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Using Innovation and Energy Efficiency Technologies to Drive Business Competitiveness

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Abstract

This study evaluates the impact of innovations and energy-saving technologies on improving business competitiveness within a dynamic market landscape. We collected relevant data on energy consumption (from 2000 to 2021) and the proportion of renewable energy sources (from 2002 to 2023), alongside investments in innovative technologies from the IEA reports, the World Bank, IRENA, and governmental databases. The practical significance of using innovations and energy-efficient technologies to enhance business competitiveness is seen in the prospect of reducing the use of non-renewable resources for sustainable societal development, consistent decarbonisation, and the preservation of ecosystems' natural potential. Additionally, scientific literature on the adoption of energy-efficient technologies across various economic sectors was reviewed. The study also explored successful companies that have embraced innovations, based on an analysis of public reports. A benchmarking analysis was performed to assess the effectiveness of new technology implementations across different industries. This was followed by forecasting the percentage of renewable energy sources in the global energy mix by 2030. The findings revealed that innovations and energy-efficient technologies significantly enhance the competitiveness of companies. They streamline costs, improve production efficiency, and bolster corporate reputations among environmentally conscious consumers. The transfer of innovations accelerates the adoption of new technologies, which aids in making informed environmental decisions. Government support for innovation and energy efficiency is also vital for the swift integration of these technologies. Ultimately, innovations and energy-efficient technologies foster sustainable business growth and positively impact the environment. The results pinpoint key areas where government support can stimulate innovation and enhance energy efficiency in the business sector.

Keywords

Innovations; Digital marketing; Energy-saving technologies; Innovative entrepreneurship; Innovation parks; Competitiveness

Introduction

In today's rapidly evolving economic landscape, businesses encounter a myriad of challenges that necessitate continuous improvement and adaptation. Innovations and energy-efficient technologies have emerged as critical factors that impact business competitiveness amidst globalization and rising consumer expectations. With finite resources and intensifying competition, companies are compelled to optimize costs and enhance production efficiency. Energy-saving technologies not only lower energy expenses but also boost overall productivity. The increasing focus on environmental concerns and climate change drives businesses to adopt sustainable practices. Implementing innovative energy-efficient technologies is vital for minimizing corporate carbon footprints, which is crucial for attracting both investors and consumers. Companies that embrace cutting-edge technologies and innovations can respond swiftly to fluctuating market conditions and evolving consumer preferences, enabling them to secure leading positions in the market and improve their competitiveness.

Many governments offer financial assistance and other forms of support to businesses that adopt innovative and energy-saving solutions. This creates additional opportunities for businesses and promotes their development and modernisation. Modern consumers increasingly value socially responsible companies. Investing in energy-saving technologies can enhance a company's image and contribute to building long-term relationships with consumers.

The eco-transformation of businesses through energy-saving practices is crucial for the low-carbon transition. Consumers influence eco-friendly production, which requires a systematic approach to business. ESCOs play a unique role in guaranteeing project efficiency. Changes in business models and resource integration will expand service-oriented businesses, promoting cooperation between manufacturers, suppliers, and consumers. Co-creation of value is key to energy services, and developing models for managing investments will foster growth. There are no alternatives to the eco-transformation of businesses due to global efforts to transition to a low-carbon economy (Kovalko, Eutukhova and Novoseltsev, 2022). To implement the strategies, it is proposed to publish data on innovation activity, develop projects in collaboration with clusters, and register them with the Ministry of Science and Higher Education of Poland (Mironova *et al.*, 2022). It is important to choose effective channels to attract clients and increase loyalty. Models for optimising investments in digital marketing based on portfolio investment theory have been developed previously (Niziaieva *et al.*, 2022).

The issue of fossil resources remains particularly problematic. Researchers (Maradin, Malnar and Kaštelan, 2022) argue that burning fossil fuels for energy production releases harmful greenhouse gases, such as carbon dioxide, which significantly contribute to environmental degradation and climate change (Quiroz, 2020). In Europe, considerable attention is devoted to minimising air emissions by increasing the share of alternative sources in energy production, improving energy efficiency, and ensuring the careful use of natural resources (Kuzmynchuk *et al.*, 2024).

