

**Climate Neutrality of the Economy**

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**EUROPEAN MODEL
OF CLIMATE-NEUTRAL BUSINESS
DEVELOPMENT BASED
ON DIGITALIZATION PRINCIPLES**

Abstract

The article explores the characteristics and approaches of climate-neutral business development in the European Union based on digital transformation. The focus is on small and medium-sized enterprises (SMEs), which currently generate a significant share of global economic emissions and need to accelerate the integration of effective decarbonization models. The data indicates that the proportion of emissions generated by SMEs in the business sector and their energy consumption represent the most crucial indicators for assessing the climate neutrality of a country's development. These indicators exhibit a considerable degree of variation across EU countries. Concurrently, the research indicates a notable disparity between SMEs and large corporations in terms of their preparedness to implement various climate-oriented initiatives and their capacity to integrate digital solutions. The article presents a systematic analysis of the potential for digitalization to reduce the SMEs' carbon footprint across various emission areas. These include direct emissions from industrial processes, indirect emissions

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from energy consumption, and key links in the value chain. Five clusters of digital solutions were identified as the most effective and particularly supported in the European model of climate-neutral development. Systemic directions and recommendations for their strengthening are identified.

Key Words:

European Union, climate neutrality, business, SMEs, digitalization, green-digital transition.

JEL: F20, L86, O10, Q40.

4 figures, 1 table, 30 literature sources.

Problem Statement

Over the past decades, the European Union has remained the undisputed global leader in the green transition, having succeeded in curbing the trend in carbon intensity of production. Moreover, the EU economy is practically the only global example of a relatively stable movement towards «net zero» against the backdrop of mega-growth in emissions and the inability of many of the world's leading industrial countries to systematically decarbonize. In this context, the research of the EU's climate-neutral development model is a relevant area, given the possibility of its scaling and implementation in the context of different countries and international organizations.

It is worth noting that the foundation of a climate-neutral economy is the business sector, which ultimately integrates the principles of climate adaptation and mitigation into its own production or, conversely, avoids social responsibility and fails to achieve «green» parity. Small and medium-sized enterprises (SMEs) play a special role in this process. In the European Union, SMEs account for up to 45% of exports, 60% of employment and more than 50% of value added (OECD,

2022). At the same time, they are responsible for at least 50% of greenhouse gas emissions (OECD, 2023).

Research shows that most SMEs are still in the early stages of their journey to net zero and are only taking basic steps to reduce their carbon footprint. According to surveys, only 10% of SMEs currently measure their greenhouse gas emissions, and 22% do not fully understand the terms «net zero» and «climate neutrality» (Stoker et al., 2023; Vasilescu et al., 2023). In addition, about a third of companies have not sought advice or information to help them develop a roadmap to zero emissions or improve their environmental performance (Stoker et al., 2023). At the same time, difficulties in accessing finance have been identified as a significant barrier to the implementation of green strategies by SMEs (Ogrea & Herciu, 2021). Furthermore, the recent modifications in EU environmental and human rights due diligence legislation have initiated a discourse surrounding the necessity of imposing the same requirements on SMEs as on large companies (Mojska; 2023). This has also highlighted the importance of proportionality and reasonableness in the formulation of environmental management regulations.

Digitalization plays an important role in the sustainable transformation of SMEs through the use of smart industry models, energy efficiency, recycling approaches, monitoring, broad communication of environmental compliance, and open sustainability reporting (Maksymova & Kurylyak, 2022). However, while digital technologies offer great opportunities for SMEs to go green, this segment of the business community has traditionally lagged behind large corporations in sustainability practices, green reporting, integration of digital solutions, and other areas of engagement.

Literature Review

The problem of finding mechanisms for decarbonizing the economy, energy efficiency, and the double green-digital transition is extremely popular in modern scientific discourse. Models of climate-neutral business development usually include the use of renewable energy sources, increased resource efficiency, the introduction of a circular economy and the latest digital technologies.

