Digital technologies and the green transition of SMEs and entrepreneurs[1]

[1] This paper builds on ongoing work of the OECD Committee on SMEs and Entrepreneurship (CSMEE) on the green transition of SMEs and green entrepreneurship. The main author is Jan-Philipp Schmidt (Junior policy analyst) under the supervision of Marco Marchese (Policy Analyst). The paper has also benefited from written contributions from David Halabisky (Project Coordinator) on green entrepreneurship, Marija Kuzmanovic (Policy Analyst) on sustainable finance for SMEs, and Marco Marchese on the environmental footprint of SMEs.

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Box 1. Key messages

- SMEs are a major source of greenhouse gas emissions and energy consumption. According to recent OECD estimates, they account for 37-40% of business-driven emissions and 43-52% of business-driven energy consumption at the EU level.
- The recent energy crisis due to Russia's war of aggression against Ukraine has cast further light on the essential role of energy efficiency in supporting the green transition of SMEs, and in addressing the rising share of SME turnover absorbed by the cost of electricity and natural gas which, according to recent OECD estimates, has increased from 4% to 6.4% between 2018 and 2022.
- Digital technologies play a key role in strengthening energy efficiency and offer significant untapped potential to reduce the energy consumption of SMEs. Two important areas of application are *measurement and control* and *automation.*
- *Smart metering* and *energy monitoring systems (EMS)* are among the most suited tools for digitally-enabled energy efficiency in SMEs, as they enable the monitoring of energy consumption patterns which can facilitate behavioural changes. Further, digital management software or smart building solutions can use advanced sensors – i.e. the Internet of Things (IoT) – to automate and optimise energy consumption.
- SMEs face specific challenges for the adoption of these technologies, such as limited financial resources, lack of awareness and management skills, which create a digital readiness gap compared to larger companies.
- Key policy considerations to foster the adoption of green-relevant digital technologies by SMEs include leveraging existing communication channels between SMEs and business organisations, providing easy access to energy advice, targeting energy-intensive SMEs, and connecting awareness and training measures to financial incentives.
- In addition to energy efficiency, digital technologies also offer opportunities to help SMEs to move to circular-economy business models (i.e., resource efficiency) and to facilitate their adoption of renewable energy microgeneration.
- Sustainable finance is one of the key enablers of SME greening, as access to finance is a key barrier that SMEs face, due to lack of awareness and ability to comply with nonfinancial disclosure requirements.
- Key issues to strengthen access to sustainable finance by SMEs include understanding SMEs' different pathways to net zero; designing policies and regulations that consider their impact on SMEs; and strengthening the transparency and inter-operability of sustainability-related data, definitions, and standards.
- SMEs are not only technology adopters in the green transition, but they can also be the source of major green innovations. Green entrepreneurship policies typically cover areas such as R&D and innovation (e.g. through targeted R&D tax credits and collaborative research programmes), skills (e.g. through business incubation and acceleration systems) and green public procurement.

Introduction

Digitalisation plays an important role in the sustainable transformation of SMEs. Digital technologies can enable improvements in energy efficiency, for example through the use of smart gas and electricity meters. Similarly, they can support the adoption of circular-economy business models, improve the traceability of products, support the diffusion of the sharing economy, and facilitate compliance with sustainability reporting requirements. Digital technologies also play a role in the diffusion of distributed renewable energy generation technologies (microgeneration). Nonetheless, SMEs face barriers to the uptake of digital technologies for the green transition, including lack of skills and insufficient financial resources for investment.

This paper analyses key issues and possible policy solutions to foster the use of green digital technologies by SMEs, with a special focus on energy efficiency, building on ongoing work of the OECD Committee on SMEs and Entrepreneurship (CSMEE) on the green transition of SMEs and green entrepreneurship. It begins by presenting new OECD estimates on the environmental footprint of SMEs, building on the OECD CSMEE project "Towards a pilot dashboard of SME greening and green entrepreneurship indicators". First estimates from this project show that SMEs account for about 40% of business-driven carbon emissions at the EU level, making a compelling case that governments cannot achieve net-zero emissions without the active involvement of SMEs in green industrial policies. The central part of the paper focuses on how digital technologies can support the green transition of SMEs. This part builds on ongoing work of the OECD CSMEE on "SME digitalisation and energy efficiency", yet to be published. The final two sections examine the role of sustainable finance for SMEs and green entrepreneurship to drive the sustainable transformation of the small business sector.

Assessing energy consumption and GHG emissions in SMEs: New OECD estimates

SMEs are the backbone of our economies, accounting for 69% of employment, 59% of turnover and 45% of exports (OECD, 2023[1]). But what is their environmental impact? Is the impact of SMEs on the environment comparable to their impact on the economy and society at large? While estimates on the SME share of value added and employment have been available for a long time, estimates on SMEs' share of greenhouse gas (GHG) emissions and energy consumption are relatively uncommon, possibly giving the false impression that SMEs need not be so concerned by the green transition as their individual impact on climate change is small. New OECD estimates suggest the contrary, however. While it is true that SMEs are comparatively less present in emissions-intensive industries such as refineries and steelmaking, their sheer number means that their aggregate emissions cannot be overlooked if governments are to achieve the current emissions targets.

The OECD has produced new estimates on five SME greening indicators to have a better understanding of the environmental impact of SMEs (OECD, 2023[2]): i) the SME share of greenhouse gas emissions in the business sector; ii) the SME share of energy consumption in the business sector; iii) SME carbon intensity; iv) SME energy intensity; and v) SME energy price burden. Box 2 provides a glimpse on the methodology behind these estimations. The rest of this section presents aggregate figures for three of the five indicators.

Box 2. Methodology for estimating the SME greening indicators

Recognising the scarcity of data on direct emissions by SMEs, the OECD has adopted a top-down approach that disaggregates data typically available at the sectoral (activity) level, covering both large firms and SMEs, to estimate the contribution of SMEs to GHG emissions and energy consumption. The approach applies output weights (i.e., SME share of value added) and employment weights (i.e., SME share of employment) to aggregate environmental indicators of GHG emissions and energy consumption. To reflect very different levels of carbon emissions and energy consumption across sectors, output and employment weights are applied at the two-digit sector level (42 sectors for carbon emissions and 37 sectors for energy consumption), which improves on previous similar approaches computed at the one-digit sector level (12 sectors), mostly only for GHG emissions.

It is worth noting that in the case of the energy indicators sector nomenclatures are different between structural business statistics, which are the main source of information for the construction of employment and output weights, and energy balances accounts, which are the main source of information for energy indicators. Therefore, different methodological steps have been necessary to match the data from these two databases and estimate the SME share of energy consumption, as well as the other two energy indicators (intensity and price burden).