The prospects for targeted financing and integrating economic tools within the framework of the European integration development strategy reveal significant practical

opportunities for the use of renewable energy sources in business (Hu and Zeng, 2024). Despite the relevance of the issue, there are still several research gaps concerning these aspects. Among such gaps are the role of environmental taxes in promoting the transition to renewable energy sources, the potential for increasing environmental taxation, and its impact on sustainable development.

Thus, the study of the role of innovations and energy-saving technologies is extremely relevant to modern business challenges. Understanding their impacts on competitiveness allows companies to adapt to new conditions and achieve sustainable development.

Literature Review

Studies on technical, economic, and social aspects, but the share of economic and social studies remains low. Collaboration between countries, particularly the USA, the UK, China, and Germany, promotes research development. These studies highlight the need for further research on the economic and social consequences of implementing energy-efficient and renewable energy technologies. Mechanisms need to be developed for the implementation of innovative technologies and "zero" energy consumption standards in new and renovated buildings (Sotnyk *et al.*, 2023).

Business innovations can both support and disrupt the market. Companies can improve their positions through innovative products and organisational changes or create competition for larger enterprises by developing new market segments. Actively seeking and implementing new ideas is critical to gaining advantages from innovations. In addition to attracting new clients, companies can receive tax breaks and grants for complex technological projects (Palmer, 2024).

Analysing the interaction of energy market participants based on oligopoly models allowed for developing recommendations to ensure strategic security and energy independence. For effective energy demand management, the implementation of budgetary regulation is recommended (Kuzmynchuk *et al.*, 2024).

After preliminary research into innovative solid-state electric devices with compact architecture, Italian researchers examined their impact on the annual energy balance and visual comfort of integrating glass into facades with various glazing technologies (Cannavale *et al.*, 2018). The research findings of another Italian scholar suggest that strategic analysis of the competitive structure and knowledge of the regulatory framework positively impact efficiency, improving service capabilities. Considering the expected increase in demand for new energy-efficient products, industrial processes require solutions with a smaller energy footprint and energy management services to facilitate the decarbonisation of the economy (Di Foggia, 2021). Comprehensive results from Portuguese scientists, obtained from a conceptual model, analyse the competitiveness of tourism and innovation factors. The study identifies and verifies the links between innovations (factors and barriers) for enhancing the competitiveness of destinations and their companies (Teixeira, Ferreira and Almeida, 2024).

Studies show that top management support and international pressure for energy conservation are key factors for successful energy management implementation. Less important factors include risk management, awareness of energy-efficient technologies, strategic planning, research, competitive advantage, green manufacturing, and supplier management. These findings will help managers take the necessary steps to effectively implement energy-efficient technologies (Iqbal *et al.*, 2021).

Government incentives are vital in fostering energy efficiency in smart buildings, particularly in rapidly developing areas like Saudi Arabia and the UAE. These incentives promote the adoption of advanced technologies by providing financial support, tax benefits, and a supportive regulatory framework, facilitating modernization. For entrepreneurs, grasping these incentives is essential, as they can help lower environmental impact, cut costs, and achieve competitive advantages (SQC, 2024).

Chen *et al.* (2023) utilize SCM, PSM-DID, SDM-DID, and mediation models to investigate how energy-saving urban construction policies influence the efficiency of green innovation in cities, using the NEDC policy as a case study. The findings reveal that the results from the SCM approach indicate that the adoption of the NEDC policy considerably enhances green innovation efficiency in pilot cities. Furthermore, this positive impact tends to grow over time and exhibits regional variations.

The study assesses the significance of innovations and energy-saving technologies in boosting business competitiveness within a fast-evolving market landscape.

Methodology

Data collection and analysis

Data for the study was obtained from national and international statistical data on energy consumption for 2000-2021, as well as the share of renewable energy sources (2002-2023) and investments in innovative technologies and their impact on business efficiency, were collected and analysed. Forecasting was used to predict the share of renewables in the global electricity sector by 2030, following Hu and Zeng (2024), Iqbal *et al*. (2021), and Mateos and Delgad (2024). The information was based on reports from the International Energy Agency (IEA), the World Bank, the International Renewable Energy Agency (IRENA), and government databases. Scientific publications on implementing energy-saving and innovative solutions in various economic sectors were analysed. Reviews and meta-analyses were conducted using Google Scholar, Clarivate, and Elsevier databases. An empirical analysis of case studies of companies that successfully integrated innovative and energy-efficient solutions was conducted based on publicly available business reports and industry studies. The case study method examined successful companies that achieved significant results through innovation. Benchmarking analysis was applied to compare the effectiveness of implementing innovative and energy-saving technologies in various sectors and countries. Benchmarking is an analysis of the world's best practices in a particular industry, an analysis of competitors, and a search for the best market offers that a company can implement in its processes. In simple terms, benchmarking is a comparative analysis when a business needs to change its direction in the process of

