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A Comprehensive Model for Developing SME Net Zero Capability Incorporating Grey Literature

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Abstract: SMEs collectively account for a significant proportion of greenhouse gas emissions and so there is a need for urgent action to be taken by SMEs in the journey to achieve net zero. In this article, we provide a comprehensive conceptual framework for SMEs to draw from in the journey towards net zero by synthesizing the academic and grey literature. By bringing together key strands of the literature, we derive a conceptual model that provides a clear pathway for SMEs to embark on their net zero journeys. The framework we invent involves understanding the position of the SME in the value chain, understanding the pressures from stakeholders, undertaking greenhouse gas accounting to measure current levels of carbon emissions, undertaking internal changes towards the net zero agenda, undertaking external facing changes towards the net zero agenda, uncoupling, community participation, and updating business activities regularly. This model acts as a progressive decision-making and continuous improvement framework that will be an asset to SMEs as they undertake net zero activities. Overall, the paper contributes to the sustainability literature by being the first to synthesize the academic and grey literature to develop a comprehensive conceptual framework for SMEs to attain net zero.

Keywords: net zero; SMEs; sustainability; climate change; enterprises; grey literature; greenhouse gases; emissions

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1. Introduction

To keep the rise in global average temperatures within certain limits, science implies that there is a finite budget of carbon dioxide that is allowed into the atmosphere, alongside other greenhouse gases [1]. It is for this reason that around 197 countries have agreed to limit global warming to below 2 °C and to make efforts to limit global warming to 1.5 °C under the Paris Agreement. They include China, the countries of the European Union and the United States, the world's three largest greenhouse gas emitters [1]. Meeting the 1.5 °C goal with a fifty per cent probability translates into a remaining carbon budget of 400–800 $GtCO_2$. Staying within this carbon budget requires CO_2 emissions to peak before 2030 and fall to net zero by around 2050 [1,2].

Beyond this, any further carbon release must be balanced by removal into sinks [3]. This is because of the monotonic, positive and near-linear relationship between cumulative net anthropogenic CO_2 emissions and CO_2-induced surface warming [1,4]. The consequence of this result is that CO_2-induced warming halts when net anthropogenic CO_2 emissions halt (i.e., CO_2 emissions reach net zero) [5]. Thus, to turn net zero into a useful frame of reference for various decision makers, the global carbon constraint needs to be translated into individual decarbonisation pathways for nations.

The term "net zero" (or 'carbon neutrality') is used to refer to a state where, in broad terms, the level of CO_2 and equivalent emissions released into the atmosphere is balanced by that being removed or securely stored. In other words, net zero refers to achieving a balance between the amount of greenhouse gas emissions produced and the amount

removed from the atmosphere [6,7]. The UK definition of a small to medium enterprise (SME) is generally any organisation that has fewer than 250 employees and a turnover of less than €50 million or a balance sheet total of less than €43 million [8].

The UK aims to decarbonise all sectors of its economy and reduce CO_2 emissions to net zero by 2050 [9,10]. Achieving net zero by 2050 will require a transformation of business across the UK. To this end, SMEs must play a vital role in sustainability because of their significance to the UK economy. Accounting for 99 per cent of all UK businesses, SMEs are crucial to whether the UK meets this 2050 net zero target. SMEs are the bloodline of the UK economy, generating 52 per cent of annual UK GDP [8]. SMEs also account for three-fifths of employment and half of the total turnover of the UK's private sector.

SMEs collectively account for around half (43–53%) of greenhouse gas emissions by UK businesses [10]. When households and the public sector are added to the mix, SMEs account for around a third (29–36%) of total UK emissions [10]. The most greenhouse gas (GHG)-intensive industries in the UK are energy supply, agriculture, water supply, mining, transport, and manufacturing (ONS,2019). Greenhouse gases are gases in the earth's atmosphere that trap heat in the atmosphere. The seven direct greenhouse gases under the Kyoto Protocol include; (1) Carbon dioxide (CO_2), (2) Methane (CH_4), (3) Nitrous oxide (N_2O), (4) Hydrofluorocarbons (HFCs), (5) Perfluorocarbons (PFCs), (6) Sulphur hexafluoride (SF_6), and (7) Nitrogen trifluoride (NF_3), [9]. CO_2 (the biggest contributor to climate change) accounts for about 79% of all U.S. greenhouse emissions, Methane accounts for 11%, Nitrous Oxide accounts for 7%, and Fluorinated Gases account for 3% [11].