Full estimates, as well as the detailed methodology, are available in the paper: OECD (2023), "Assessing greenhouse gas emissions and energy consumption in SMEs: Towards a pilot dashboard of SME greening and green entrepreneurship indicators".

Source: (OECD, 2023[2]).

SME shares of GHG emissions and energy consumption in the business sector

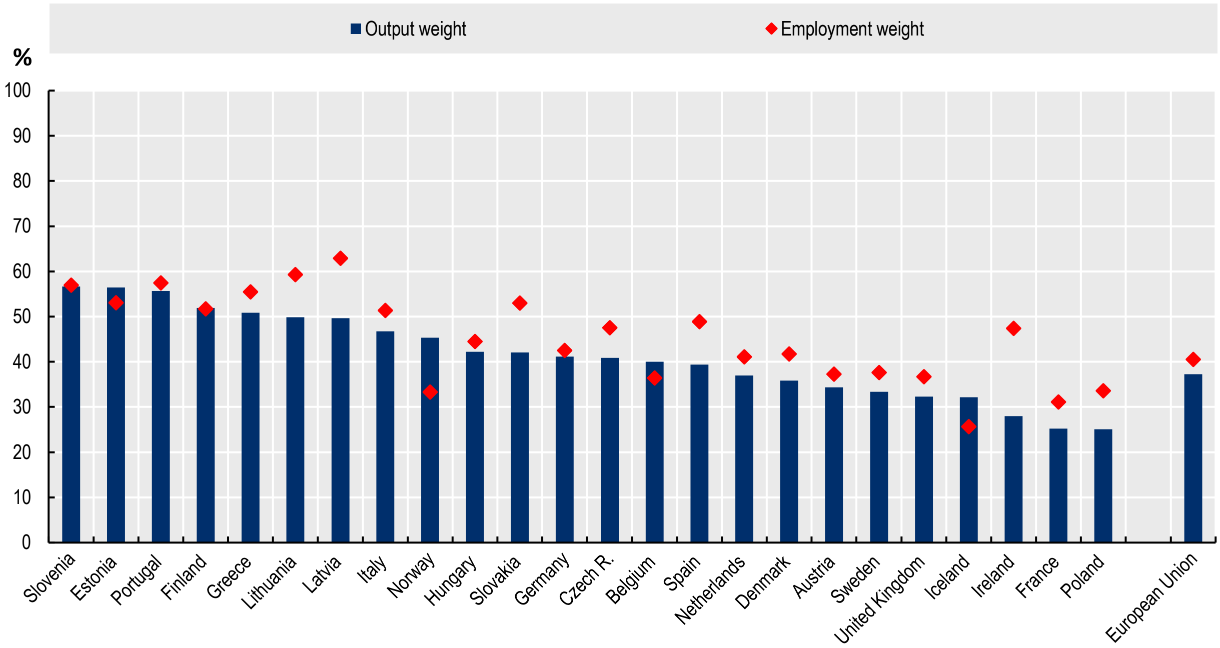
Figure 1 presents estimates for the SME share of GHG emissions in the whole business sector, based on output weights and employment weights, as defined in Box 2. The business sector includes manufacturing, services, and construction, but excludes agriculture and public administration activities. In general, as also shown in other graphs, the use of employment weights results in higher estimates of the environmental footprint of SMEs, which in part reflects the average lower productivity of SMEs compared to larger companies.

Looking at the range of values for this indicator, based on the output weight, the SME share of GHG emissions in the business sector varies between 57% in Slovenia and 25% in Poland, with the aggregate EU level standing at 37%[2]. Based on the employment weight, the range is between 63% (Latvia) and 26% (Iceland), with the EU aggregate level standing at 40.5%, 3.5 percentage points higher than in the first case.

Figure 1. SME share of GHG emissions in the business sector, 2018

Percentage of total GHG emissions in the business sector

[2] Because data presented in the report refer to 2018, before the withdrawal process of the United Kingdom (UK) from the European Union (EU) was finalised, EU aggregate values include the UK.

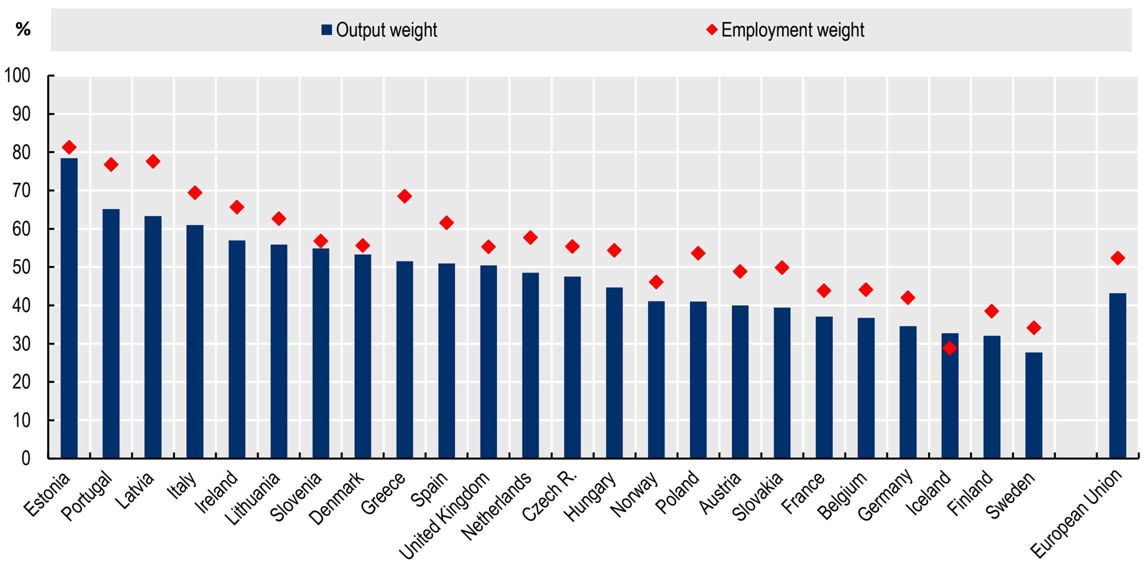


Note: Output weight is the SME share of value added at two-digit sector level. Employment weight is the SME share of employment at two-digit sector level.
Source: (OECD, 2023[2]) (OECD calculations based on Eurostat's Air Emissions Database and Structural Business Statistics)

Figure 2 shows the SME share of energy consumption in the business sector. In this case, OECD estimates show that when output weights are used, the SME share of energy consumption varies between 78% (Estonia) and 28% (Sweden), with the EU level being 43%. When employment weights are used, the range becomes slightly wider, i.e., between 81% (still Estonia) and 29% (Iceland), with the EU value standing at 52%, 9 percentage points higher than in the first case.