identifying new needs of users of its products. The main task of benchmarking is to bring the company to a new level and make it more competitive. The research findings and the identification of critical areas of government support needed to stimulate innovation and improve business energy efficiency were summarised using the synthesis method. Through synthesis, individual components and properties identified through analysis were combined into a unified whole. In this process, meaningful integration occurred, moving from identical and essential elements to differentiation and diversity, integrating both general and specific aspects into a single concept.

Results and Discussion

Innovations and Energy Efficiency

Large corporations spend millions on energy and significant amounts on logistics and outsourcing. However, many companies view energy only as a cost, which is a strategic mistake, as it neglects opportunities for value creation and reducing risks. Innovations in energy technologies and global carbon emissions regulations create new challenges and opportunities for improving energy efficiency. Sub-metering systems help companies monitor energy consumption in real-time, allowing for cost reduction and better energy-saving goals. Nevertheless, many organizations remain unaware of the advantages offered by these technologies. Meeting government requirements can be leveraged for competitive advantage if approached with awareness and innovation. The energy sector is transforming into a unified service sector, requiring companies to view energy suppliers as partners. Corporate responsibility initiatives increasingly influence organizational reputations, making it essential to have an energy efficiency strategy. An accurate understanding of energy consumption is essential for achieving corporate objectives. Changing the corporate approach to energy efficiency is critical for survival in today's economic climate (Quiroz, 2020).

Energy efficiency is becoming increasingly popular because reducing energy consumption benefits the planet and businesses. It helps decrease the carbon footprint and increase profits. Companies can benefit from energy efficiency in offices, stores, and other facilities. It allows for reduced energy costs, which is important for profitability, and lowers financial risks associated with rising energy prices.

Customers value a business's environmental efforts and are willing to pay more for “green” initiatives. Energy efficiency can help attract top talent, as 67% of employees consider a company's sustainability necessary (Budderfly, 2023). Reducing the carbon footprint demonstrates real action, increasing the chances of attracting talented employees. Energy efficiency is becoming crucial for businesses, and its implementation can become a competitive advantage.

According to the International Renewable Energy Agency (IRENA, 2024), global renewable energy capacity reached 3865 gigawatts (GW) in 2023 (Datawrapper, 2024). This is 473 GW more than in 2022, marking the most significant annual increase since records began (QERY, 2024). The share of renewable energy in the global energy balance increased significantly from 2000 to 2023 (Figure 1).

