used for millennia, but onshore and offshore wind technologies have advanced significantly in recent years to maximize electricity production using taller turbines and larger rotor diameters (Twidell, 2021).

Hydropower uses the energy of water moving from higher to lower altitudes. It can be generated from reservoirs and rivers. Reservoir-based hydroelectric plants rely on stored water, while run-of-the-river hydro plants generate energy from the natural flow of the river (Twidell, 2021). This energy source is often more reliable than solar or wind power and also allows energy storage for use during peak demand. However, the infrastructure needed for hydropower can negatively impact ecosystems. For this reason, many consider small-scale hydro plants a more environmentally friendly option, particularly suitable for remote communities.

Ocean energy comes from technologies that use the kinetic and thermal energy of seawater—such as waves or currents—to generate electricity or thermal energy. Ocean energy systems are still in the early development stage, with numerous prototypes of wave and tidal energy devices under investigation. The theoretical potential of ocean energy far exceeds current human energy needs.

Bioenergy is generated from various organic materials, known as biomass, such as wood, charcoal, manure, and other animal waste to produce heat and electricity, as well as agricultural crops for liquid biofuels. This involves converting solid fuel made from plant materials into electricity. Although it typically involves burning organic materials to produce power, today it is a much cleaner and more energy-efficient process. By converting agricultural, industrial, and household waste into solid, liquid, and gaseous fuels, biomass generates energy at significantly lower economic and environmental costs. While burning biomass does emit greenhouse gases, these emissions are lower than those from burning fossil fuels like coal, oil, or gas.

Fossil fuels are not a renewable energy source because they are finite. Additionally, they release carbon dioxide into the atmosphere, contributing to climate change and global warming. Burning wood instead of coal is somewhat better but remains complex. On one hand, wood is a renewable resource—if sourced from sustainably managed forests. On the other hand, burning wood releases particles into the atmosphere.

As the world's population grows, so does the demand for energy to power homes, businesses, and communities. Innovation and expansion of renewable energy sources are essential to maintaining a sustainable energy level and protecting the planet from climate change. Renewable energy sources today account for 26% of global electricity, but according to the International Energy Agency (IEA), their share is expected to reach 30% by 2024 (Braun & Glidden, 2014).

Companies, which often contribute to CO₂ emissions due to their reliance on fossil fuels in energy consumption and production processes, see green technologies as an effective way to mitigate these impacts. For example, numerous companies in the transportation sector—particularly in the U.S. and the European Union—are investing in electric vehicles (EVs) as a greener alternative to traditional internal combustion engine vehicles. The paradigm has shifted in many industrial sectors toward energy efficiency and the use of new energy sources from renewables, such as solar and wind. Energy storage technologies, for instance, optimize the use of solar energy, reducing dependence on fossil fuels for energy production. Solar panels, a well-known example of green innovation, have been widely adopted by businesses across various sectors to harness solar power. Solar-powered companies represent innovative applications of green technology in urban areas, demonstrating a positive environmental impact while also adding economic value.

Renewable resources, therefore, can be used indefinitely only if they are exploited responsibly and managed appropriately. Establishing proactive environmental policies within companies and adopting adequate models for managing renewable energy sources and sustainable development undoubtedly lead to competitive advantages, better financial performance, and the minimization of risk and uncertainty in green investments.

Based on previous studies, the following research questions (RQ) are formulated:

1. Does the concept of sustainability, driven by environmental issues, encourage companies to implement green innovations in their business operations?
2. To what extent are renewable energy sources, as innovative approaches, increasingly displacing “dirty” fossil fuels by offering the advantage of lower carbon emissions and other types of pollution?
3. Do companies from industries with negative externalities, such as the automotive industry, consider green innovations an effective way to mitigate environmental impact?