In 2019, in the context of the Green Deal, a team of scientists led by Capros P. developed the PRIMES assessment model (Capros et al., 2019). This revealed that the challenge of achieving climate neutrality in the EU by 2050 requires the implementation of new digital solutions that are not yet adequately developed in industrial sectors and that are not readily understandable to businesses. Researchers Lenz N. and Fajdetic B. (Lenz & Fajdetic, 2021) also emphasized the need to adjust the EU's industrial paradigm, which should be based on the principle that only economic growth based on the introduction of low-

carbon technologies in the economy will be able to overcome the negative climate consequences and «break the trend» of emissions. However, as shown by the work of Axelson M. et al. (Axelson et al., 2021), climate-neutral economic strategies aimed at reducing the direct emissions of companies now require fundamental changes in business models in terms of resource management and efficiency.

Digital transformation plays a key role in supporting the green transition of SMEs in the European Union. According to the research by Bastar K. and Pucihar A. (Ogrean & Herciu, 2021), the key factor in ensuring sustainable development, especially in achieving climate goals, is the digital maturity of enterprises. The research by Ogreaan S. and Herciu M. (Ogrean & Herciu, 2021) on business readiness for the green-digital transition confirmed that SMEs need more support for the effective implementation of digital and green technologies. The main barriers are lack of awareness and financial resources.

The work of the research team of Krogt A. et al. (Krogt et al., 2023) has shown that SMEs should implement dual green-digital innovation projects to increase sustainability and competitiveness. However, only a small proportion of SMEs actively invest in these innovations due to high costs and lack of awareness of the potential business impact. In this context, the analysis by Ionascu L. et al. (Ionascu et al., 2022) shows that digital transformation can have a positive impact on the financial performance of companies by supporting responsible environmental practices.

Currently, despite the broad scope of the work, there is a need to systematize the experience of various green-digital transition practices and identify effective approaches to using digital technologies for climate-neutral business development.

The aim of the article is to identify the characteristics, barriers and drivers of climate-neutral business development based on the research of digitization experiences and best practices of energy efficiency of SMEs in the European Union.

Methodology

The study employs a combined approach that integrates quantitative and qualitative data analysis. This approach enables a comprehensive understanding of the European model of climate-neutral SME development that leverages the opportunities offered by pervasive digitalization. Quantitative statistical analysis was utilized to investigate the dynamics and structure of opportunities and barriers for SMEs in comparison to large corporations in the adoption of digital technologies, as well as the characteristics of energy and carbon intensity of business in different EU countries. The combination of inductive and deductive methods enabled the identification of clusters of digital solutions that are most effective in

decarbonising SMEs. The synthesis of the obtained information analytics facilitated the formulation of certain systemic directions and recommendations for the reinforcement of climate-neutral SME development based on digital solutions.

Research results

Over the last decade, the global business community has shown quite significant shifts towards the search for models of sustainable development, the double green-digital transition and the implementation of low-carbon production practices. Such transformation processes reflect international trends in the climate-neutral economy, which have become particularly important after the signing of the Paris Agreement in 2015, the Green Deal in 2019, the Climate Law in 2020 and the adoption of climate-oriented program initiatives in 2020-2022 on emissions trading, green finance and CBAM.