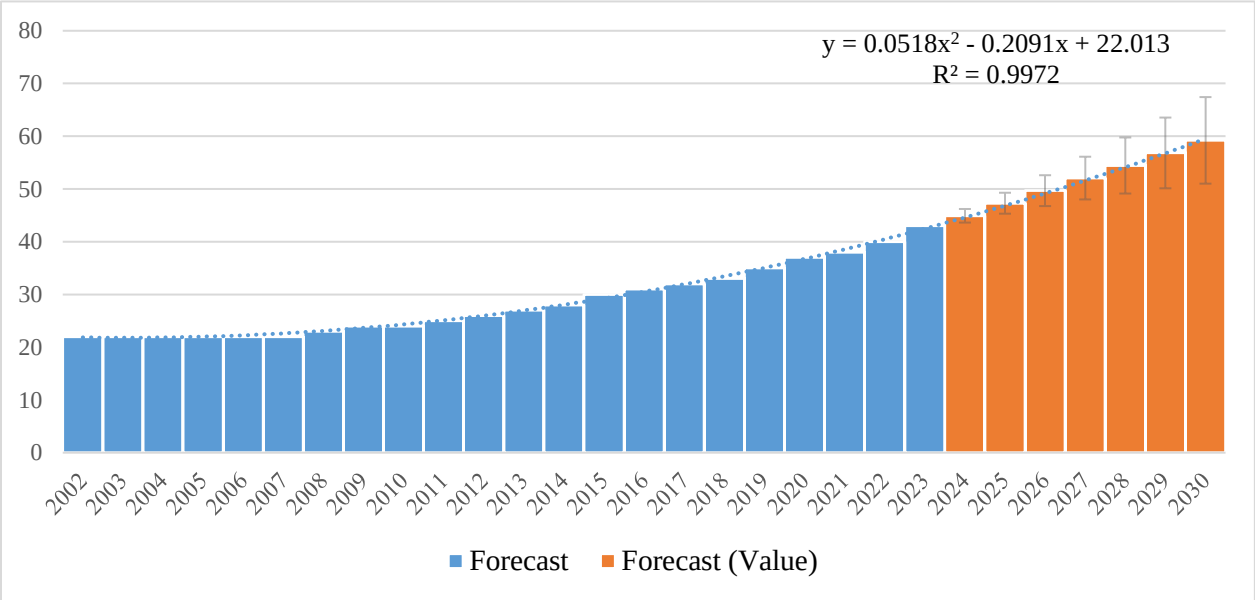

Figure 1: Percentage Contribution of Renewable Sources to the Total Capacity of the Global Electricity Industry (QERY, 2024; IRENASTAT, 2024)

Since the early 2000s, the share of renewable energy in the global energy balance has steadily increased. This growth has been driven by adopting solar, wind, and hydropower technologies. During the 2010s, investments in renewable energy sources significantly increased due to government support programmes, tax incentives, and the decreasing cost of technologies. The most rapid growth occurred in the solar and wind energy sectors. According to the International Renewable Energy Agency (IRENA, 2024), the share of renewables in global electricity generation reached around 43% in 2023, a record figure (IRENASTAT, 2024). Global renewable energy capacity reached 3865 GW, far exceeding the 2000 level. In addition to developed countries, significant growth in renewables was observed in developing countries, especially China and India, which have actively implemented solar and wind installations. This growth reflects the global trend toward transitioning to clean energy sources to reduce CO_2 emissions and combat climate change.

In competitive markets, innovation is crucial for the survival and growth of companies. Those that do not adopt innovations risk losing market share. However, competition can negatively impact innovation. Companies that focus on short-term profits may not invest enough in research and development. Intense competition may lead to incremental improvements rather than bold, breakthrough ideas. Thus, the impact of competition on innovation depends on market dynamics, competition intensity, and corporate strategies. A balanced competitive environment and policies that encourage innovation can promote innovation growth and overall economic expansion (Ferrante, 2023).

A business innovation culture is critical for medium-sized companies as it allows them to stay ahead of competitors. Creating an environment encouraging creativity, experimentation, and risk-taking helps these companies adapt to changing market conditions and quickly implement new solutions (Forbes, 2022). Businesses can

generate competitive advantages by being open to new ideas and willing to invest in research and development. An innovation culture also helps attract talented professionals who seek to work in dynamic and progressive environments. This enables companies to retain existing customers and attract new ones, ensuring sustainable growth and development. Implementing innovative processes, such as agile methodologies or design thinking, can improve efficiency and respond quickly to customer needs. Therefore, a business innovation culture is not just an advantage but a necessity for medium-sized companies striving to compete successfully in today's market. Energy consumption intensity per capita reflects a country's level of development, energy policies, capacity for innovation, and efficient resource use. Analytics for the period from 2000 to 2021 demonstrate trends toward adopting more energy-efficient technologies, the impact of global decarbonisation initiatives, and the spread of renewable energy sources (Figure 2).