3. METHODOLOGY

The empirical research is based on data on the application of green innovations in the automotive industry in the USA. Since our main goal is to examine the effect of green innovations in integrating new methods into the company's business practice, an in-depth analysis of case studies pointed to the application of green innovations as a model of renewable energy management in the example of General Motors, and green product innovations in the example of Tesla. The implementation of emission reduction technologies is taken as a variable. Car manufacturers have made significant progress in reducing emissions through the implementation of emission control systems. Catalytic converters, advancements in engine design, and improvements in fuel efficiency have played a key role in reducing air pollution and minimizing the environmental impact of vehicles. Recycling and sustainable materials are taken as a variable. Recycling plays a vital role in reducing the environmental impact of the automotive industry. Car manufacturers are increasingly using sustainable materials in vehicle production, such as recycled plastic and bio-based materials. However, there are challenges in recycling processes, including the complexity of vehicle disassembly and the development of innovative recycling technologies. Renewable energy sources are taken as a variable. The automotive manufacturing sector is increasingly turning to renewable energy sources such as wind, solar energy, biogas, and electricity to support its operations, as the industry moves toward sustainability and carbon neutrality. The transition to electric vehicles (EVs) is taken as a variable. The adoption of electric vehicles has gained momentum due to their environmental advantages, including zero exhaust emissions. Governments have provided incentives and support to encourage the production and adoption of electric vehicles. However, challenges related to EV charging infrastructure and battery disposal must be addressed in order to enable widespread adoption.

4. RESULTS

The automotive industry plays a significant role in global emissions and environmental impact and is an industry with negative environmental externalities. Automakers are often considered among the largest polluters, both in the production process and with their final products. Sustainability is currently one of the main issues, especially in the automotive industry, with topics such as electric vehicles, lightweight construction, and CO₂ emission reduction becoming key concerns. The rapid development of innovation is particularly evident in the automotive industry. The industry as a whole has developed a number of green technologies to ensure sustainability and reduce the negative effects of the industry on the planet. The introduction of electric vehicles, the development of hydrogen technology, and the recycling of materials used in vehicle production are just some of the measures being taken to protect the environment.

General Motors is a global company headquartered in the USA, focused on advancing an all-electric future that is inclusive and accessible to all. One of the key ways the company is working to reduce CO₂ emissions is through alternative energy sources that do not produce greenhouse gas emissions. The company supports the growth of renewable energy generation through direct investments, on-site electricity production, green tariffs, and power purchase agreements. Through changes in all areas from production to finalization, the company is working to achieve carbon neutrality in global products and operations by 2040. In 2022, the company reported its Scope 1 and 2 emissions at 3.5 million mtCO₂e and Scope 3 emissions at 208.6 million mtCO₂e. For 2035, it set a goal of 1.6 mtCO₂e and 155.2 mtCO₂e for Scope 1 and 2 and Scope 3 emissions. As part of its strategy to reduce Scope 1 and 2 greenhouse gas emissions, the company is working to reduce energy consumption by improving the energy efficiency of its facilities through a global energy management system (EMS) ([General Motors, 2024](#)).

General Motors' commitment to using electricity from renewable sources began more than two decades ago. Initially, General Motors decided to seek help outside the company and chose Altenex, an Edison Energy Company, to support its efforts in finding renewable energy sources. Altenex helps energy users like General Motors navigate electricity markets and specializes in monitoring, analyzing, and negotiating renewable energy projects that meet tailored economic goals, risk management targets, and sustainability objectives. General Motors and Altenex worked together to develop the blueprint for an "ideal" renewable energy transaction. The result was a formalized process that delivered the best market opportunities for General Motors ([Jaderna & Prikrylova, 2018](#)). Today,

General Motors has made significant progress in building its energy portfolio based on an analytically rigorous methodology aligned with the company's long-term business plans. Renewable energy initiatives are being successfully integrated into the company's brand and operational planning and have received tactical support from senior leadership across the organization.