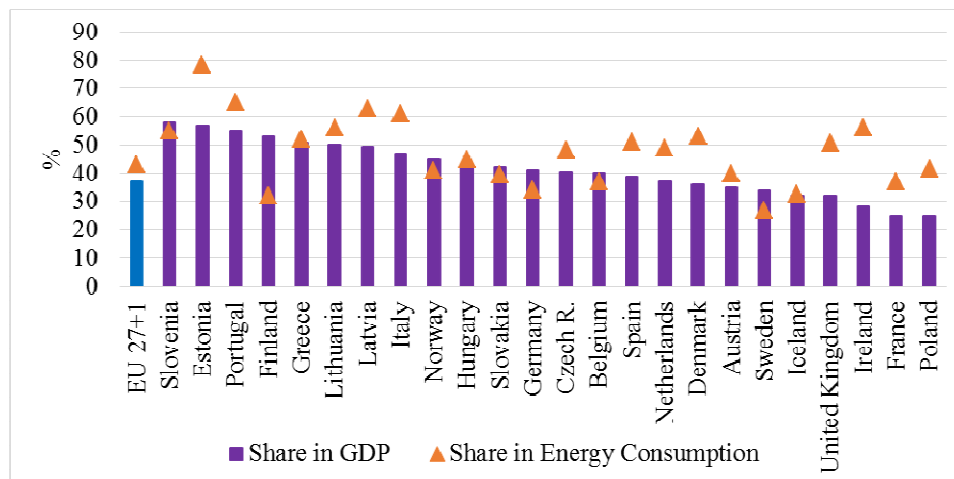
The starting point for a company's «greening» strategy is first and foremost an understanding of its environmental impact, including the energy intensity of its products, the nature of its resource consumption, etc. The Organization for Economic Cooperation and Development (OECD) suggests that such an assessment should be carried out in 5 dimensions (OECD, 2023):

1. The share of SMEs in the greenhouse gas emissions of the business sector;
2. The share of SMEs in the energy consumption of the business sector;
3. Carbon intensity of SMEs;
4. Energy intensity of SMEs;
5. Energy price burden of SMEs.

Currently, EU countries have different patterns of CO₂ emissions generation in relation to business energy demand (Fig. 1).

It should be noted that SMEs in Europe are mostly concentrated in the manufacturing, services and construction sectors, and much less so in agriculture. The share of SMEs in GHG emissions in the business sector varies considerably from country to country, ranging from 57% in Slovenia to 25% in Poland, while the total level of SME emissions in the EU is 37%. At the same time, the energy demand of the business sector has a slightly different structure. The share of SMEs in energy consumption ranges from 78% in Estonia to 28% in Sweden, while the EU average is 43%.

Figure 1

Share of SMEs in greenhouse gas emissions and total energy consumption in the business sector

Source: compiled by the author on the basis of the open EU statistical database Eurostat

Thus, in some EU countries (Slovenia, Estonia, Portugal, Finland, Greece, Latvia, and Lithuania), small and medium-sized businesses are responsible for more than 50% of carbon emissions, which puts them at the forefront of the fight for climate neutrality and necessitates the rapid implementation of low-carbon practices. The combination of high energy consumption and, at the same time, CO₂ emissions (Estonia, Portugal, Lithuania, Latvia) indicates the business sector's dependence on primary energy and the need to switch to «green sources» to decarbonize its operations. On the other hand, high emissions generation by SMEs is not always related to the level of energy consumption. For example, SMEs in Ireland, Denmark, and the Netherlands are significant consumers of energy (over 45%) with a relatively low share of emissions generation. In the case of these countries, this can be explained by the widespread implementation of energy efficiency and green energy programs.