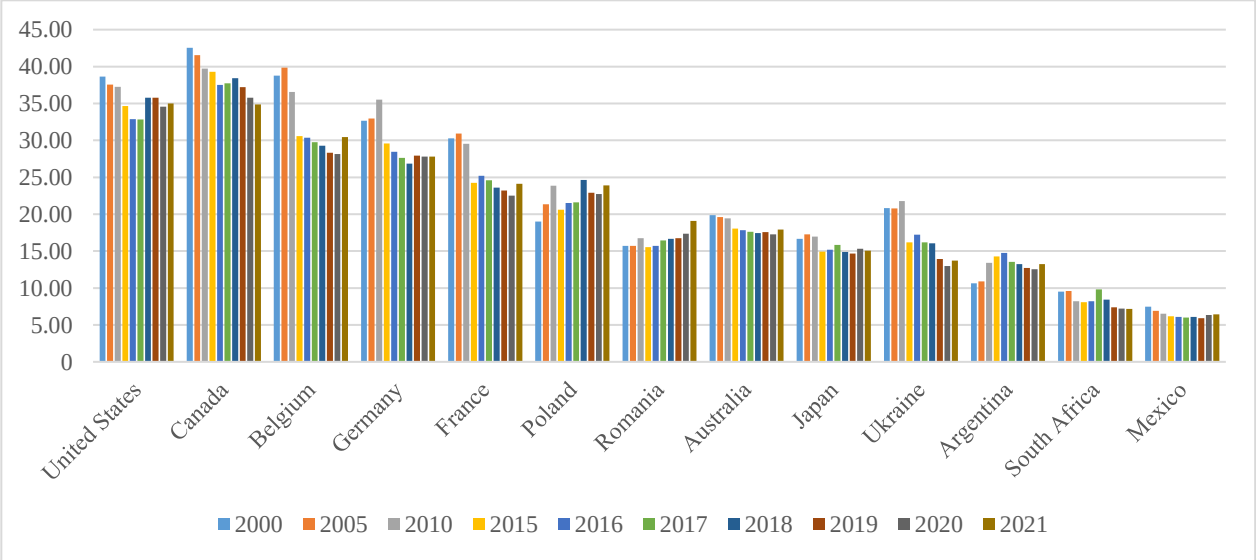

Figure 2: Energy Consumption Per Capita in Selected Countries of the World, (2000-2021), GJ/person) (IEA, 2022)

Energy consumption intensity per capita from 2000 to 2021 reveals that this metric is generally higher in developed countries due to the high industrialisation, infrastructure, and consumption of energy-intensive goods and services. Economically developed countries like the United States, Germany, and Japan demonstrate higher energy consumption rates. At the same time, implementing energy-saving technologies and policies indicates a reduction in per capita energy consumption growth. This is due to improvements in energy efficiency, the transition to renewable energy sources, and reduced dependence on fossil fuels. Energy efficiency indicators depend on climatic and social factors: countries with colder climates (Canada, Norway) have higher consumption levels due to heating, while warmer countries (Mexico, Argentina) have lower levels, although air conditioning in hot regions increases consumption. Rapid population growth and urbanisation affect energy consumption in developing countries (China, India). Many governments have implemented decarbonisation policies, which contribute to reducing consumption intensity.

Several world-renowned companies run successful businesses by efficiently using innovations and energy-saving technologies (Table 1).

Table 1: Benchmarking Analysis of Best Business Practices in Using Innovations and Sustainable Technologies

Company	*Field of activity*	*Practical activities*
Tesla, Inc	Automotive	Pioneer in electric vehicles and renewable energy. Their cars are equipped with autonomous driving, and the company also produces solar panels and batteries for energy storage.
Siemens AG	Electronics and automation	Develops energy efficiency solutions for industry and construction, including smart buildings that optimise energy consumption through automation and monitoring. It also introduces digital twin technologies to reduce energy costs.
Unilever	Consumer goods	Implements sustainable development strategies, including reducing its operations' carbon footprint, actively using energy-saving technologies and renewable energy sources, and developing environmentally friendly products.
IKEA	Furniture retail	Uses renewable energy to power facilities, incorporates energy-saving technologies into products, and promotes recyclable furniture design.
Patagonia	Clothing	Focuses on environmental responsibility by using recycled materials in its products. The company supports environmental protection initiatives and encourages customers to repair and recycle clothing.
Apple Inc.	Technology	Reduces the carbon footprint of its products by using renewable energy sources in factories and offices and developing energy-efficient components.
Schneider Electric	Energy management	Develops energy efficiency solutions, including energy management software, and is actively innovating in automation and smart grids.

Source: APPLE (2024), Hu and Zeng (2024), Maradin, Malnar and Kaštelan (2022), Patagonia (2024), PxWEB.IRENA (2020), SIEMENS (2024), Unilever (2021), WEF (2023)

The companies examined illustrate how innovations and energy-saving technologies can be integrated into business models to achieve sustainable development, reduce costs, and enhance competitiveness. These examples serve as benchmarks for organizations aiming to adopt similar practices.