In 2022, the company announced that it had finalized energy sourcing agreements needed to supply 100% of the electricity required to power all its U.S. sites with renewable electricity by the end of 2025, with expectations to culminate by 2035 when the company plans to achieve 100% renewable electricity globally (General Motors, 2023). For this purpose, General Motors opened its first battery manufacturing plant, Ultium Cells LLC, in Warren, Ohio, with plans for additional facilities. Additionally, General Motors joined the First Movers Coalition through a commitment to low-carbon concrete, cement, aluminum, and steel.

As part of its innovation efforts, General Motors established General Motors Energy, a new business unit aimed at providing a holistic ecosystem of connected energy management solutions for residential, commercial, and EV customers. General Motors achieved its goal of diverting more than 90% of its total operational waste from landfills, incinerators, and waste-to-energy facilities three years ahead of its 2025 target (General Motors, 2023). General Motors is investing in energy-efficient systems and renewable energy strategies to reduce Scope 1 and 2 emissions and is implementing energy projects focused on both base and variable energy consumption to achieve lower intensity as vehicle volume stabilizes.

In 2023, the company held an industry-leading position in sustainable energy among all manufacturing companies, becoming the top renewable energy buyer through power purchase agreements. With these acquisitions, the company ranked as the highest-listed automaker on the EPA's Green Power Partners list. In 2023, the use of renewable energy in the U.S. rose to 59%. In 2023, the company's global renewable energy consumption reached 2.2 million MWh, an increase compared to 2022. Additionally, the company's share of global renewable energy use rose to 39% (General Motors, 2023).

With an annual global energy consumption of 9 terawatt-hours, or 9 billion kilowatt-hours, General Motors' energy portfolio is massive. General Motors operates 350 plants, warehouses, technical centers, and offices in 59 countries worldwide and seeks the right energy mix to power each site. For this purpose, General Motors has explored on-site and off-site renewable energy opportunities and is focused on sourcing the "right blend" of renewables to power its operations. Two of its landfill gas projects were awarded Green Power Leadership Awards by the U.S. Environmental Protection Agency. Twenty-four solar projects located at General Motors facilities around the world generate 48 megawatts (MW) of energy. Furthermore, General Motors has signed power purchase agreements (PPAs) totaling 30 MW of wind energy in Mexico and completed power procurement contracts of 30 MW (2015) and 50 MW (2016) in Texas (Environmental Protection Agency U.S., 2022). General Motors' use of renewable energy has saved the company \$80 million over the past two decades. General Motors currently operates 17 renewable energy plants across 11 states, making it the largest renewable energy buyer in the automotive sector by capacity.

General Motors' strategy and changes for renewable energy, based on four pillars, focus on ensuring that the total amount of electricity will ultimately come from 100 percent renewable energy sources (General Motors, 2024):

- **Energy efficiency** - through investments in new technologies and daily efforts to save electricity in facilities. General Motors spends about 20 million dollars annually on energy efficiency and energy demand projects.
- **Procurement of renewable sources** - through various methods such as on-site projects, power purchase agreements (PPAs), and green tariffs. General Motors' locations in Michigan are powered by renewable energy from new projects in the state, which led to the creation of around 1,200 jobs in Michigan. In 2020, General Motors implemented the largest solar project of 300 megawatts in Michigan through a green tariff agreement, so that all General Motors sites in southeastern Michigan are served by DTE with renewable energy, including the headquarters in Detroit and the Warren Technical Center, as part of DTE's MIGreenPower program, which provides 500 megawatts of solar energy.

- **Energy storage** is a reliable way to help solve the challenge of intermittency. General Motors operates the largest and most advanced battery testing laboratory in the United States and uses the global capabilities and resources of this technology in various potential applications, including the reuse of EV batteries after their initial use in vehicles.
- **Policy and the company's scope of influence**, with efforts such as the Renewable Energy Buyers Alliance (REBA), help implement organizational changes. Green tariffs and collaboration with electric utilities to enable companies and consumers to access more renewable electricity through fixed-rate pricing are part of the company's renewable energy plan. Vehicle-grid integration and services related to electrification offer complementary strategies for reimagining local distribution networks.