SMEs have a huge task and opportunity to help the UK meet its net zero 2050 target and understanding how their current activities contribute to carbon emissions and what needs to be done to meet the net zero target is vital if the UK is to achieve net zero by 2050. The UK is a principal actor in the net zero discussion because the industrial revolution started in the UK and soon spread to the rest of the world, including the United States [12]. As industrialisation spread, CO_2 emissions naturally increased [13]. In this regard, it is not possible to ignore the aggregate impact of SMEs on CO_2 emissions. SMEs can not only reduce their emissions; they can also have an important indirect influence on the climate agenda through their influence on other actors, including suppliers, customers, and other organisations [14].

In this article, we contribute to the extant literature by providing a comprehensive conceptual framework for SMEs to draw from in their net zero transitions. We do this by synthesizing commonalities across SME operations primarily in the UK, but also often drawing from other relevant contexts and kneading together the academic literature and non-academic perspectives from the grey literature. The research objectives for this paper are given below:

- Research objective 1: To determine what the barriers that prevent SMEs from engaging in net zero activities are based on the academic and grey literature.
- Research objective 2: To determine what the drivers for SMEs to engage in net zero activities are based on the academic and grey literature.
- Research objective 3: To derive a conceptual framework to help SMEs achieve net zero capability based on the academic and grey literature.

Our motivation for this paper is to bring the grey literature into the academic literature on SME net zero activities. Grey literature can broaden the scope of literary analysis to include more recent and relevant studies, thereby providing a more complete assessment of available evidence [15–17]. Grey literature is a field in library and information science that deals with the production, distribution, and access to multiple document types produced on all levels of government, academics, business, and organization in electronic and print formats not controlled by commercial publishing i.e., where publishing is not the primary activity of the producing body [18,19].

Grey literature is produced at all levels of academia, business, government, and industry in print and electronic formats not controlled by commercial publishers [20]. Grey literature can include academic papers, conference papers and abstracts, discussion papers,

government reports, committee reports, newsletters, conference proceedings, program evaluation reports, standards/best practice documents, technical specifications and standards, and working papers [21]. Grey literature is troublesome to search and locate because there are no central sources, such as libraries or databases, where it is collected or housed. It thus requires considerable time and effort to locate [15–17].

Despite the difficulty in locating grey literature, purely empirical research-based reviews and papers have been criticized for their inability to provide meaningful conclusions about complex interventions and a national or regional context for differences in implementation [20,22]. It is for this reason that reviewing grey literate is preferred in the case of complexity in intervention and outcomes as is the case concerning SMEs and their net zero activities. Often, variations in outcomes cannot be explained by only reviewing empirical academic research-based studies because the actual mechanisms occurring within the intervention and useful ideas about the implementation of interventions are habitually not described [22,23]. In addition, there could be a lack of consensus, low volume and quality of evidence, complex outcomes and interventions, and important contexts for implementing interventions [20]. Such factors may be critical to support policy and program decisions regarding how SMEs can help to achieve net zero [22,24].

This paper is unique because it proposes an implementation framework for SMEs to implement their net zero strategies based on the academic and grey literature. Since this domain is not well researched within academia, this study develops an understanding of the multi-criteria relationships for SME decision making when implementing net zero activities. The rest of the paper proceeds as follows: we review the extant academic literature and then explain our materials and methods before discussing key themes that highlight the barriers and drivers for SMEs who wish to engage with the net zero agenda. We then build and explain our framework based on the academic and grey literature and then conclude.

2. Literature Review

The extant literature suggests that SMEs play a crucial and pivotal role in the reduction of carbon emissions and in addressing climate change [6,25–27]. For example, research argues that because SMEs account for 13% of global energy usage, there is a need for SMEs to take a proactive approach to contribute to reducing global carbon emissions [28].

However, many SMEs are still dominated by a very narrow world view which is primarily framed around economic growth as opposed to the contribution of their economic activities to climate change and global carbon emissions [2,26,29]. Within this context, the achievement of net zero capabilities is also being applied in a community where critical values around environmental protection are personal [6,28,30,31]. This makes the process challenging as the focus now shifts to SME behaviours and characteristics alongside external influences [32,33]. It follows that SMEs can generate net zero capability by implementing a range of strategies that reduce greenhouse gas (GHG) emissions and contribute to sustainable development. We conduct a thematic review of some examples of these strategies next.