Figure 2. SME share of energy consumption in the business sector, 2018

Percentage of total energy consumption in the business sector



Note: Output weight is the SME share of value added at two-digit sector level. Employment weight is the SME share of employment at two-digit sector level. Energy indicators do not include the Transport sector.
Source: OECD (2023[3]), (OECD calculations based on Eurostat's Energy Balances Accounts and Structural Business Statistics).

SME energy price burden

This indicator is particularly relevant in the wake of the 2022 energy crisis caused by Russia's war of aggression against Ukraine. It measures the impact of the cost of electricity and natural gas on SME turnover and is presented in percentage terms relative to turnover. To assess the impact of the energy crisis on SME activity, an estimate for the first semester of 2022 was produced based on 2018 levels of SME electricity and gas consumption and 2022 (first semester, S1) energy price levels. More specifically, the prices of electricity and natural gas in the first semester of 2022 are multiplied by the 2018 levels of SME electricity and natural gas consumption and divided by the 2018 levels of SME turnover, which was the latest year for which data was available at the time of this exercise. However, given that SME turnover and energy consumption may also have changed in the face of energy price volatility, the 2022 estimates of this indicator should be considered approximate.

This indicator is affected by the presence of fossil fuel subsidies at national level – i.e., countries with higher levels of subsidies will show a lower energy price burden, as the indicator takes into consideration the final consumer price. The 2022 value, however, is also affected by the overall exposure of different countries to natural gas as a main source of electricity and feedstock for certain energy-intensive industries, as well as by the policy responses put in place by governments to shield businesses and households from the increased cost of energy following Russia's war of aggression against Ukraine (see Box 3.).

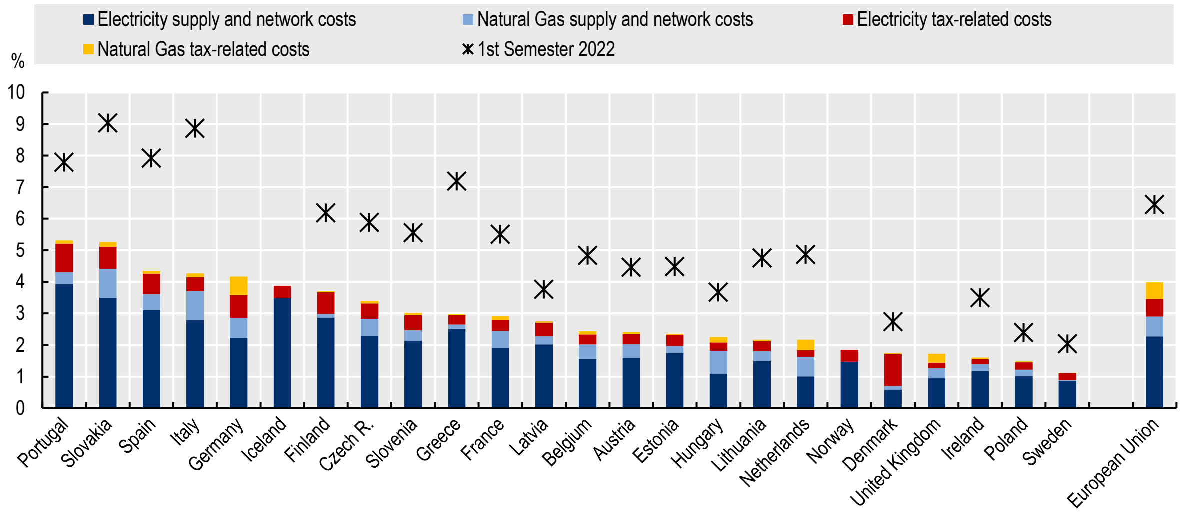
Against this backdrop, Figure 3 shows that the SME energy price burden in 2018 was the highest in Portugal and Slovakia (5.3% of turnover in 2018) and the lowest in Sweden (1.1%), with the EU aggregate level being 4%. The SME energy price burden increased significantly in the first half of 2022 across all countries.[3] In 2022, the countries with the highest SME energy price burden were Slovakia (9%) followed closely by Italy (8.9%). The increase at the EU aggregate level was also remarkable, from 4% to 6.4%.

The impact of the energy crisis on business turnover has cast further light on the importance of energy efficiency as a driver of both reduced carbon emissions and productivity growth. Digital technologies can enable energy efficiency improvements, for example through the adoption of technologies that improve operational efficiency at the firm level or that enable monitoring and assessment of consumption. The following section dives deep into this topic, presenting barriers to and drivers behind the adoption of green digital technologies in SMEs, as well as policies that can support this process.

[3] As of end-October 2022, price information for the first semester of 2022 was not yet available for the following countries: Denmark, Germany, Iceland, and the United Kingdom.

Figure 3. SME energy price burden in the business sector, 2018 and 2022 (1st semester)

Impact of electricity and natural gas costs on SME turnover



Note: This indicator covers the cost of electricity and natural gas consumption, but not of other sources of energy such as the direct use of oil in the production process. For this indicator, we follow a four-staged approach. Firstly, we estimate the share of electricity and natural gas consumption in total energy consumption across sectors. Secondly, we apply the SME share of energy consumption at two-digit sector level, which we had previously calculated, in equal way to consumption volumes of electricity and natural gas to gauge SME consumption. Thirdly, we multiply these two volumes by the average non-household price of electricity and natural gas. Finally, we put the final energy cost (electricity and natural gas) in relation to SME turnover. There is no data for natural gas in Iceland and Norway.
Source: OECD (2023[3]) (OECD calculations based on Eurostat's Energy Balances Accounts and OECD Structural and Demographic Business Statistics (SDBS) database).

Box 3. Taking stock of one year of SME policy responses to the energy crisis

In February 2022, Russia's war of aggression against Ukraine caused one of the worst energy crises in decades, propelling the price of natural gas to unprecedented levels from June to August 2022. Because of the way power markets function, the surge in the price of natural gas had an immediate and direct impact on the price of electricity, extending the effects of the crisis beyond energy-intensive industries that use natural gas as feedstock in the production process. Although the price of natural gas eventually declined after summer 2022, most government measures introduced at the peak of the crisis were still in place as of mid-2023, which reflects the delay with which wholesale prices are passed into retail contracts (i.e. pass-through effects), as well as continued uncertainty in energy markets.

In April 2024, the OECD released a paper taking stock of one year of policy responses to the energy crisis from an SME perspective. In the context of this work, "SME policy responses" are defined as all government policies, whether SME-specific or not, which have lowered or affected in other ways the price of electricity and natural gas which SMEs have paid during the energy crisis.