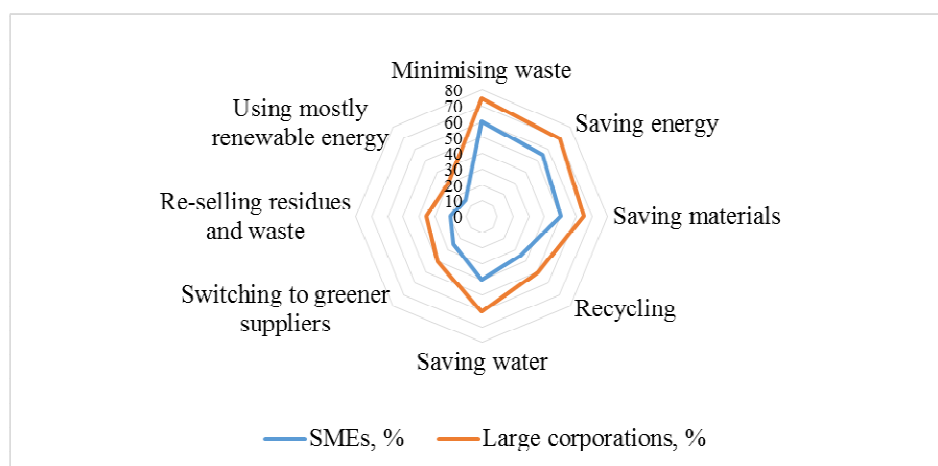
Most SMEs are in the early stages of their journey to zero emissions and have only taken basic steps to reduce their carbon footprint. According to a global survey conducted by the SME Climate Hub in 2021 (SME Climate Hub, 2023), the majority of companies (82%) recognize that going green is a priority, but have only taken basic steps to integrate green business models, such as implementing energy efficiency and waste reduction measures (82%), training employees

(64%), and upgrading facilities and equipment (52%). In addition, only 60% of companies had a long-term plan to reduce emissions. Other EU surveys (Business NSW, 2022) have found similar results. Relatively few companies have taken measures to reduce emissions in the extractive and manufacturing industries. Similarly, few have implemented comprehensive measures, such as redesigning production or service processes to be zero-emission or using external environmental audits.

At the same time, the scale of a company significantly affects its ability to implement climate-oriented initiatives, as SMEs have relatively low productivity compared to industrial giants and multinationals (Figure 2).

Figure 2

Implementation of climate initiatives by SMEs and large corporations



Source: compiled by the author based on (OECD, 2022)

As we can see, solutions in the areas of waste management, energy, water and material savings have made the most progress in being integrated into business models, with at least 50% of SMEs and large companies successfully implementing them. At the same time, some initiatives pose a real challenge for SMEs. Recycling practices are more intensively implemented by large companies than by SMEs (50% vs. 35%). Switching to greener suppliers, reselling waste and using renewable energy are also difficult for SMEs, with only 25%, 20% and 10% of companies currently implementing them respectively.

To achieve climate neutrality, modern business models should focus not only on decarbonizing their own operations, but also on reducing emissions as far upstream and downstream in the value chain as possible, and on offsetting emissions that cannot be eliminated. The EU's current approach is to enable SMEs to identify and measure their emission sources, develop long-term decarbonisation plans, and take the necessary actions and investments to change their business models accordingly (Blundel & Hampton, 2021). This process is challenging and resource-intensive for all companies, but especially for SMEs, which have more limited financial and non-financial resources (staff, skills, etc.) to devote to this goal (Agrawal et al., 2023).

Digitalization is a powerful driver in addressing these issues, as it can optimize production processes and accelerate emissions reductions in three key areas at once (Table 1).

Table 1

Opportunities for digitalization in reducing the carbon footprint of SMEs by emission area

| Emission area | Control points | Opportunities for digitalization in reducing carbon footprint |
|---|--|---|
| 1. Direct greenhouse gas emissions from sources directly owned and controlled by SMEs | Emissions from industrial processes. Emissions from fuel combustion in boilers and furnaces. Emissions from company-owned vehicles. | Using IoT to monitor and optimize energy use at production facilities. Automate processes to reduce energy consumption. Implementation of software to manage energy consumption and reduce waste. |
| 2. Indirect emissions of SMEs from energy consumed and purchased by the enterprise | Electricity purchased from power plants (for lighting, heating and cooling). Heat purchased from a centralized heating system. | Use of smart grids to optimize energy consumption. Transition to renewable energy sources through digital platforms for energy management. |
| 3. All other emissions from sources beyond the direct control of the SME | Emissions from the entire value chain: goods and services purchased from suppliers; ordered transportation; disposal and recycling of company waste; travel by vehicles not owned by the SME (public transport, air travel, business trips, etc.); further use of company products, etc. | Implementation of supply chain management systems to monitor and reduce emissions. Big Data to analyze and optimize logistics. Use of digital platforms to collaborate with suppliers to select more environmentally friendly ones. |