2.1. Measuring and Managing Carbon Emissions

One element which can be used by SMEs to answer the economic problem and to change their views on the climate issue is proper measuring and managing of carbon emissions to ensure that adequate importance is given to reducing emissions. Firstly, the measuring of carbon emissions helps SMEs realise what their GHG footprint is. This does, however, come with its challenges as active monitoring will be required so that SMEs can balance between carbon emissions and the amount they offset [29]. Thus, the key aspect at this point is SMEs need to undertake an audit of their current climate footprint which will act as a benchmark for the carbon offset. Any such benchmark must take into account all emissions associated with traditional business operations including energy consumption, transportation, and waste [28].

Secondly, the process of change is not without its challenges and in the context of climate change and global footprints, many SMEs might need to go through a process of digital transformation [34,35]. This process of transformation includes adopting new technologies and systems that enable better tracking and reporting. In developing a process of measurement and management, SMEs can also measure their GHG emissions using tools such as the GHG Protocol, and then set targets for reducing them. After GHG emissions have been measured, they can then be managed using insights gained during the measurement phase. Overall, SMEs can benefit from cost savings, increased competitiveness, and improved reputation by measuring and managing their carbon emissions [2].

2.2. Adopting Renewable Energy Sources

SMEs can reduce their carbon footprint by using renewable energy sources such as solar, wind, or hydropower. To reduce their global GHG footprint, there is also an onus on SMEs to adopt renewable energy sources because SMEs account for 13% of global energy usage [28]. Technologies which can harness solar, wind and geothermal power offer significant advantages in reducing GHG footprints compared to traditional fossil fuels [36–38]. This reduction in footprint can also lead to other benefits; for example, the installation of solar panels or wind turbines on roofs or premises can act as a catalyst to generate electricity cleanly and efficiently, lowering operating costs and reducing reliance on grid power [6,33,39].

This approach towards renewable energy can also act as a marketing platform and can focus on environmentally conscious customers. While the benefits of adopting a net zero strategy are many, there are still considerable challenges which organisations need to consider when employing renewable energy, mainly upfront costs. These upfront costs may be a challenge for some SMEs. Investigating financial possibilities, such as grants and loans, that assist the development of renewable energy sources is one way to surmount this problem [30,40]. Joining community solar programmes or renewable energy cooperatives, which offer access to renewable energy sources without the need for substantial capital commitments, is a more creative solution to this problem for SMEs [6,41]. Renewable energy is becoming increasingly cost competitive and can provide a stable source of energy for SMEs [26,33,42].

2.3. Improving Energy Efficiency

SMEs can also reduce their energy consumption and emissions by improving the energy efficiency of their buildings and equipment. This can include measures such as upgrading insulation, installing energy-efficient lighting and appliances, and optimizing heating and cooling systems [2]. Research also suggests that there are many ways for SMEs to improve efficiency to minimise carbon footprints [28,33]. For many SMEs, the focus on improving energy efficiency is a key business strategy with targets set by the central government [31,43]. With minimal up-front costs, the implementation of such a strategy is a low-risk approach to a fundamental problem [44]. The benefits of such an approach allow SMEs to decrease their energy usage, operational expenses, and carbon footprint without having the huge upfront costs of installing renewable technology.

SMEs can improve their energy efficiency through a variety of mechanisms and methods. One example is conducting an energy audit, which is useful for identifying areas of waste and expense. This may entail locating inefficient lighting systems, obsolete heating and cooling systems, and other energy-intensive equipment [45]. The other approach is more holistic and companywide, involving education and support for all stakeholders. This requires educating people about energy-saving practises and changing their behaviour to improve efficiency. Simple actions such as turning off lights and appliances when not in use and encouraging employees to take public transportation, ride their bikes, or carpool can help reduce energy consumption and carbon emissions [46].

2.4. Implementing Circular Economy Principles

Another popular approach to reducing waste and maximising efficiency is the utilisation of circular economy approaches and strategies [47]. The principles of the circular economy provide a framework for long-term economic development by reducing waste and optimising resource utilization. SMEs are critical players in the global economy, but due to limited resources and knowledge, they frequently face unique challenges in adopting circular economy principles. Thus, a cheap and efficient approach to reducing environmental impact and achieving net zero capability is useful [44].

These principles, from an organisational perspective, also provide significant benefits to SMEs, including the reduction of material and production costs while promoting resource efficiency and sustainability by implementing closed-loop supply chains and designing products for circularity [37]. This is, in the view of the researchers, a critical approach to embracing sharing and collaborative consumption models; SMEs can reduce capital expenditures while also encouraging social responsibility and community engagement [48]. Overall, SMEs can adopt circular economy principles, such as reducing waste and reusing materials, to minimize their environmental impact.