Mechanisms for Supporting Innovations

Mechanisms for supporting innovation in different countries largely depend on the specifics of the economy, level of development, and national priorities. However, several key approaches can be identified to support innovations and contribute to business competitiveness in the face of global challenges and climate change (Table 2).

Table 2: Fundamental Mechanisms for Promoting Innovation to Increase Business Competitiveness in the Era of Global Challenges and Climate Change

Direction	*Country*	*Support mechanisms*
Financial support and investments	European Union	It actively invests in Horizon Europe and Green Deal programmes, which aim to promote sustainable economic growth, decarbonisation, and environmental technologies through innovation transfer.
	United States	The Green New Deal and Energy Star programmes provide massive investments in renewable energy and innovative technologies to combat climate change.
	China	Through the Made in China 2025 initiative, the government is investing heavily in the development of green energy and the research and development of innovative technologies.
Tax incentives and benefits	Germany	A system of tax incentives has been introduced for companies investing in renewable energy or energy-efficient technologies. The Energieeinsparverordnung (EnEV) programme supports reducing energy consumption in production.
	France	In addition to subsidies, tax credits are available for companies engaged in research and innovation in energy savings and CO_2 emissions reduction.
	Canada	The Scientific Research and Experimental Development (SR&ED) programme offers tax credits for companies that invest in research and innovation, including green technologies.
Support for research and development (R&D)	South Korea	Investment in research and development of energy-saving technologies is one of the priorities of the government strategy. South Korea also stimulates the development of new technologies through public-private partnerships.
	Japan	The Japanese government actively funds research into new energy solutions, such as hydrogen energy, and programmes to introduce innovations in industry (the Top Runner programme).
Creation of innovation clusters and infrastructure	Finland	Creating research and innovation parks, such as the Espoo Innovation Garden, promotes the development of startups and innovative companies in technology and energy saving.
	Singapore	The Singapore government creates clusters for the development of green startups and supports research in energy and future technologies.

Source: FG (2014), Galvin and Healy (2020), Mateos and Delgad (2024), Nair (2022), OECD (2023), Scandicorp (2024), Schwanen (2017), Vattenfall (2024), WBG (2023), WIPO (2024)

Mechanisms for supporting innovation globally often emphasize financial support, tax incentives, the development of research and technology, and public-private partnerships. These measures help businesses implement innovative solutions and energy-saving technologies, strengthening their competitiveness in the global market.

Trends and Forecasts in Energy Intensity Reduction

Energy intensity, or the amount of energy used to produce a unit of GDP (TPES/GDP), decreased by 36% globally from 1990 to 2021, although these figures vary significantly between regions (Figure 3).

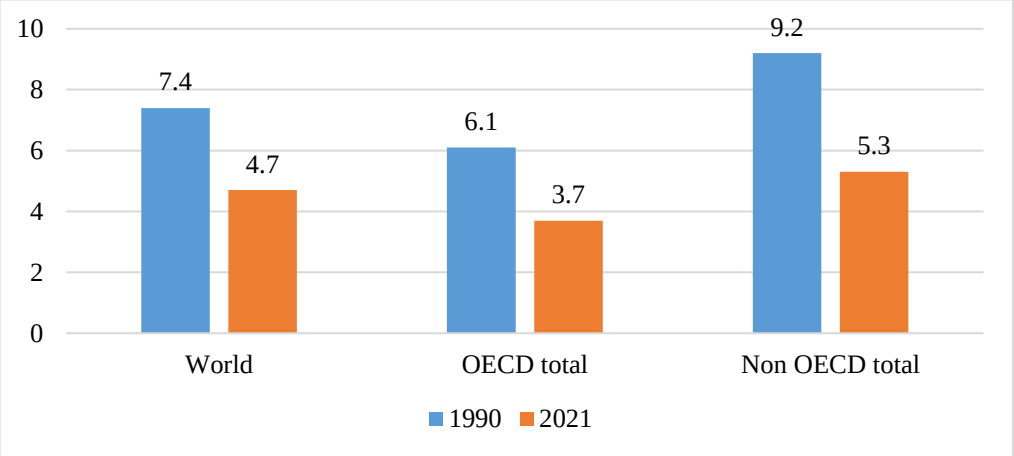

Figure 3. Energy Intensity of the Economy in 2021 vs. 1990 (GJ per thousand USD) (IEA, 2022)

The largest reduction was observed in non-OECD countries. For example, during this period, energy intensity decreased by more than half, by 72%, in China, indicating a significant improvement in energy resource efficiency in its economy. Such regional differences reflect the varying pace of economic reforms and the level of implementation of energy-saving technologies.