SME policy responses were grouped into three broad categories: i) price-support measures, such as gas/electricity price caps and tax rebates on gas/electricity bills; ii) income-support measures, such as energy-related tax credits, grants, subsidised loans, and credit guarantees; and iii) complementary measures, which have included monetary and non-monetary incentives to help companies invest in the green transition and become better aware of energy efficiency. This third group of measures are considered complementary in the context of the energy crisis, but they are pivotal to the green transition of the business sector in the immediate future.

At the beginning of the crisis, in the first half of 2022, the paper finds that government interventions mostly focused on energy-intensive sectors where SMEs are generally underrepresented. As the war continued, however, many governments in the most affected countries ramped up the scale and scope of their action, reaching more sectors and businesses, including many more SMEs. Two common approaches to achieve this objective have been extending energy price caps initially conceived for households to micro-enterprises and lowering electricity and gas consumption thresholds that companies had to meet in order to claim a government benefit.

Price-support measures, especially price caps, have been the main and most expensive government policy, often committing between 2% and 4% of national GDP in the largest European countries. Although these programmes often had an initial short duration of 6-12 months, the majority of them were still in place as of mid-2023 and set to last at least until the end of the year. Income-support measures have been used less extensively in the context of the last energy crisis, although there have been some exceptions (e.g., Italy, Austria and Ireland). Grants, in particular, were mostly used in the first phase of the crisis for energy-intensive companies, especially those in trade-exposed sectors. In addition, they have also sometimes been made conditional on the achievement of other objectives, such as improved energy efficiency.

Overall, evidence on one year of policy responses to the energy crisis suggests that liquidity support in the form of price-support measures has played a major role in avoiding a global recession. Nonetheless, trade-offs have also emerged, as price-caps blur the energy price signal and, therefore, may slow down the green transition by keeping energy consumption patterns unchanged. Furthermore, these measures weigh heavily on public finances at a time of high inflation. The paper concludes that price-support measures should be phased out and that government funding should rather focus on facilitating the green transition of the business sector, including SMEs.

Source: (OECD, 2023[4])

Digital technologies for the green transition of SMEs

This central part of the paper includes three main sections. The first section describes the main areas of application of digital technologies in the green transition of SMEs, making a distinction between automation, measurement and control, and micro-generation. The second section provides an overview of the main barriers which SMEs face in the uptake of these technologies. The third and final section discusses the main policies which can help SME overcome these barriers.

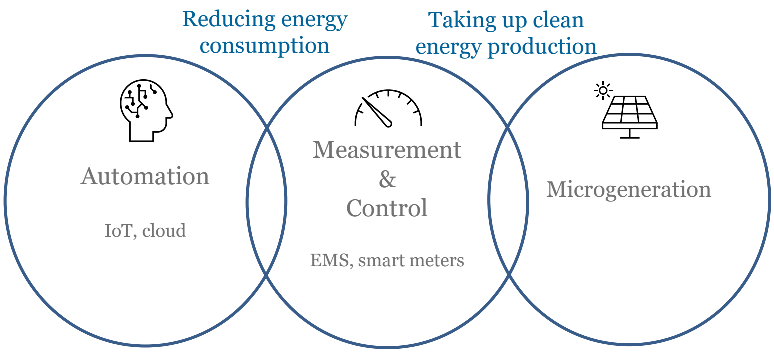
Main green digital technologies for SMEs

Digital technologies can help reduce GHG emissions caused by SMEs by promoting energy efficiency and facilitating the adoption of renewable microgeneration. In clean energy transitions, energy efficiency is often called the "first fuel" due to its triple function of delivering quick carbon mitigation, lowering energy bills and strengthening energy security (IEA, 2023[6]). The recent energy crisis has further amplified the business case for accelerating the transition to more energy-efficient business models and practices.

Digital technologies are often behind energy efficiency improvements; for example, digitalised energy systems equipped with smart appliances allow for monitoring energy consumption, flexible adaption to changing energy demands, and targeted supply of energy at the lowest cost. Similarly, digital technologies can support the adoption of renewable energy sources (i.e. microgeneration from solar photovoltaics or small wind turbines) and its integration into national grid, thereby helping to reduce carbon emissions from fossil fuels at the source.

Three main green digital technologies can be identified which are particularly relevant to SMEs: i) Measurement and control; ii) automation; and iii) and microgeneration (Figure.4). First, SMEs which are willing and able to leverage digital tools to improve energy efficiency need to optimise their use of data, as gathering better consumption data is the first step to identify waste and conceive feasible solutions. Second, digital management software can leverage advanced sensors (IoT) and algorithms (e.g., machine learning) to automate such optimal solutions. Finally, SMEs can become energy producers themselves, micro-generating low-carbon energy to minimise electricity consumption from the grid or even contribute energy to the grid.

Figure.4. Three major areas of application of digital technologies to reduce SMEs' carbon emissions



Source: Author's elaboration.

Measurement and Control

Smart electricity/gas meters and energy monitoring systems (EMS) are easy-to-adopt digital solutions to improve energy efficiency at firm level, as they allow businesses to monitor energy consumption patterns and change behaviour accordingly.

Smart meters can help SMEs reduce energy use by up to 40% at little or no extra cost by providing improved data and better understanding of energy consumption patterns (IEA, 2022[7]). For example, latest forecasts from the UK government anticipate an energy consumption reduction of around 3% due to the about 31 million smart meters installed in households and businesses at the end of 2022 (Chan et al., 2023[8]). Smart meters are a particularly fitting solution for SMEs, as they involve low adoption and installation costs and provide easy-to-use data information which can potentially lead to a change in energy consumption patterns (B. Janda, Bottrill and Layberry, 2014[9]) (Hilger et al., 2022[10]).

Energy monitoring systems (EMS) go beyond measuring total consumption (as done by smart meters) by collecting data at a submeter level.[4] In doing so, they enable the analysis of the electrical distribution system (Hilger et al., 2022[10]). Ranging from mobile measurement solutions to more investment-intensive stationary systems, their added value consists in disintegrating the energy consumption structure by gathering data through different submeters, which allows for measuring energy consumption at different steps of the production process (Hilger et al., 2022[10]). Furthermore, EMS that include different types of sensors using wireless communication technologies can provide access to real-time data on energy consumption and current electricity prices, and enable remote application monitoring (Panda et al., 2022[11]). The adoption of these more advanced EMS can allow SMEs to identify the most energy-intensive processes and to adjust consumption behaviour according to price signals, with an overall positive impact on the grid balancing.

Smart meters and EMS serve as the foundation for implementing digitally-driven energy management strategies. However, the true realisation of energy efficiency benefits will depend on effectively training SME owners on the potential of data-driven energy management practices (Hilger et al., 2022[10]).