2.5. Collaborating with Other Businesses and Organizations

Finally, there is scope to reduce carbon emissions and accomplish net zero through collaboration with other businesses and organisations [27,33,37]. In many cases, SMEs lack the resources, knowledge, and expertise to implement sustainability measures on their own. SMEs can work with suppliers, customers, industry groups, and local governments to share knowledge, resources, and best practices for achieving net zero emissions. SMEs can also accelerate their sustainability journey by collaborating with other businesses and organisations to share resources, knowledge, and best practices. Supply chain engagement, joint ventures, partnerships, and knowledge-sharing networks are all examples of collaboration [48]. These collaborations can assist SMEs in identifying and implementing opportunities to reduce carbon emissions, implement renewable energy solutions, and reduce waste [46]. Furthermore, collaboration can assist SMEs in gaining access to funding, technology, and other resources that they might not have otherwise.

By working together, SMEs can share knowledge, resources, and expertise to achieve common sustainability goals and reduce their environmental impact. Collaboration with other businesses and organisations can provide significant benefits to SMEs while also reducing their environmental impact [47]. SMEs can reduce costs, increase efficiency, and gain access to new markets and customers by collaborating. Furthermore, SMEs can improve their reputation and attract environmentally conscious customers and partners by demonstrating a commitment to sustainability and social responsibility through collaboration.

3. Materials and Methods

In addition to the literature we have already reviewed, the search terms 'Net Zero' and 'SMEs' were used jointly to search the titles and abstracts in three research databases, namely—Scopus, Business Source Complete (EBSCO) and Google Scholar. Scopus was chosen for its expansive multidisciplinary coverage, while Business Source Complete (EBSCO) and Google Scholar were used as supplementary databases for the opportunity to offer a cross-mapping or triangulation check on Scopus. We found a total of 24 articles that were directly relevant to our net zero SME review. The largest proportion were from Scopus (documents: $n = 13$, secondary documents: $n = 3$, patents $n = 1$), followed by Google Scholar ($n = 7$), and then Business Source Complete (EBSCO) ($n = 3$). Figure 1 gives a diagrammatical representation of the documents from Scopus and reveals that interest in SMEs' contribution to net zero has increased in recent years.