The solar agreement in Arkansas is the company's first project to procure panels from First Solar in Ohio, a U.S. solar panel manufacturer. With the help of First Solar, their circularity, and sustainable panel technology, General Motors is helping define the future of solar energy in the United States. By the end of 2022, the largest facility in North America—Spring Hill Manufacturing—was powered 100 percent by solar energy, enabled by a green tariff agreement with the Tennessee Valley Authority, which supplies up to 100 megawatts of solar energy annually.

The latest report shows that General Motors signed a 15-year renewable energy power purchase agreement with NorthStar Clean Energy to support its operations at three assembly plants located in Michigan and Missouri. The agreement will enable General Motors to source renewable electricity from NorthStar's 180-megawatt solar project in Newport. The solar PPA will support General Motors' operations at Lansing Delta Township Assembly and Lansing Grand River Assembly plants in Michigan, as well as the Wentzville Assembly plant in Missouri (Mirza, 2024).

The automotive industry as a whole has developed a range of green technologies to ensure sustainability and reduce the negative effects of the industry on the planet. Some companies have done this better than others. Innovative green technology is most often associated with Tesla, as a company accelerating the transition to sustainable energy. Tesla is considered the leading electric vehicle manufacturer on the market. It was the first company to recognize the need for a more sustainable vehicle than traditional gasoline-powered cars and offered its solution to the market. The company combined electric energy generation via solar panels and other products from SolarCity with its vehicles, giving it a competitive advantage no other competitor has. Tesla's cars are the result of continuous investment in research and development and a forward-thinking approach. Through its innovations, the company has made such an impact that it has influenced the direction of its competitors and the industry as a whole. As part of the green economy movement, Tesla was definitely one of the pioneers that influenced companies in other industries and inspired them to adopt a greener and more sustainable approach.

Tesla was founded in 2003 by a group of engineers who wanted to prove to the world that electric vehicles were not a fiction, by creating the world's first purely electric vehicle powered by lithium-ion batteries (Chang, 2014). Using innovative technologies and sustainable practices, Tesla not only revolutionized the automotive industry but also pioneered a new era of sustainable transport. Tesla offers electric vehicles and infinitely scalable clean energy generation and storage products. The company focuses on developing sustainable technology that can influence existing trends. Tesla emphasizes that electric cars are significantly more sustainable because they are not powered by fossil fuels.

Martin Eberhard and Marc Tarpenning, who had previously co-founded the successful company NuvoMedia, established Tesla Motors in July 2003, and Elon Musk joined as the main investor in early 2004. The founders of Tesla Motors realized that they could benefit from outsourcing the manufacturing and assembly of most standard components, thereby avoiding initial capital expenditures required for setting up their own production facilities (Abrams, 2006). At the beginning, a specialized manufacturer in the United Kingdom, who had a high-speed vehicle called the Lotus Elise, was ready to assist in designing and assembling the Tesla Roadster vehicle at their UK plant. In this way, the Tesla Roadster was based on the initial drivetrain technology licensed from AC Propulsion and built into a modified version of the Lotus Elise (Rechtin, 2007). The carbon fiber/epoxy composite body designed for the Tesla Roadster by Lotus Engineering and employees hired by Lotus

for Tesla Motors UK enabled low production volumes, a higher level of performance, and design flexibility (Rechtin, 2007). The company first focused on developing the Roadster, a premium EV sports car based on the Lotus Elise platform. The intention was to replace the internal combustion engine (ICE) drivetrain with an electric one, consisting of lithium-ion batteries. This type of battery can store twice as much energy per pound as the nickel-metal hydride batteries used in older electric cars and current hybrids. Tesla used standard 18,650 battery cells and combined them by the thousands in parallel to form a battery pack. After launching its first electric car, the Roadster, in 2008, Tesla officially introduced its state-of-the-art battery technology and electric drivetrain.