Source: systematized by the author based on (OECD, 2022; Krogt et al., 2023; SME Climate Hub, 2023)

The EU has identified three main areas of digital transformation that are particularly relevant to climate-neutral business development: metering and control, automation, and micro-generation (OECD, 2023). In the transition to clean energy, energy efficiency is often referred to as the «first fuel» because of its triple function: rapid reduction of carbon emissions, lower energy bills, and increased energy security (IEA, 2022). The recent energy crisis caused by the Russia-Ukraine war has further strengthened the EU's economic case for accelerating the transition to more energy efficient business models and practices.

Currently, the EU market is saturated with a variety of business proposals in the field of green digital transition, which are available for mass consumption and contribute to energy efficiency. It is appropriate to distinguish several clusters of such digital products and services that receive special support in the European Union.

Cluster 1. The most common solutions are integrated digitalized energy systems. Such systems are equipped with smart devices that allow monitoring of energy consumption, flexible adaptation to changing energy demand, and automated selection of energy suppliers at the lowest cost.

Cluster 2. Digital solutions that facilitate the adoption of renewable energy sources by businesses and their integration into the national grid. This includes micro-generation from solar photovoltaic systems or small wind turbines that help reduce carbon emissions from fossil fuels.

Cluster 3. Digital technologies for self-generation. Today, SMEs can become energy producers themselves, generating low-carbon energy to minimize their consumption of electricity from the grid, or even sell their surplus back to the grid. This type of solution is becoming increasingly popular in the EU, as self-generation gives companies full control and responsibility over their carbon footprint, which is particularly important to ensure carbon-neutral development.

Cluster 4. Smart digital meters for ubiquitous monitoring. These technologies are becoming increasingly popular among European SMEs due to their affordability and relative ease of installation compared to other digital green solutions (Hilger et al., 2018). Smart electricity/gas meters and energy monitoring systems allow businesses to track energy consumption patterns and change behavior accordingly. Researches have shown that such energy monitoring can reduce SME energy consumption by up to 40% at little or no additional cost by providing better data and understanding of energy consumption patterns (IEA, 2022).

Cluster 5. IoT-based solutions that allow remote control of individual devices and links in the production process, contributing to better energy efficiency. In fact, such systems are the simplest form of automation that can compensate for or even replace inefficient user behavior (Hilger et al., 2022). For SMEs, this opens up great opportunities to implement «predictive maintenance» practices, which involve the end-to-end digitalization of key processes in companies and are

increasingly being used in various manufacturing and service sectors in the EU (Tanane et al., 2022).

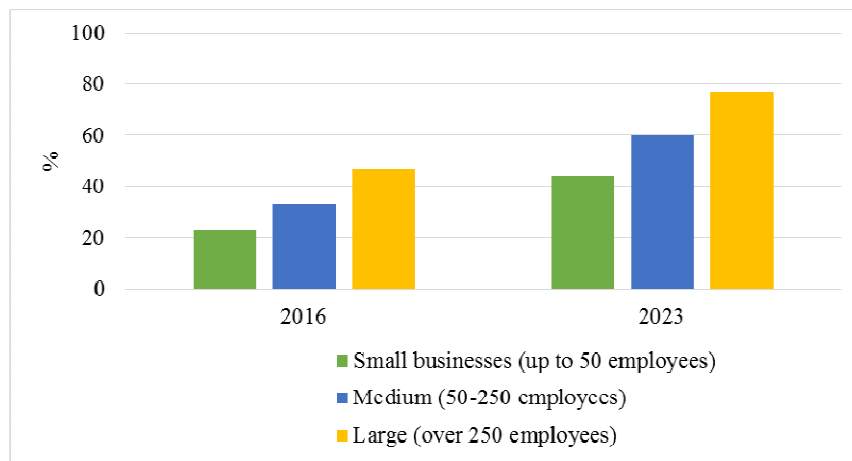
It is worth noting that the digital technologies mentioned above serve as the basis for implementing modern energy and climate management business strategies. However, the actual realization of energy efficiency benefits will depend primarily on effective education of SME owners on the potential of data-driven climate-oriented practices (Hilger et al., 2022). Research conducted in the United Kingdom shows that this approach to business management, based on big data, integrated management of company buildings and facilities, smart meters, etc., has the greatest potential for energy savings and climate-neutral development of SMEs (Warren, 2017).