Automation

Data on energy consumption can help make energy-efficient practices automated. Digital technologies such as smart lighting systems and fleet management[5] allow for automation and optimisation of energy demand through the use of big data. Research from the UK suggests that fleet management (mainly leveraging vehicle data), integrated building management and smart meters have the biggest potential to lead to energy savings in SMEs (Warren, 2017[12]). The remote control of devices through energy management systems (EnMS)[6] represents the simplest form of automation. Going further, automation through EnMS can replace inefficient user behaviour (Hilger et al., 2022[10]). Automatic control of IoT-enabled devices can support SME energy demand based on weather forecasts or light conditions (Whiffen et al., 2016[13]).

[4] Submetering refers to the measurement of specific sub-distributions and single consumers in an electrical distribution system (Hilger et al., 2022[10]), for example, it enables to compare energy consumption of different building compartments or production processes in the value chain.

[5] Fleet management refers to software-based solutions that help SMEs managing a vehicle fleet to optimise fleet usage and service routes and reduce fuel consumption by leveraging vehicle data (including vehicle types driving routes, number of stops etc.) (Gov UK, 2016[78]).

[6] Energy Management Systems can be broadly defined as a framework for energy consumers to manage their energy use (UNIDO, 2021[76]), as such, they usually integrate Energy Monitoring Systems.

Other examples from smart manufacturing show how automation through digital technologies can boost energy efficiency at the level of the entire production process. When production lines are equipped with IoT sensors, systems can communicate with each other to find an optimal operating scenario (Rogers, 2014[14]). Similarly, in the realm of more complex operations, digitalised production processes can perform predictive maintenance – a practice increasingly adopted in various manufacturing and service industries (Selcuk, 2016[15]). Early detection of machine failures helps preventing production stops, thereby saving energy.

Microgeneration

Digital technologies also underpin the diffusion of renewable energy microgeneration systems, which can help SMEs save on their energy bills, reduce emissions and, in some cases, contribute to the grid and become a net energy contributor. For example, adoption of digital tools both at the grid and firm level can help to ensure an effective deployment of Photovoltaic (PV) installations. Examples of technologies on the firm side include digitally-enabled distributed PV registries, which can provide users with the information for the installation and management of PV installations, and smart inverters, which convert the electrical output of PV panels to the alternating current electricity often used by grids (IEA, 2023[16]).

Box 4. Digital technologies and the circular economy

In addition to energy-efficiency and renewable energy adoption, digital technologies can also support the use of circular-economy business models (e.g., ability to trace components and recycling viability) (ECERA, 2020[17]). The adoption of these practices can be achieved by harnessing different digital tools, such as IoT devices gathering real-time data on material usage. Increased connectivity also reduces transaction costs and risks connected to sharing goods (OECD, 2019[18]).

SMEs play a key role in making material circulation within the economy possible, notably in the role of suppliers of larger companies. Policy initiatives such as the *Digital Product Passport* proposed by the European Commission aim at enabling information-sharing across entire product lifecycles to promote the transition to the circular economy. To ensure full transparency along the value chain, it will be important to integrate SMEs into this regulatory framework, keeping in mind their specificities. However, although the introduction of this regulation is expected in 2024, it is still unclear whether it will initially focus only on large companies (World Business Council for Sustainable Development, 2023[19]).

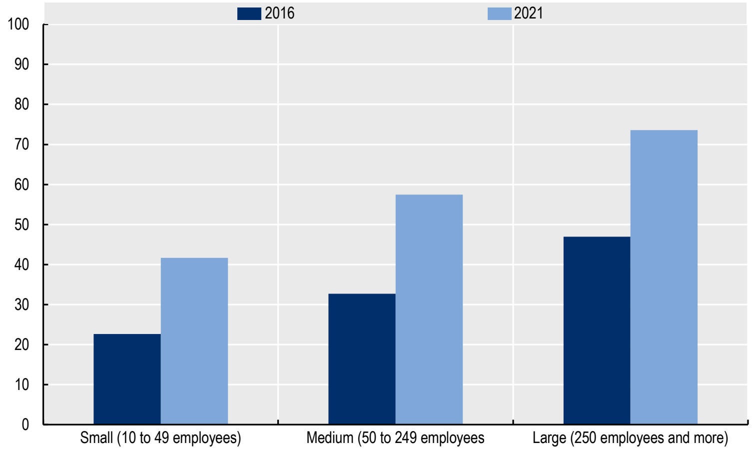
Barriers to the uptake of digital green technologies by SMEs

While digital technologies offer sizeable opportunities for the green transition of SMEs, this segment of the business population also face barriers to the adoption of these technologies, such as the lack of financial resources and poor management skills. Usually, energy management in SMEs tends to be informal, with only one or a few people in the company in charge of it, and generally shaped by daily routines, without a professional dedicated to it (Sa et al., 2015[20]; Fawcett and Hampton, 2020[21]). Besides the organisational barriers and lack of dedicated staff and internal capacities, Jalo et al. (2021[22]) identify the lack of time and prioritisation of non-energy-related working tasks as a main barrier to the adoption of efficient energy management practices in SMEs. Moreover, according to Mickovic and Wouters (2020[23]), SMEs tend to underestimate the saving potential of energy efficiency investments due to limited understanding of their energy costs.

The challenge of adopting digitally-enabled green technologies is linked to broader barriers to leveraging the benefits of digitalisation. A 2020-21 EU survey, for example, shows that less digitalised SMEs tend to have no clear digitalisation strategy in place (European Union, 2022[24]). Moreover, despite an increased uptake of digital technologies that are also relevant for energy efficiency improvements, such as cloud computing, SMEs still lag behind large companies when it comes to the uptake of those digital tools (Figure 5).

Figure 5. Small businesses lag behind large businesses in adoption of digital technologies, 2016 and 2021

Businesses purchasing cloud computing services (%) (OECD averages)



Source: OECD ICT Access and Usage by Businesses Database (2023[25]), https://stats.oecd.org/Index.aspx?DataSetCode=ICT_BUS (accessed 22 August 2023).

Box 5. Digital technologies and negative environmental externalities

Digital technologies can help reduce the energy consumption of SMEs. However, they can also have relevant environmental costs. Digital technologies themselves require energy, as well as other resources such as metals for the production of ICT hardware. In particular, ICT technologies consume considerable amounts of energy in manufacturing, distribution, use, and end-of-life phase (Bordage et al., 2021[26]). To illustrate, the Internet alone, including the activity of data centres, networks and ICT devices such as smartphones and computer screens, was responsible for up to 7% of the global electricity consumption and 3.8% of global greenhouse gas emissions in 2020 (Bordage, 2019[27]; Andrae, 2020[28]). Despite past energy savings due to efficiency gains, energy demand from digital technologies is expected to further increase in the future – due to increased use of technologies such as cryptocurrency mining, clouds, AI, IoT, and implementation of 5G (UNEP, 2021[29]). Furthermore, increased SME participation in e-commerce may lead to overall higher e-commerce activity. This, in turn, may result in greater energy consumption in the retail sector, particularly in the energy-intensive last-mile delivery process (Villa et al., 2023[30]). Further, the increased amount of packaging waste stemming from the steady growth of e-commerce in recent years represents a growing environmental concern (Escursell, Llorach-Massana and Roncero, 2021[31]).