After launching the Roadster in 2008, Tesla acquired its own factory in Fremont, California, and later bought the GM-Toyota NUMMI plant in 2010. Initially, it renovated a small part of the NUMMI factory with innovative production equipment and high automation, launching the aluminum-bodied Model S sedan in 2012 (Chang, 2014). Model S was the first luxury EV sedan with high performance, accelerating faster than many sports cars. Model S also included many innovations from the IT sector, including a digital dashboard and a touchscreen that allowed users to control all vehicle functions. Built-in IT functionality enabled features such as summon, auto-parking, and autopilot. The combination of more electronic components, fewer moving parts, and online connectivity meant that Tesla's vehicles could be significantly upgraded via software, unlike conventional ICE vehicles (Chang, 2014). Tesla began building Superchargers in the United States and Europe, where Tesla owners could quickly charge their vehicle batteries for free.

The Model X SUV followed in the fall of 2015. The launch of each model gradually targeted larger market segments. Tesla Motors' market capitalization grew as a result of this strategy and continued to rise. By continually improving its technologies through incremental innovation, Tesla expanded into other market segments, commercializing the Model S in 2012 and the Model X in 2015.

Tesla's strategy evolved in several phases. Key elements of Tesla's strategy include: proprietary integrated electric drivetrain; vertical integration from development to production and retail; significant incorporation of IT capabilities in the vehicle; uncompromising focus on battery electric vehicles; building a Supercharger network and offering free charging to customers (Thomas & Maine, 2019). Tesla's electric cars are designed to minimize their carbon footprint. In fact, since 2008, Tesla vehicles have saved over 3.5 million tons of CO₂ emissions. The company's factories also prioritize sustainability. For example, the Gigafactory in Nevada is powered 100% by renewable energy, and the Gigafactory in Shanghai uses solar arrays and other green solutions (Thomas & Maine, 2019). Tesla also holds the highest level of innovation in the automotive world. The company has more control than any of its competitors over the production processes and quality—not only of its own products but also those of its suppliers—because it is vertically integrated with SolarCity. This integration provides the company with additional flexibility and space for innovation. The company's research is also focused on improving safety, which has paid off, as Tesla vehicles are considered the safest cars in the world. This is supported by the U.S. government's New Car Assessment Program, where tests for the Model S, Model X, and Model 3 achieved the lowest overall probability of injury of any vehicle ever tested. Tesla's performance is exceptional on all levels, making the company a powerful symbol of innovation and a "car of the future." The innovative nature of the company gives it a high profile in the electric vehicle industry and makes it the number one.

In addition to manufacturing environmentally friendly vehicles, Tesla is also focused on energy generation and storage solutions. Tesla's pursuit of sustainability goals has also driven its efforts in digital transformation. The company's commitment to reducing greenhouse gas emissions and promoting the adoption of renewable energy sources has sparked innovation in energy storage and solar technologies. Tesla has expanded its digital ecosystem through the development and integration of sustainable energy solutions, offering users integrated platforms for energy management and storage. Tesla's causal connection between digital transformation and sustainability has resulted in significant positive outcomes and global impact. The company's solar products, such as the Solar Roof and solar panels, aim to reduce reliance on fossil fuels for electricity generation. Tesla's energy storage solutions—Powerwall, Powerpack, and Megapack—enable the storage of renewable energy, further promoting the adoption of sustainable energy sources (Lu, 2024).

Tesla is a leading example of how businesses can reduce their environmental impact and contribute to a cleaner and healthier planet. By investing in sustainable practices, Tesla is helping to shape the future of transportation and energy. Tesla produces zero-emission transportation and energy products. Tesla vehicles are popular due to having the highest energy efficiency of all modern electric vehicles. Its digital mindset and focus on sustainability have attracted a loyal customer base and created a strong brand identity associated with technological advancement and environmental stewardship. Tesla's electrification revolution is a testament to the transformative power of integrating digital transformation and sustainability. By using advanced technologies and a commitment to sustainable practices, Tesla has not only disrupted the automotive industry but also launched a movement toward a more sustainable future. The causal relationship between digital transformation and sustainability has led to outstanding results for Tesla, including market leadership, emission reductions, and global influence in shifting the automotive industry—one of the industries with negative externalities—toward innovative and sustainable practices.