Estimated energy savings in 2023-2024 at the global level are expected due to several important factors, including stricter energy efficiency policies and increased use of renewable energy sources. According to data from the International Energy Agency (IEA, 2024), developing and developed countries are actively implementing measures to improve energy efficiency. Global energy intensity continues to decline, thanks partly to the electrification of industry and transport, building upgrades, and the adoption of more energy-efficient technologies. In some countries, such as China, a significant reduction in energy intensity of more than 4% per year has been observed in recent years.

Forecasts for 2024 predict that the main energy savings will be achieved through more efficient use of materials and energy in industry, the transition to the electrification of transport, and the growing demand for energy-efficient technologies in construction. Global energy consumption could decrease by up to 10% by 2030 while maintaining economic growth, provided countries adhere to ambitious measures to improve energy efficiency. At the same time, political instability and wars, particularly in Ukraine, may

continue to impact energy markets, but the current trend toward reducing dependence on fossil fuels will contribute to overall energy savings in 2023-2024.

Role of Government Policy

Government policy is key in promoting innovation and energy-saving technologies in business (Figure 4).

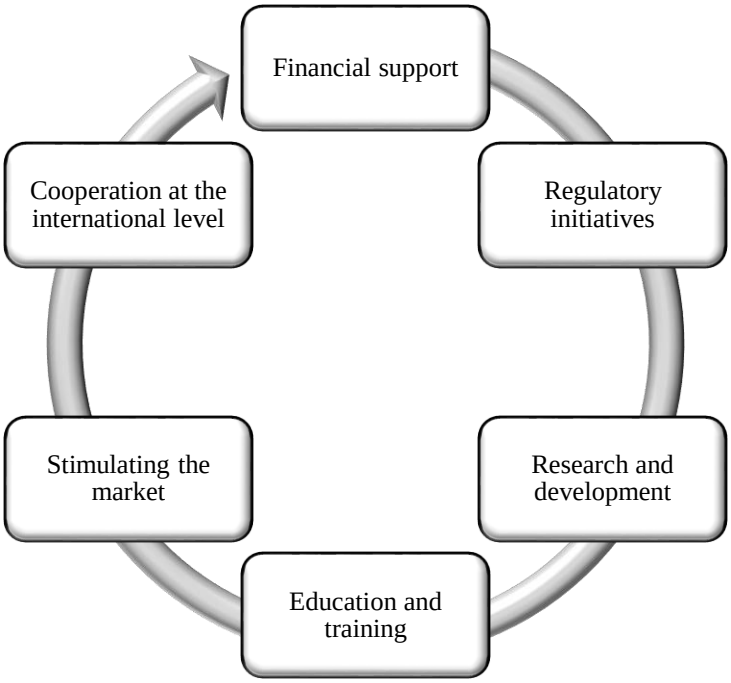

Figure 4: Government Support as a Key Factor for Innovation and Energy Efficiency in Business

Government programs can offer businesses subsidies, grants, and tax incentives for adopting innovative and energy-efficient technologies, thus minimizing financial risks and promoting investment in new solutions. The establishment of standards for energy efficiency and environmental safety encourages companies to implement new technologies, including mandates to reduce emissions, utilize renewable energy sources, and enhance production efficiency. Additionally, the government can invest in research and development, backing innovative projects for industrial application. Partnerships among universities, research institutions, and businesses stimulate innovation. Moreover, government initiatives can increase awareness of energy-efficient technologies and provide the necessary training for personnel through programs, seminars, and exhibitions. Creating favourable conditions for developing the energy-efficient products and services market, including supporting startups and small businesses, can accelerate the adoption of new technologies. Engagement in international agreements and programs allows countries to exchange experiences, technologies, and resources for the implementation of innovative and energy-saving solutions. In general, effective government policies can foster a supportive environment

for innovation development and enhanced energy efficiency, resulting in cost reductions, improved business competitiveness, and better environmental conditions. However, the shift towards innovative technologies and energy conservation comes with various economic and social risks (Figure 5).