While digitalization offers great opportunities for SMEs to make a green transition, this segment of the business community currently faces barriers to digitalization, such as a lack of financial resources and low management skills. Typically, climate management in companies tends to be «informal», with only one or a few people in the company responsible for it, and is usually shaped by daily routine, without the involvement of a specialist who would deal with the issue separately (Fawcett & Hampton, 2020). In addition to organizational barriers and lack of dedicated staff and internal capacity, lack of time and prioritization of non-energy related work tasks are identified as the main barriers to implementing effective energy management practices in SMEs (Jalo et al., 2021). In addition, SMEs tend to underestimate the savings potential of energy efficiency investments due to a limited understanding of their energy costs (Mickovic & Wouters, 2020).

The problem of adopting green and digital technologies is also linked to broader barriers to reaping the benefits of digitalization. EU 2020-21 research found that less digital SMEs tend not to have a clear digital strategy at all (European Union, 2022). Moreover, despite the increased use of digital technologies, SMEs still lag behind large enterprises in understanding the applied capabilities of digitalization and the potential to implement relevant solutions on the path to carbon neutrality (Figure 3).

Despite the rapid growth in the overall share of digitalization in the economy in recent years, there is a significant gap between small, medium and large enterprises. Almost two-thirds of large EU companies are able to integrate basic digital technologies (big data, cloud technologies, pervasive analytics, etc.) into their operations, while less than half of small companies have this potential. Moreover, the results of the analysis show that in the most carbon-intensive industries (manufacturing, construction, transport), 65% of SMEs are currently developing energy-saving measures, compared to 81% of large companies (European Union, 2022), indicating an urgent need to strengthen the capacity for green-digital business transition. Some of the reasons for this lag are limited resources for the transition, lack of professional practices and understanding of the importance of achieving net zero, and insufficient or no green financing compared to large companies (Fawcett & Hampton, 2020).

Figure 3

**Share of purchases and adoption of basic digital solutions
in the business sector**

Source: compiled by the author on the basis of the open EU statistical database Eurostat

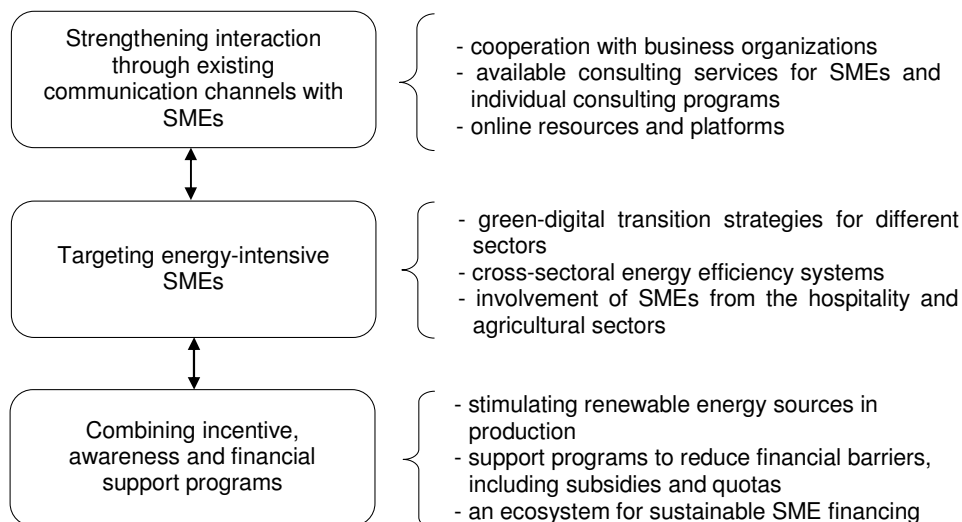
At the same time, the implementation of environmental policies in the EU differs somewhat between SMEs and large companies (SME Climate Hub, 2023; Business NSW, 2022; IEA, 2022). The main differences relate to the type of interaction with companies and communication channels (offline versus online), the type of advice (e.g. from one-on-one advice to industry guidelines), different approaches to performance evaluation (e.g. online surveys, before-and-after energy consumption comparison, qualitative feedback), and different approaches to supporting climate and energy management (external consultants versus in-house trained staff).