5. DISCUSSION

This section discusses the findings obtained in the context of the main objective and research questions. Green innovations play a key role in mitigating the negative environmental impacts associated with business operations. These environmental issues range from carbon emissions to resource consumption, encouraging companies globally to focus on innovation as the key to improving their environmental performance, reducing carbon footprint, and enhancing competitiveness in rapidly changing markets. Green innovations involve the development and social application of new net-zero technologies, production processes, and sustainable business models, which ultimately allow companies to reduce overall greenhouse gas emissions, control environmental pollution, and pave the way toward sustainable growth.

Changes, or rather green innovations, in line with environmental requirements primarily represent innovations that require new or improved ways of conducting business and using resources. Green innovations in business practice imply the implementation of innovative processes both within the company and externally, which includes the application of innovative strategies and the development of practices for managing the entire supply chain. Green innovations generate technological changes, which may include process redesign to improve environmental performance. The introduction of new practices also refers to embedding creative ideas into modern business to improve procedures, practices, or products. Integrating new methods into the company's business practice contributes to the application of green innovations by following innovative strategies for organizing the entire business process. Therefore, the introduction of so-called green practices is positively associated with raising environmental awareness and green innovation.

Green product innovations refer to the use of materials that have a lower environmental impact, require less energy and fewer resources, and to the provision of environmentally friendly products that are easily recyclable, reusable, or biodegradable. Green process innovation delivers efficiency by reducing the use of raw materials and the generation of hazardous substances and waste, as well as by minimizing the consumption of electricity, water, and oil. Green organizational innovation includes the creation of new and valuable ideas for green products, processes, services, and behaviors that can strengthen business models and shift management attitudes toward establishing a green organizational identity. In business, this translates into new equipment, new ideas that go into the production line, and, of course, new raw materials for maximum positive impact (Kozina et al., 2019).

As a result of increasing environmental regulations, stakeholder pressures, and competition, companies must be prepared to cope with expected changes by investing in green projects. Additionally, competitive pressures stimulate enterprises to increase their market share and competitive advantages, as well as to maintain their environmental image through efficient production processes and economical use of materials and energy. Innovative change is more likely in industries with significant environmental impact and strong stakeholder pressure.

In line with this trend, companies operating in so-called “dirty industries” are those in sectors recognized as having the highest pollution intensity, or negative externalities. In this way, they have great-

er opportunities to benefit from environmental regulations by improving resource usage and process control. Since they are subject to higher levels of environmental regulation, they may find that unit compliance costs are actually lower compared to less polluting industries. This aligns with Porter's hypothesis, which suggests that companies producing higher levels of pollution have greater opportunities to eliminate inefficiencies (World Economic Forum, 2022). Therefore, companies with negative externalities are more inclined to organize their activities through the adoption of green practices in order to improve their corporate image in the marketplace by aligning with environmental protection regulations, while also responding to stakeholder pressure. To survive in the market, companies with negative externalities are required to innovate by becoming cleaner, whereas companies in clean industries already meet the norms. Thus, companies with negative externalities are more likely to adopt green innovations due to their need to be more innovative in general and as a reflection of potential pressure from and imposition of environmental regulations and consumer demands.

Industrial greening, especially in industries with negative environmental externalities, includes the application of sustainable production practices that minimize negative environmental impacts. Car manufacturers are often considered among the largest polluters, both in the production process and with their final products. The automotive industry plays a significant role in global emissions and environmental impact and is an industry with negative environmental externalities (Wells & Nieuwenhuis, 2019). Therefore, the automotive industry has developed a range of green technologies to ensure sustainability and reduce the industry's negative effects on the planet. The automotive industry is adopting green technology at an unprecedented rate, driven by the urgent need for sustainable transportation solutions. As one of the largest polluters, but also a pioneer in introducing green practices and transformations, the automotive industry is currently showing good results in implementing green innovations as a modern business concept, as demonstrated by companies such as General Motors and Tesla.