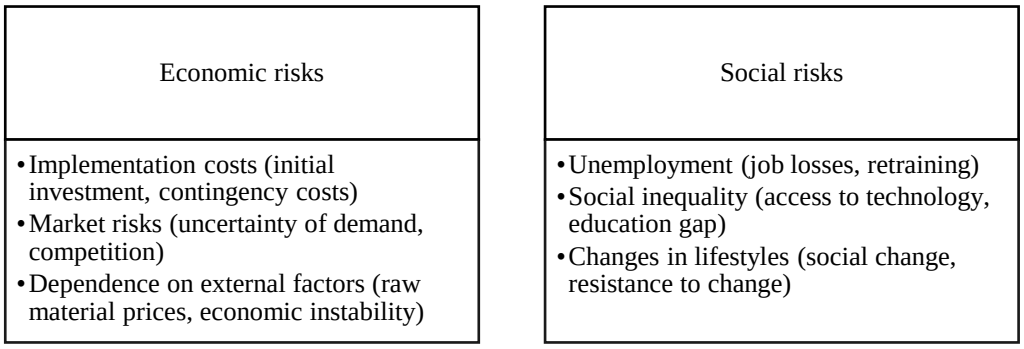

Figure 5: Socio-Economic Risks of Implementing Innovative Technologies and Energy-Saving [*Source:* Cannavale *et al.*(2018)]

Adopting new technologies and upgrading equipment can impose a substantial financial burden on businesses. Additional costs may arise from staff training and technical support for these innovations. Transitioning to new technologies may not always align with consumer needs, potentially leading to a drop in sales. Market changes can heighten competition, risking market share for companies unable to adapt. Rising raw material prices essential for new technologies can also negatively impact expenses, while global economic crises may limit funding for innovative initiatives. Automation and new technologies could lead to job reductions, especially in traditional sectors. Employees may need to learn new skills, creating social tension. Unequal access to innovations might worsen social inequality, particularly in resource-limited regions. Educational programs may struggle to keep up with rapid changes, leading to disparities in access to knowledge and technology. Additionally, the transition to new technologies may alter consumer lifestyles and habits, requiring time for adaptation. Society might resist innovations due to fear of the unknown.

While ongoing technological development may mitigate some risks, it also introduces new challenges. Changes in government policies can affect business models and innovation strategies. The increasing emphasis on sustainable development and climate change may create new economic opportunities but also heighten social risks. Thus, an effective transition to innovative technologies and energy conservation necessitates a comprehensive approach that includes strategic planning, education, and support to minimize risks and ensure sustainable development.

Conclusion

The study aimed to assess the impact of innovations and energy-saving technologies on improving business competitiveness in a dynamic market environment. The study also planned to investigate successful companies that have implemented innovations based on the analysis of public reports. The study found that innovations and energy-saving technologies are crucial for enhancing companies' competitiveness. They enable cost

optimization, increased production efficiency, and improved brand image among environmentally conscious consumers. Reducing energy consumption and transitioning to renewable energy sources not only lower energy costs but also enhance businesses' environmental sustainability, which is increasingly vital amid climate change concerns. We found that innovative technologies allow companies to quickly adapt to new requirements, including environmental standards and regulations, helping them stay competitive. Effectively using energy-saving technologies boosts productivity and reduces operational costs, making companies more resilient to market fluctuations, economic downturns, and rising resource prices. The transfer of innovations is key to accelerating the integration of new technologies and adopting more sustainable solutions globally. Additionally, strong government support for innovation and energy conservation is essential for easing technology implementation and promoting its wider adoption. Therefore, innovations and energy-saving technologies are fundamental to sustainable business development, offering both economic advantages and positive environmental outcomes. The results of the study will facilitate the prompt identification of fluctuations in resource security zones in the dynamics, timely identification of existing risks, threats and imbalances, and their ranking by the strength of influence, which will allow making optimised management decisions. A promising area for further research is a detailed study of the potential of economic incentives and the motivation of businesses for sustainable development.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	Author 1	Author 2	Author 3	Author 4	Author 5
Conceived and designed the research or analysis	Yes	No	Yes	Yes	No
Collected the data	Yes	No	Yes	No	Yes
Contributed to data analysis & interpretation	Yes	Yes	No	Yes	No
Wrote the article/paper	Yes	Yes	Yes	Yes	Yes
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