The analysis of the climate-neutral development of SMEs allows us to outline the following areas for their strengthening in terms of integrating digital solutions in various aspects of the green business transition (Fig. 4).

The outlined areas are driven by the following trends.

Currently, the European business sector is characterized by an established and mature system of relationships that can be used to disseminate ideas and scale up climate project experiences by working with business organizations as implementation partners. Given the diverse nature of SMEs, even within the same region and sector, energy efficiency advice is most effective when provided in face-to-face meetings, especially in an atmosphere of trust through already established communication channels (European Union, 2022).

Figure 4

Directions for enhancing climate-neutral development of SMEs

Source: compiled by the author based on the study (OECD, 2022; SME Climate Hub, 2023; Business NSW, 2022)

At the same time, SMEs have limited time and resources to devote to developing an effective energy management system (Jalo et al., 2021). It is therefore very important to make energy advice or financing opportunities easily accessible (for example, through online resources) and to highlight measures that do not require significant investment. SMEs vary considerably, so it is important to provide tailored advice to specific sectors, with a particular focus on those with the highest energy consumption.

An important aspect is to ensure systematic and comprehensive efforts by combining awareness-raising and training activities with financial opportunities, including incentives for renewable energy production. In this respect, an interesting example is the EU program «Financing Energy Management in SMEs (2018-2025)» (Johansson et al., 2020). It demonstrates how individual energy advice can be combined with financial support to support the green-digital transition and upgrade business production facilities. Starting with the identification of primary energy sources, the program partially covers the costs of investments in equipment, including energy monitoring devices and possible certification of energy management systems. In this way, the program creates a «corridor of change» for SMEs to gradually achieve carbon neutrality.

Sustainable finance is critical for SMEs to implement climate-neutral development programs. Financing conditions are increasingly dependent on sustainability considerations, and financial institutions are facing non-financial ESG reporting requirements that place new responsibilities, including reputational ones, on SMEs (SME Climate Hub, 2023). Under these conditions, there is a risk that SMEs' access to finance will become even more limited, as not all companies are able to provide high-quality information and communication support for green transformation initiatives. Some institutions also offer special financing schemes or more favourable conditions for investments aimed at achieving green goals, including through loans and factoring, loan guarantees and other financial instruments (Ionascu et al., 2022).

Therefore, ensuring that companies have access to tailored, sustainable financial solutions to meet their investment needs is increasingly important for the transition to net zero. This is also true for investments in energy efficiency measures, which can be associated with high upfront costs and low short-term returns (OECD, 2022). For example, a research of German SMEs shows that high upfront costs can hinder the implementation of energy efficiency measures, even when these measures are considered profitable (Fleitera et al., 2012).

An equally important challenge is the limited demand for sustainable finance by SMEs due to information and awareness barriers, technical and regulatory uncertainty, and limited capacity and resources. SMEs need a stronger business case and external support to increase investment in sustainability and find appropriate financing. In the absence of demand from SMEs, public and private financial institutions have limited incentives to develop tailored financial solutions to finance SMEs' zero emission investment needs.