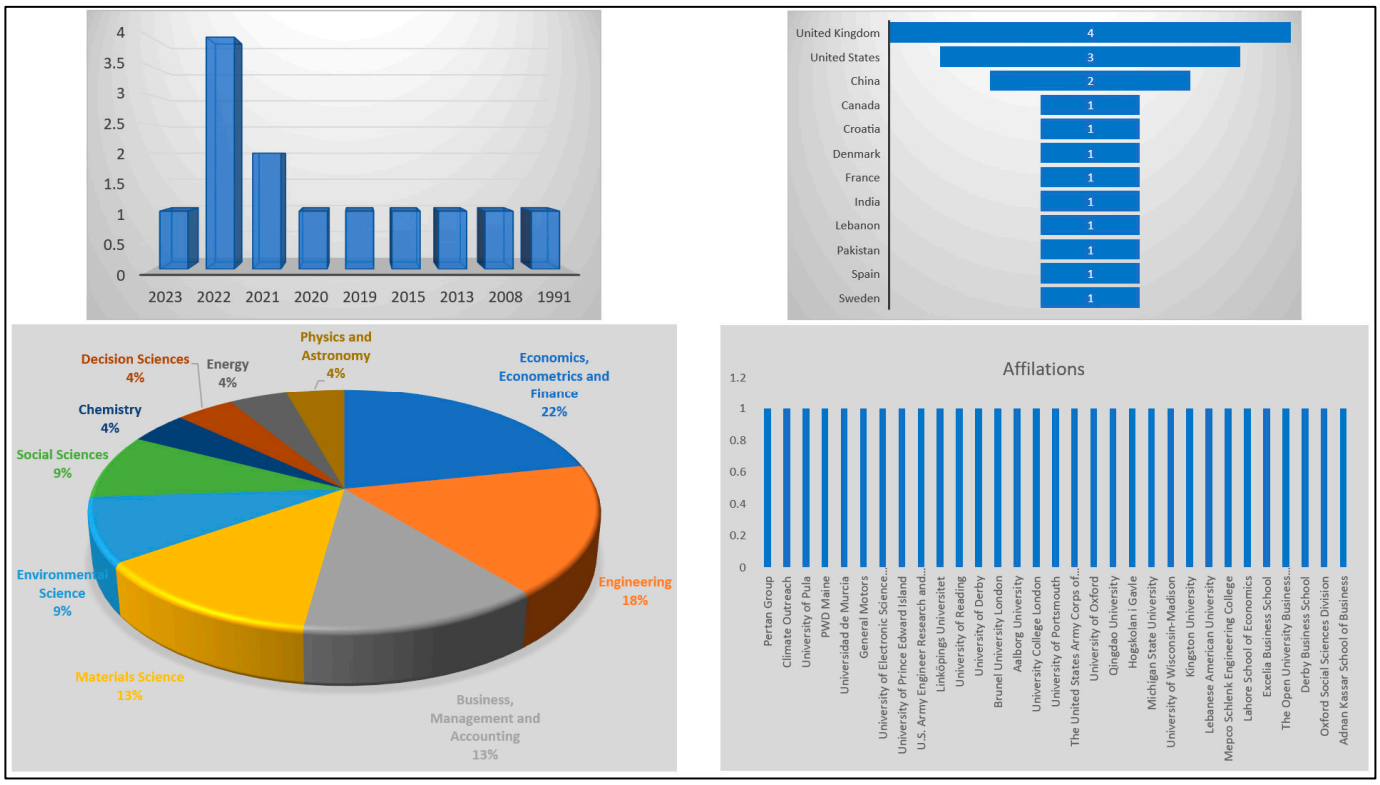

Figure 1. Scopus documents by year, country or territory, subject area and author affiliation (Source: Authors' analysis).

The UK has been the largest contributor to this research area and the subject area and affiliations of contributors have been varied. After the elimination of duplicates from all three databases, these articles were then supplemented with other grey literature comprising recent publications by the Bank of Scotland [10], the largest professional body for environmental practitioners in the United Kingdom and worldwide, the Institute of Environmental Management and Assessment [42], the Carbon Trust [2], and the World Economic Forum [27]. Other key academic and grey literature that we included in our thematic literature review in Section 2 after this process was completed is shown in Table 1.

Table 1. Some other key grey and non-grey literature incorporated (Source: Authors' analysis).

Authors	Title	Year	Source Title	Document Type
Carbon Trust [2]	The Journey to Net Zero for SMEs	2022	Carbon Trust	Publication
Blundel, R., Hampton, S. [6]	How can SMEs contribute to net zero?: An evidence review (no. 51), state of the art reviews	2021		Article/Report
Luong et al. [7]	Northern Ireland SMEs and the Net Zero target amidst the COVID-19 pandemic	2021	ERC Research Report	Research Report
Bank of Scotland (BOS) [10]	From Now to Net Zero: a practical guide for SMEs	2020	Bank of Scotland	Research Report
OECD [26]	No Net Zero without SMEs: Exploring the Key Issues for Greening SMEs and Green Entrepreneurship	2021	OECD SME and Entrepreneurship Papers	Article/Report

Table 1. *Cont.*

Authors	Title	Year	Source Title	Document Type
World Economic Forum (WEF) [27]	The "No-Excuse" Framework to Accelerate the Path to Net-Zero Manufacturing and Value Chains	2023	WEF	White Paper
Hampton et al. [28]	Transforming small and medium-sized enterprises to address the climate emergency: The case for values-based engagement	2022	Corporate Social Responsibility and Environmental Management	Article
Kesidou, E., Ri, A. [30]	Drivers and Performance Outcomes of Net Zero Practices from UK SMEs", Research Paper 95, Enterprise Research Centre	2021	Enterprise Research Centre	Article/Report
Wilkinson-Dix, Jack. [31]	How can policy better support SMEs in the pathway to Net Zero?	2022	policycommons.net	Article/Report
Institute of Environmental Management and Assessment (IEMA) [42]	Pathways to Net Zero: Using the IEMA Green House Gas (GHG) Management Hierarchy	2020	IEMA	Publication
Afolabi et al. [49]	Exploration of small and medium entities' actions on sustainability practices and their implications for a greener economy	2022	Journal of Applied Accounting Research	Article
Groot et al. [50]	Business models of SMEs as a mechanism for scaling climate smart technologies: The case of Punjab, India	2019	Journal of Cleaner Production	Article
Johansson et al. [51]	Impact evaluation of an energy efficiency network policy programme for industrial SMEs in Sweden	2022	Resources, Environment and Sustainability	Article
Kenington et al. [52]	Encouraging energy efficiency in United Kingdom independent retail? The case of the butcher, fishmonger and cycle-shop	2020	Energy Research and Social Science	Article
Mirza et al. [53]	The impact of green lending on banking performance: Evidence from SME credit portfolios in the BRIC	2023	Economic Analysis and Policy	Article
Paterson et al. [54]	Towards a conceptual framework of enterprise support for pro-environmental small and medium-sized enterprises: A contextualised review of diverse knowledge domains	2022	Local Economy	Review
Afolabi et al. [55]	Attitudes and Perspectives of SMEs' Sustainability Reporting Toward Transition to the Net Zero Carbon Emissions	2023	Emerald	Research Paper
Fenton et al. [56]	Exploring SMEs attitudes to Net Zero & social media: Action Case research as a force for good	2022	British Academy of Management	Conference Paper
Liesen et al. [57]	Energy master planning toward net zero energy installation—Portsmouth Naval Shipyard	2015	ASHRAE Transactions	Conference Paper/Book