A greater adoption of digital technologies by SMEs may also result in increased environmental harm from e-waste disposal. Recycling rates of ICT are high for primary scrap but minuscule for end-of-life products, such as smart phones (under 1% for ICT elements such as Gallium, Germanium, Indium and Tantalum) – due to low economic incentives for recycling of ICT elements and sizeable technical challenges (UNCTAD, 2020[32]). One major concern resulting from the existence of significant amounts of e-waste are informal recycling practices in the Global South in combination with poor environmental regulations and insufficient waste management, which can impact for example the microbial biodiversity, flora, and fauna in e-waste recycling sites (Purchase et al., 2020[33]).

SME policies for the uptake of green digital technologies

Existing evidence shows that in manufacturing – one of the three highest-emitting sectors and also among the least digitalised – only 67% of SMEs take measures to save energy, versus 81% of large manufacturing companies (European Union, 2022[34]), pointing to the urgency of policy action in this area. While the details of energy use by SMEs are still poorly understood, it is clear that SMEs have more limited resources to dedicate to professional energy management practices compared to large companies (Fawcett and Hampton, 2020[21]).

Ongoing work on green digital policies, including those promoting energy efficiency, shows that they differ significantly along different dimensions, such as the channels used to interact with SMEs (e.g., face-to-face, online), the type of advice (e.g., from tailored advice to sector-specific recommendations), different means of evaluating impact (e.g. online surveys, pre-post energy consumption comparison, qualitative feedback) and different organisations contracted to provide advice (external consultants versus trained employees).

However, green digital policies also share common features, such as:

- The twin objective of boosting SME productivity and reducing energy consumption;
- The provision of tailored advice, ranging from sector-specific recommendations to individual auditing and advice;

- The common use of of digital information instruments, such as energy consumption self-assessment tools or energy advice applications, to benchmark energy consumption levels and energy actions against those of peers and provide an initial gateway for further support.

In addition, the following key success factors have been identified for designing and implementing programmes that encourage energy efficiency in SMEs through the use of digital technologies.

- **Leveraging existing communication channels with SMEs, for example by working with business organisations as implementation partners.** Given the diverse nature of SMEs even within the same region and sector, energy efficiency advice is most effective when provided through personalised discussions, particularly in an atmosphere of trust thanks to already-established communication channels. A good example is the Australian *Business Energy Advice Program* (2019-2022), which is indeed implemented by a business association that can use existing close ties with its members.
- **Making advice services on energy efficiency easily accessible and actionable for SMEs.** SMEs have limited time and resources to dedicate to energy management. Thus, it is key to make energy advice or funding opportunities easily available (e.g., through online resources) and point to measures that involve low investment. For example, the *Mexican National Commission for the Efficient Use of Energy (CONUEE)* launched an online self-assessment tool in 2018 and a digital application in 2020 to provide sector-tailored energy advice to SMEs to support the development of energy efficiency projects.
- **Targeting energy-intensive SMEs.** Energy consumption patterns vary significantly among SMEs. Thus, it is crucial to provide tailored advice based on specific sectors, with a particular focus on those with highest levels of energy consumption (e.g., small manufacturers, the hospitality sector, and agricultural SMEs).
- **Linking awareness and training measures to financial opportunities, including incentives to take up renewable energy generation.** While awareness and initial identification of energy saving opportunities remain the first step, successful implementation of energy efficiency measures, including the adoption of digital tools, hinges upon overcoming financial barriers. For example, the Austrian programme *Funding for energy management in SMEs (2018–2025)* demonstrates how tailored energy advice can be combined with financial assistance to replace inefficient equipment. Starting with the identification of primary energy sources, the programme partially covers costs for investments in equipment including energy monitoring devices and potential certification of energy management systems. Another example is given by Australia, which offers subsidies to partially cover the cost of solar photovoltaic (PV) panels and other microgeneration technologies for small businesses (Australian Government, 2023[35]). It is important to consider that the effectiveness of these policies also depends on other factors, such as the ownership of business premises (Business NSW, 2022[36]).

The last two sections of the paper turn the attention to two key policy enablers of the green transition of SMEs, sustainable finance and green entrepreneurship, whose operations also often hinge on the extensive use of digital technologies.

The contribution of sustainable finance to the green transition of SMEs

Sustainable finance is critical for enabling SMEs to engage in green activities. A recent survey from the SME Climate Hub identifies access to finance as the key barrier for SMEs to take actions addressing climate change (SME Climate Hub, 2023[39]). As financing conditions become increasingly dependent on sustainability considerations, and as financial institutions (FIs) face non-financial reporting requirements that place a reporting burden on SMEs, it is likely that access to finance will become even more constrained, compounding existing difficulties for SMEs.

Ensuring that SMEs have access to tailored sustainable financing solutions to meet their net-zero investment needs is therefore critical for the net-zero transition (OECD, 2022[40]). This is true also for investments in energy efficiency measures, which may be associated with high upfront costs and low short-term returns (OECD, 2022[41]). For example, research on German SMEs shows that high upfront costs can impede SMEs' adoption of energy efficiency measures even when those measures are considered profitable (Fleitera, Schleich and Ravivanpong, 2012[42]).

The supply of sustainable finance has been growing rapidly in response to stakeholder demand and bank risk management in the net zero-transition. According to a recent OECD survey on *Financing SMEs for Sustainability – Financial institutions' strategies and approaches* (OECD, Forthcoming[43]), both public and private FIs are increasingly integrating climate considerations in their operations, including by developing institutional objectives and plans and assessing some or all of their financing and investment opportunities against environmental criteria. Some FIs are also providing dedicated financing programmes or more advantageous conditions for investments focused on green objectives, including through loans and factoring, credit guarantees and other financing instruments (OECD, Forthcoming[44]).

However, SMEs may not be able to tap into this growing pool of sustainable finance. Financial institutions increasingly need and seek out granular data on their clients' sustainability performance to manage risks, develop financing instruments and meet reporting requirements. SMEs are not as well-equipped as large entities to provide these data due to their relatively limited capacities to identify, measure and report on their environmental performance. This poses potential risks to SMEs' ability to access future financing. SMEs also risk losing access to finance if they cannot advance sufficiently rapidly on the journey to net-zero emissions or demonstrate credible transition plans. This is a strong risk particularly for SMEs in high-emitting and hard-to-abate sectors, which are the target of transition finance (OECD, Forthcoming[45]).