General Motors continuously evaluates and takes steps to reduce the environmental impact of its products and operations. For example, General Motors focuses on energy management, reducing carbon and waste intensity, conserving resources, and developing more efficient vehicles through technological advancement, global scale, and employee innovation. These areas of change help the company reduce its environmental footprint. General Motors supports the growth of renewable energy production through direct investments, on-site electricity generation, green tariffs, and power purchase agreements. General Motors' 100% commitment to renewable energy, along with its pursuit of electrified vehicles and efficient manufacturing, is part of the company's approach to addressing climate change. General Motors has developed an implementation strategy that includes various energy generation technologies and financing approaches to achieve success. In developing its long-term plan for 100% renewable energy, General Motors focused on four pillars: energy efficiency, procurement, energy storage, and supportive policy development. General Motors currently operates 17 renewable energy power plants in 11 states, making it the largest buyer of renewable energy in the automotive sector by capacity.

Innovative green technology is most often associated with Tesla, which has accelerated the shift to sustainable energy. Tesla is considered the leading electric vehicle manufacturer on the market. It was the first company to recognize the need for a more sustainable vehicle than traditional gasoline-powered cars and offered its solution to the market. The company's core mission has been to accelerate the world's transition to sustainable energy through the production of electric vehicles (EVs) and renewable energy solutions. Tesla's electric vehicles are significantly more sustainable, as they are not powered by fossil fuels. Tesla's innovative approach to electric vehicles and sustainable energy solutions has positioned the company as a market leader in the rapidly growing EV industry. By using innovative technologies and sustainable practices, Tesla has not only revolutionized the automotive industry but also pioneered a new era of sustainable transportation. Tesla's success can be attributed not only to its cutting-edge technology but also to a change in design principles. Tesla has redefined the perception of electric vehicles, moved the industry forward, and paved the way for a greener and more sustainable future. Green product innovations have led to exceptional outcomes for Tesla, including

market leadership, emission reductions, and a global influence in shifting the automotive industry—as one of the industries with negative externalities—toward innovative, sustainable practices.

The use of renewable energy sources is increasing worldwide to achieve energy production sustainability. Managing renewable or sustainable energy is the process by which an organization focuses its energy use on alternative, renewable sources. Renewable energy production generates far lower emissions compared to burning fossil fuels. The transition from fossil fuels, which currently account for the majority of emissions, to renewable energy is essential for addressing the climate crisis. Innovation and the expansion of renewable energy sources are crucial for maintaining a sustainable energy level and protecting the planet from climate change.

Following climate change and the climate crisis, the role of the private sector in reducing carbon emissions has never been more significant. Businesses, which often contribute to carbon dioxide emissions due to their reliance on fossil fuels in their energy consumption and production processes, consider green technologies an effective way to mitigate these impacts. The paradigm in many industrial sectors has shifted toward energy efficiency and the use of new energy sources from renewables, such as solar and wind power. Energy storage technologies, for instance, optimize the use of solar energy, reducing reliance on fossil fuels for electricity generation. Solar panels, a well-known example of green innovation, have been widely adopted by businesses across various sectors to harness solar power. Solar-powered companies represent innovative applications of green technology in urban environments, showing a positive environmental impact while simultaneously adding economic value (Fraanje et al., 2019).