The Bank of Scotland commissioned Yonder to understand the perspectives of SMEs on sustainability issues and the challenges they face on their road to Net zero [10]. The research combined expert insight from industry and academia as well as the viewpoint of the SMEs themselves. It covered a survey of more than 1000 SME business leaders across the UK; in-depth interviews with 10 sustainability experts; six focus groups with SME business leaders and follow-up conversations with individual business leaders. The research gives a comprehensive picture of where SMEs are on their journey, and of their views and concerns about what Net zero means for their businesses, and so was useful in helping us to develop a conceptual framework that is based on the experiences of SMEs themselves. The IEMA [42] publication updates IEMA's widely used Green House Gas Management Hierarchy, with additional guidance considerations and planning diagrams that are useful for SMEs. The focus of this IEMA [42] publication is on optimum carbon reductions. The publication recognises that the climate emergency now requires an escalation of action across all fronts and offers practical solutions for SMEs, and is thus useful for our conceptual framework.

In the same manner, the Carbon Trust is an expert partner for businesses, governments and organisations around the world—helping them decarbonise and accelerate to net zero. The Carbon Trust provides solutions to the climate crisis by supporting organisations globally as they accelerate towards net zero. From target setting, net zero pathways, assurance and footprinting, to policy advice, strategy setting and programme delivery, the organisation seeks smarter ways to turn intent into impact, where sustainability and economic realities go hand in hand. The Carbon Trust [2] publication we employ aims to guide SMEs and relevant stakeholders on how SMEs can best undertake the journey to net zero. Finally, the World Economic Forum (WEF) was established in 1971 as a not-for-profit foundation and is headquartered in Geneva, Switzerland. It is independent, impartial and not tied to any special interests. The WEF strives in all its efforts to demonstrate entrepreneurship in the global public interest while upholding the highest standards of governance. The WEF [27] white paper we incorporate seeks to provide detailed information to businesses on how they can operationalize their commitments and address their carbon emission challenges throughout their operations and supply chains. These four publications, the grey literature we uncovered, and pertinent academic literature were the principal methods of deriving our conceptual framework.

4. Results

The UK was the first major economy to pass a net zero emissions law via legislation in 2019 [58]. This target commits the UK to a legally binding target of net zero emissions by 2050. Although this is an ambitious target, a climate emergency is driving several other economically advanced countries to commit to deep reductions in net emissions. For example, Sweden and Scotland have committed to net zero by 2045, and Denmark, France, and New Zealand by 2050. A majority of the academic and grey literature we uncovered emanated from the UK because of its ambitious agenda and the net zero emissions law.

To put the situation in the UK in context, CO_2 emissions in the UK increased by 6.3% to 341.5 million tonnes (Mt), and total greenhouse gas emissions by 4.7% to 424.5 million tonnes of carbon dioxide equivalent ($MtCO_2e$) between 2020 and 2021 [38]. Although total greenhouse gas emissions in the UK are 47.3% lower than they were in 1990 [38], they are nowhere near net zero. To combat this, government environmental regulations could restrict the use of GHG-intensive technologies [59]. Environmental taxes, such as the Emission Trading System (ETS) could also increase the cost of operating pollution-intensive processes and technologies. However, 99% of the EU27's non-financial businesses are SMEs, the majority of which are not covered by ETS, the core policy tool used in the EU for reducing greenhouse gas emissions in Europe [60].

A UK Emissions Trading Scheme (UK ETS) replaced the UK's participation In the EU ETS on 1 January 2021, but data on SMEs who participate in this scheme are not

available [61]. In the same vein, the government could stimulate green innovation through policies that provide incentives in the form of subsidies and grants that shift investments towards green R&D [62]. These kinds of incentives are highly relevant to SMEs because even though large corporations play a pivotal role in making green innovations more acceptable, SMEs are more prone to generate and implement radical green innovations [63].