Limited demand by SMEs for sustainable finance is an equally important challenge, which is the result of information and awareness-related barriers, technical and regulatory uncertainty, and capacity and resource constraints. This has several important implications for policy and finance. SMEs need a stronger business case and external support to boost investments in sustainability and seek related financing. In the absence of SME demand, public and private FIs have limited incentives to develop tailored financing solutions for financing SMEs' net zero investment needs.

Critical considerations for enhancing the provision and uptake of sustainable finance for SMEs include:

- **Understanding SMEs' diverse needs and pathways to net zero and nature positive.** SMEs are composed of a diverse set of enterprises ranging from microenterprises with fewer than ten employees to mid-sized firms with hundreds of employees that may also be part of very complex global value chains. These enterprises have very diverse levels of understanding of the sustainability transition, diverse starting points in the net-zero journey, different awareness and capacities to, and different levels of resources. Public actors need to map out well the different actors and needs and devise tailored solutions accordingly.
- **Design policies and regulations to take potential impacts on SMEs into account.** As elaborated in the previous section, SMEs have more limited capacities and resources to devote to regulatory and policy compliance compared to large enterprises. Providing due consideration to SMEs in regulation and policy making may entail, for example, the development of proportionally less-demanding requirements that can meet the regulatory and policy needs without putting an excessive burden on SMEs. This can apply to mandatory or voluntary non-financial disclosure requirements.
- **Strengthen the transparency and interoperability of sustainability-related data, definitions and standards.** Lack of interoperability magnifies the burden on SMEs that must respond to

different data requirements or meet different criteria to access financing or value chains across different institutions and jurisdictions.

- **Ensure that a stable, transparent, and comprehensive policy and regulatory framework is in place to support investment and financing of the green transition**. Regulatory stability helps reduce uncertainty and incentivizes SMEs' investments in greening. The regulatory environment also plays a role in incentivizing FIs to integrate comprehensively climate- and nature-related considerations and risks into their operations, which can in turn create broader incentives for SME greening.
- **Provide financial support to address challenges impeding SME access to sustainable finance.** Financial support can entail direct financing from public entities through loans, equity or grants, or indirect support through guarantees and other instruments that can crowd in private financing for SME clients.
- **Provide non-financial support for SMEs to foster their access to, and uptake of, sustainable finance.** Non-financial support is critical to address knowledge, awareness and resource gaps that SMEs face in embarking and advancing on the journey to net zero and nature positive. It is also critical in enabling SMEs to measure and report on their progress.
- **Foster the sustainable finance ecosystem for SMEs by promoting dialogue and knowledge-sharing among diverse actors.** Many different actors must be mobilised to support SMEs' transition to sustainability, including regulators, policy makers, public and private financial institutions, ESG intermediaries, accountants, providers of digital financial and non-financial solutions and others. Fostering regular dialogue, knowledge-sharing and partnerships among these different entities is important for the transition. The OECD Platform on Financing SMEs for Sustainability supports this endeavour through analytical work, data collection, webinars, conferences and other knowledge-sharing events. It also seeks to support efforts to build consensus around the types of data that FIs should seek from SMEs to minimise their compliance burden.

The role of green entrepreneurship

Entrepreneurship has an important role to play in making progress towards green growth objectives. In general, entrepreneurship is widely recognised as boosting economic activity and stimulating job creation (OECD, 2020[46]). Increasingly, entrepreneurship is also being recognised as a means of addressing societal challenges, including environmental sustainability. The role of entrepreneurs in this area is twofold:

- By developing and bringing to market innovative products, entrepreneurs can propagate environmentally sustainable solutions throughout the economy.
- By taking steps to improve the environmental sustainability of their businesses, entrepreneurs can collectively have an impact on progress towards green objectives.

The promotion of green entrepreneurship is complex because social returns typically exceed private returns (Gompers and Lerner, 2001[47]). Also, there are high fixed costs in the research and development stages and high risks in the commercialisation phase, suggesting that a reliance on private markets alone would be suboptimal (Popp, 2012[48]). Furthermore, policy uncertainty is linked to possible changes in both innovation (e.g. changes in tax credit mechanism for R&D investment) and environmental policy (e.g. cancellation of a carbon tax, which may hamper the market for a new green service/technology).

Box 6. Defining green entrepreneurship

Despite much discourse over the past 20 years, a consensus on the definition of “green entrepreneurship” has yet to emerge. Building on previous OECD work on green entrepreneurship (OECD/Eurostat, 1999[49]; OECD, 2011[50]), and recent concepts used across OECD countries, green entrepreneurship is considered as the development and deployment by new start-ups of green products, services and processes, i.e. those that either:

- reduce or prevent any type of environmental damage; or
- emit less pollution and waste, and/or are more resource-efficient than equivalent normal products, services and processes that have the same result. Their primary use, however, is not one of environmental protection.

This understanding of green entrepreneurship covers entrepreneurs who create and commercialise products by forming new start-ups that help to tackle environmental challenges, rather than the broader population of entrepreneurs and micro businesses who are taking steps to reduce their businesses’ environmental footprint. It also focuses on the role of new enterprises in developing green products, as opposed to green innovations taking place within established companies. The definition is not limited to any specific sectors, issues or drivers.

This concept of green entrepreneurship is broadly consistent with previous frameworks for measuring green entrepreneurship (OECD, 2011[51]) but two important advances are put forward. First, it makes a strong distinction between pre-start-up and early-stage entrepreneurship activities and those undertaken by existing firms. Second, it does not limit itself to businesses whose primary or secondary activities are in core environmental sectors.

Governments in OECD countries have introduced a wide range of policies and schemes to stimulate and support green entrepreneurship in recent years. These include measures that seek to build a demand for green solutions, as well as direct support measures for entrepreneurs. Despite the variety of measures introduced, policies and schemes are still in their early stages of development. Most governments have developed green entrepreneurship supports by adapting instruments used for supporting innovation and entrepreneurship more generally. Little is known about the effectiveness of green entrepreneurship support measures, but some success factors can be identified from leading international cases, such as building funding pipelines (ensuring sustained and organised flow of investments into green startups), fostering networks and engaging the private sector. Non-government actors can also play an important role. This includes wealthy individual donors who support green projects (i.e. through philanthropic capital), as well as cluster and industry organisations that support green innovation and specialised community organisations that offer training or other support services.