Renewable energy is on the rise, as innovations reduce costs and begin to fulfill the promise of a clean energy future, meaning that renewables are increasingly displacing “dirty” fossil fuels in the energy sector, offering the advantage of lower carbon and other pollutant emissions. Sustainable energy production requires low-carbon energy systems that do not cause negative social and environmental impacts. Solar and wind energy sources are currently popular around the world, contributing to the reduction of greenhouse gas emissions and the dependence on fossil fuels. Electric vehicles and public transportation are also examples of more environmentally friendly solutions. Energy consumption can be significantly reduced through green building techniques, such as the use of sustainable materials and energy-saving equipment. Carbon emissions as well. Organic and precision farming are examples of sustainable agricultural methods that support healthier ecosystems and conserve water supplies. Innovations in waste management, such as recycling and waste-to-energy technologies, help conserve resources and minimize environmental pollution. Green innovations based on renewable energy sources are essential to addressing environmental problems. Through the use of renewable energy in its production processes, General Motors has made an impact in the automotive industry, as one of the industries with negative externalities, moving toward innovative, sustainable practices.

6. CONCLUSION

Green innovations encompass all types of innovations that contribute to the creation of key products, services, or processes aimed at reducing harm, impact, and environmental degradation, while simultaneously optimizing the use of natural resources. This type of innovation plays a key role today as it channels the appropriate use of natural resources to improve human well-being. Furthermore, the creation and incorporation of changes into products and production processes contribute to sustainable development.

The accelerated industrial and technological development, particularly characteristic of the second half of the 20th century, has left—and continues to leave—significant marks on the natural environment. In the 1980s, global warming became a dominant topic in scientific circles, and it was unequivocally proven that the greatest contributor to the observed warming was the increase of carbon dioxide in the atmosphere and that human influence has been the dominant cause of this warming since the mid-20th century. As a result, today, environmental protection is governed by a legislative and institutional framework that allows the use of natural resources in a sustainable way, albeit differently across countries. A new relationship with the environment has become an imperative of modern society. Ecological awareness represents a lifestyle pattern that respects and harmonizes

with natural laws, encouraging people to take from nature only as much as is necessary to meet basic human needs. Thus, ecological ethics represents a moral relationship between humans/technosphere and nature/biosphere.

With the globalization of the economy, environmental issues are becoming increasingly prominent on a global scale. In recent years, as carbon neutrality and peak carbon goals continue to be promoted, a growing number of companies have become aware of the importance of environmental responsibility. These companies not only aim to save energy and reduce emissions by setting green targets that limit their production activities, but also seek green changes in their management models to reduce potential environmental hazards.

In response to the rise of environmental awareness, institutional pressures, and the emergence of a segment of green consumers, companies are implementing certain changes in all aspects of business to improve their performance by differentiating their products and promoting process efficiency, thereby gaining a competitive advantage. Accordingly, companies are introducing a range of innovative practices not only to meet regulatory requirements but also to signal their commitment to the environment. Green innovation refers to the adoption of innovative practices aimed at developing environmentally friendly products and processes, increasing resource efficiency, and reducing environmental impact.

Green innovations are becoming attractive across several industries such as energy, construction, transportation, agriculture, and more. Solar and wind energy sources are currently popular worldwide, contributing to the reduction of greenhouse gas emissions and reliance on fossil fuels. Electric vehicles and public transportation are also examples of more environmentally friendly solutions. Energy consumption can be significantly reduced through green building techniques, such as using sustainable materials and energy-saving equipment. Carbon emissions, too. Organic and precision farming are examples of sustainable agricultural methods that support healthier ecosystems and conserve water supplies. Innovations in waste management, such as recycling and waste-to-energy technologies, preserve resources and minimize environmental pollution. Green innovations are essential for solving environmental problems and providing economic opportunities, which ultimately improve the standard of living.

Green innovations can help companies reduce costs, access new markets, and promote process efficiency—all of which positively impact their financial status. This requires updating their business models and practices and investing more effort into the careful use of resources and the introduction of new, environmentally friendly products and processes. Establishing proactive environmental policies and innovative practices undoubtedly leads to competitive advantages, improved financial performance, and minimized risks and uncertainties associated with investments in green projects.

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