A UK government study found that SMEs could save up to 25% of their energy consumption through cost-effective efficiency measures including upgrading building fabric, replacing lighting, heating and cooling equipment, and other process machinery; and implementing energy management systems [6]. SMEs can recoup their investment in implementing these measures through energy savings within a few years [64]. Moreover, the same study estimated that 37% of the savings could be achieved with zero capital investment [65], including turning down thermostats and switching off electronic equipment. Carbon emissions from electricity use can also be reduced by shifting the time of day at which energy-intensive processes are carried out.

Cleaner production technologies can modify the production process and stimulate the adoption of carbon-reducing practices, but net zero practices vary in their effects on environmental and business performance. For example, research from Germany indicates that only those net zero practices that increase production efficiency significantly can boost business performance [66]. SMEs can update their practices by considering best practices in green purchasing and procurement, sustainable supply network management, green transportation and logistics (including for employees), and green packaging and storage [30,67]. In the same vein, investing in net zero business training allows businesses to adopt a systematic approach to increasing the environmental awareness of employees. This also helps businesses to appraise, structure, and enhance the knowledge and capabilities of employees on environmental matters [68].

There is extensive literature addressing the reasons why it is difficult to improve the environmental performance of SMEs, and the dominant framing for this is as barriers and drivers [6,30]. The barriers and drivers approach provides a suitable and organised way of investigating the challenges linked with reducing the environmental impact of SMEs. It has also influenced the design of policy interventions in the UK and internationally [30,49]. We present the dominant barriers and drivers in Table 2.

Table 2. Barriers and drivers for SME net zero activities (Source: Authors' analysis).

Barriers	Drivers
(1) The costs of transitioning to cleaner technology/access to capital.	(1) Pro-environmental values.
(2) Uncertainty about the business environment.	(2) Legislation and government targets.
(3) Uncertainty about the usefulness of greener technologies.	(3) Some net zero activities could be cost saving.
(4) Lack of specialist knowledge about greener technologies.	(4) Some net zero activities may provide a competitive advantage.
(5) Scarcity of time and other resource constraints.	(5) Some net zero activities could open new market opportunities.
(6) Unclear energy management responsibilities.	(6) Pressure from customers and other stakeholders.
(7) Split incentives and priorities for SMEs.	(7) Corporate reputation.
(8) Lack of control over certain aspects of SME operations (for example domestic and international supply chains and short-term tenancy agreements).	(8) Government grants or subsidies
(9) Limitations in absorptive capacity.	(9) Risk mitigation.
(10) Limitations in organisational learning.	(10) Staff morale.
(11) Lack of trusted brokers/intermediaries.	(11) Voluntary agreements and self-regulation.
(12) Lack of awareness about greener technology products and the net zero agenda.	(12) Conditions for access to some sources of finance.
(13) Disinformation.	(13) High operational costs due to rising energy and related bills.

However, the concept of barriers and drivers in this context has been criticised, arguing that they fundamentally misunderstand organisational behaviour by assuming they are

'rational' economic actors. Understanding organisational behaviour as the outcome of a much wider set of socio-technical factors offers a more useful approach, which can more effectively inform policy [50].

4.1. Barriers to SME Net Zero Activities

Different studies describe a variety of barriers to the adoption of energy efficiency measures by SMEs. These barriers usually vary by industry/sector, size of SME, geographies, market behaviour and amount of legislative support [51–53]. For example, a lack of legislative support in certain sectors typically reduces the probability of the adoption of cleaner technology in those sectors. The take-up of measures by SMEs to adopt net zero measures could be low due to such barriers [69].

The literature seems to agree that the most significant barriers are the costs of transitioning to cleaner technology, access to capital, uncertainty about the business environment and usefulness of greener technologies, lack of specialist knowledge about greener technologies, scarcity of time and resource constraints, unclear energy management responsibilities, split incentives and priorities, and a lack of control over some aspects of SME operations (for example domestic and international supply chains and short-term tenancy agreements) [7,31,50,52]. These barriers generally do not incentivise SME owners to make long-term investments that could contribute to reaching net zero.

SMEs might also often be hampered by a lack of strategic alignment between their goals and that of the net zero agenda [6]. This might be especially true for manufacturing sector SMEs that typically report other priorities not aligned towards the net zero agenda, less time to implement sustainability measures, and a lack of information about energy efficiency measures [51]. Some authors also stress that trading opportunities may not be present for green-minded SMEs and so there may be low financial rewards for adopting cleaner technologies [33,70].