EU experience shows that digitalization plays an important role in addressing sustainable financing for SMEs, especially in the context of climate-neutral development. The use of digital technologies and platforms helps to increase the availability of alternative sources of finance through crowdfunding and peer-to-peer lending, and to simplify banking processes through fintech solutions, thereby reducing the cost of loans. The use of electronic document management and digital reporting systems improves the quality and accessibility of information and communication support, and the automation of environmental data collection allows SMEs to more effectively demonstrate their green initiatives. On the other hand, digital environmental impact and carbon footprint assessment tools help companies to assess the contribution of their initiatives to sustainability and attract investors interested in financing environmentally sustainable projects (Maksymova et al., 2023). Digital analytics tools and artificial intelligence offer the ability to develop compelling business plans for sustainability investments that are supported by accurate data and analysis. In particular, e-learning platforms and webinars provide SMEs with the necessary knowledge to overcome information barriers and technical uncertainty, which reduces access to finance and helps increase investment in sustainable development.

Conclusions

In the context of the increasing challenges posed by climate change, the European Union continues to demonstrate leadership in the transition to a green economy. Its efforts have contributed to a reduction in the carbon intensity of production and the promotion of a net-zero economy. Consequently, European practices can be utilized as a model for the strategic planning of a climate-neutral economy in other regions of the world.

Small and medium-sized enterprises occupy a pivotal position in this process, as they exert a profound influence on the economic landscape while simultaneously accounting for a considerable proportion of emissions. The analysis revealed that in numerous EU countries, SMEs are responsible for more than 50% of carbon emissions and exhibit a high degree of dependence on energy resources. This underscores the pivotal role of this business sector in the pursuit of climate neutrality and the urgent need for the rapid implementation of low-carbon practices.

The issue at hand is that while a significant number of SMEs are aware of the necessity for climate-neutral development, they are still in the nascent stages of the green transition and encounter significant obstacles in accessing sustainable finance, digital solutions, and information resources on the topic.

The size of a company has a significant impact on its ability to implement climate-related initiatives. At least 50% of SMEs and large companies have made the most progress in implementing climate-friendly solutions such as waste management and resource conservation. However, SMEs have encountered difficulties in implementing tasks such as recycling, switching to greener supplies, and using renewable energy, with success rates of only 25%, 20%, and 10%, respectively.

In order to achieve carbon neutrality, contemporary business models must prioritize not only the decarbonization of their own operations but also the reduction of emissions in upstream and downstream parts of the value chain. Additionally, they must engage in offsetting emissions that cannot be eliminated. The European Union has identified three main areas of digital transformation that are particularly relevant to climate-neutral business development: metering and control, automation, and micro-generation.

The European market offers a diverse array of green and digital solutions that enhance energy efficiency and are accessible to businesses. These solutions can be grouped into the following clusters: integrated energy systems, digital renewable energy solutions, autonomous energy generation technologies, smart meters for monitoring, and the Internet of Things for managing energy efficiency through remote control of equipment.

Although digitalization offers significant potential for small and medium-sized enterprises to adopt environmentally sustainable practices, this segment of the business community currently encounters several obstacles to digitalization, including a lack of financial resources and limited managerial expertise.

Key areas for promoting climate-neutral business development through digital mechanisms include: strengthening engagement through existing communication channels with SMEs (using existing channels and platforms to disseminate knowledge, provide advice and encourage SMEs to adopt climate-neutral practices); targeting energy-intensive SMEs (specializing in approaches and solutions that address the specific needs of high-energy-intensive enterprises); combining incentive, awareness and financial support programs (developing and launching initiatives that promote climate-neutral business development through digital mechanisms); and combining incentive, awareness and financial support programs (developing and launching initiatives that promote climate-neutral business development through digital mechanisms).

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