The provision of direct support to green entrepreneurs is one way that governments can foster green entrepreneurship. Improving access to finance is a critical area for policy intervention given the greater risks and longer time to market for green innovations. Governments across the OECD are using a range of debt, equity and hybrid instruments to support green entrepreneurs, often managed through public financial institutions (see previous section). Another important area of intervention is to support the development of green skills among entrepreneurs and help eco-innovators commercialise their work. Some small-scale training programmes have been implemented across OECD countries, but an emerging approach is to provide integrated support packages through dedicated cleantech or climate tech incubator and accelerator programmes. However, there is still only a very small number of such specialised incubator programmes. It is also important for governments to create and expand green markets, including through the use of regulatory changes (e.g., energy efficiency standards).

Based on existing work of the OECD on green entrepreneurship, the following policy lessons can be drawn to better promote green entrepreneurship.

- **Integrated governance:** Many policy actions put forward by public authorities are managed by a common effort that connects different authorities, ministries and public agencies. Developing high levels of co-operation between public entities for the promotion of green entrepreneurship is important because it enables a greater degree of policy coherence and effectiveness (OECD, 2021[55]). For example, many green entrepreneurship programmes in Israel are a shared effort of different public entities such as the Israel Innovation Authority, the Israel Investment Centre, and the Ministry of Environmental Protection.
- **A "whole business" approach to support green entrepreneurship:** The path to success for entrepreneurs requires significant efforts in a variety of different areas and a "whole business" approach can respond to different needs as their arise. In Canada, for example, the Business Development Bank of Canada (BDC) adopts a segment-based approach that provides tailored support to entrepreneurs depending on the businesses' size and growth trajectory. For instance, BDC Capital has an arm dedicated to businesses with an intellectual property (IP) portfolio, providing them with patient capital and guidance from experts with experience in funding companies with intangible assets.
- **Green entrepreneurship is not only about cleantech:** High-tech green businesses are often referred to as cleantech businesses, and green entrepreneurship is typically associated with cleantech businesses involved in the development of technologies, products and services that help to address climate change. Entrepreneurs involved in these endeavours can benefit from being embedded within technological ecosystems and connected with financing partners, including venture capitalists. The cleantech industry is growing rapidly, with the sector's global market volume reaching EUR 4.6 trillion in 2021. Although high-tech green entrepreneurship (or cleantech) is rightly a focus for policy makers, it is also important to acknowledge the role that low-tech projects can play in achieving environmental objectives. Examples of low-tech green entrepreneurship include plant-based restaurants (serving mostly vegetables, fruits, nuts and whole grains) or consultants providing advice on the implementation of green solutions. It is important to ensure that public support schemes also address the needs and challenges of low-tech green entrepreneurs, to avoid a situation in which these businesses fall through the cracks[7].
- **Development of strategic partnerships to advance green entrepreneurship:** Governments invest in building networks of public and private sector stakeholders to support green entrepreneurs in many OECD countries. These networks are an invaluable resource for green entrepreneurs because they can offer knowledge, expertise, as well as access to funding and market opportunities. Government actions can play an important role in the development of strategic partnerships with business associations, private incubators, universities, and other relevant stakeholders. In Canada, BDC uses its network of 100 business centres across the country to provide in-person services to entrepreneurs with more complex borrowing needs. At the same time, it collaborates with both private and public sector organisations to increase their outreach and to engage more actively with entrepreneurs who want to contribute to environmental goals. These partnerships create a more favourable environment for starting and growing a business.
- **Overcoming funding gaps:** Green entrepreneurs often face higher levels of difficulty in accessing finance for their environmental projects. This is due to a variety of factors including a more extended

[7] Examples of public projects that support low-tech green entrepreneurs are the SwitchMed project in Israel and the DBU's Green Startup Programme in Germany.

path to market, policy uncertainty and the capital-intensive nature of many environmental projects, which can deter business angels, venture capital funds or other financial investors from lending. OECD countries with green entrepreneurship policies are working on this challenge by developing a range of initiatives to reinforce the financial support that is available to green entrepreneurial projects, particularly in the areas of clean technologies. In Canada, BDC created the Cleantech Practice, which invests in globally competitive cleantech firms as they discover and commercialise ways of combatting climate change and pollution. Many of BDC's financing options provide long-term funding with flexible repayment terms, alleviating some of the challenges encountered by green entrepreneurs in funding capital-intensive projects over extended periods of time. In Germany, the GreenUpInvest initiative aims to involve business angels and other early investors in the field of green start-ups. The Israel Innovation Authority's Seed Programme supports start-ups in areas with stringent regulation, while the Ideation Programme helps entrepreneurs to develop a technological proof-of-concept, which in turn assists them in raising private funding or finding a business partner for further development.

Conclusions

The paper has started by showing how new OECD estimates on the environmental footprint of SMEs demonstrate the substantial collective impact that SMEs have on the environment. The recent global energy crisis, which has resulted into an increased cost of energy for SMEs, has cast light on the need to accelerate the transition to more energy-efficient practices, which can reduce operational costs and environmental impacts, while strengthening business resilience to external shocks.

Digital technologies can play a key role in supporting the implementation of energy and resource efficiency measures and the adoption of distributed renewable energy generation solutions by SMEs. Due to their low installation workload and good cost-benefit ratios, digital technologies such as smart meters and energy monitoring systems offer the most suitable means for SMEs to measure and control their energy consumption. In addition, automation, for example through IoT-enabled devices, can further yield energy efficiency gains. Finally, renewable energy microgeneration, which involves SMEs generating their own energy (e.g., through photovoltaics), can help promote the diffusion of renewable energy technologies in the overall economy.

Despite the potential of digital technologies for the green transition, SMEs face specific challenges for the adoption of these technologies, such as limited financial resources, lack of awareness and weak management skills, which result in informal energy management practices and low prioritisation of energy management-related tasks. A broader challenge is linked to the digital readiness gap which many SMEs experience compared to larger companies. Policy lessons from selected OECD country experiences on promoting digital tools for SME energy efficiency include the importance of leveraging existing communication channels between SMEs and business associations, ensuring easy accessibility to energy efficiency advice, focusing on energy-intensive SMEs, and linking awareness measures with financial support to implement energy-saving recommendations.

Sustainable finance plays a key role to support the green transition of SMEs especially since, as noted above, access to finance is a major obstacle to the implementation of green investments for many small businesses. Policy lessons in sustainable finance for SMEs include understanding the diverse needs and pathways to net zero of the SME population; devising policies that take the impact on SMEs into account; strengthening transparency and interoperability of sustainability-related data and requirements; ensuring a stable regulatory framework; combining financial and non-financial support; and fostering the sustainable finance ecosystem through dialogue and knowledge-sharing among a diverse set of actors.

Finally, entrepreneurs have an important role to play in advancing the climate agenda. Policy makers have introduced various measures to support green entrepreneurship, such as improving access to finance, fostering green skills, and creating and expanding green markets through regulatory changes and green procurement. Crucial factors to consider in designing green entrepreneurship policies are the need for integrated governance and strategic partnerships while overcoming existing funding gaps.

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