Related to this line of thought, SMEs may also suffer from having internal and external stakeholders that may not benefit from the net zero agenda [54]. This is because greener technology innovations may not be suitable for some risk-exposed SMEs and their stakeholders [50]. Other SMEs report that the cost of meeting regulations or standards and the uncertain demand for low-carbon products or services are major obstacles to committing to net zero practices [7]. Other researchers also highlight barriers on the supply side (e.g., financial costs), and the demand side of cleaner technologies (e.g., conflict with traditional methods). These studies identify low awareness of climate change, limited understanding of what works in different contexts and difficulties in proving the added value of CSA technologies as factors constraining the adoption of clean technologies [50]. Furthermore, false claims on climate change undermine the existence or impacts of climate change, the unambiguous human influence on climate change, and the need for corresponding urgent action. Such disinformation erodes trust in climate science and its perpetrators increasingly use 'distract and delay' tactics to delay much needed action.

While government support is seen as a driver of net zero activities, there are barriers to the adoption of low-carbon technologies even when there is government support, as has been seen in the case of European Regional Development Fund (ERDF)-funded projects. These are mostly due to the short project timeframes of most government projects, the involvement of partners with limited experience in net zero projects, lack of learning and knowledge exchange between projects, lack of coordination with other government SME decarbonisation policies, and the possible 'crowding-out' of private activity [31].

The time horizon for net zero itself could be a potential hurdle as SMEs may be particularly concerned about the payback time for investment in decarbonisation and other sustainability initiatives. The year 2045 appears so far in the future for many that it seems out of reach for many SMEs who could find it both impractical and unrealistic [10]. As one might expect, the COVID-19 pandemic was also a major obstacle to clean technology

adoption reported by SMEs in Northern Ireland and the rest of the UK [7], although some researchers report that even in the context of the COVID-19 pandemic, there was a strong, statistically significant relationship between both technological and organisational net zero practices and business performance, proxied by employment growth [30].

4.2. Drivers for SMEs Net Zero Activities

The principal reasons for SMEs to take part in net zero activities have been framed as drivers [6,30]. There are two categories of drivers, namely external and internal. External drivers are those forces outside the SME that encourage it to engage in net zero activities while internal drivers are forces within the SME that stimulate it to engage in net zero activities. External drivers entail government policies that encourage SMEs to reduce carbon emissions, voluntary regulations imposed by SMEs themselves, conditions for access to external finance, the desire to improve corporate reputation, and pressure from customers, whereas internal drivers include the motivation of businesses to improve their image, generating comparative advantage, environmental concerns and to reduce costs [6,35].

Government policies, either employing coercion or persuasion, can induce SMEs to adopt net zero practices. For example, mandatory social and environmental regulations (MSER) have been found to have an impact on firm innovation in China [71]. However, such policies need to be implemented coherently across different sectors and a mix of policies seems to be more effective [30,31]. Voluntary agreements by SMEs across the supply chain could induce businesses to commit to net zero [52,55]. In the same manner, voluntary GHG reporting might be relevant for SMEs, because it can be effective in monitoring how SMEs reduce their GHG emissions [60]. Such net zero strategies that focus on re-organising distribution processes across the supply chain can also reduce carbon emissions [72,73].

Some external funding from banks is only available to SMEs that engage in capital-intensive net zero practices. In the UK, for example, the now-privatised Green Investment Bank played a key role in financing renewable energy projects, as did the government's creation of the First Infrastructure Bank [30,53]. SMEs may invest in net zero practices to legitimise their business activities and gain approval from various national and international stakeholders. SMEs may also undertake net zero activities to enhance their image and reputation and these activities could be a result of customer feedback/demand or the desire to attract customers who prefer to patronise businesses that engage in net zero activities [26,56].

There is research that shows that environmental corporate social responsibility is positively associated with green innovation performance and also that shared vision capability mediates environmental corporate social responsibility, a green innovation performance link [74]. Interestingly, numerous SMEs, particularly those in the manufacturing of apparel and restaurant sectors, exhibit energy efficiency and differentiation in being environmentally friendly or sustainable [31]. Thus, being engaged in net zero activities may be a source of competitive advantage for SMEs. SMEs might simply want to 'do the right thing' and run their businesses responsibly and ethically, which benefits the planet [28,31]. Finally, the increasing costs of energy for heating, running machinery, and transportation could drive SMEs to adopt net zero practices.

4.3. Conceptual Framework for SME Net Zero Implementation Activities

The academic literature reviewed discussed the drivers and barriers to achieving net zero activities within SMEs. The academic literature reviewed has thoroughly investigated 'why' SMEs should be involved in NetZero implementation, and 'what' SMEs will need to overcome to achieve success in being carbon free. However, the academic literature has not incorporated the grey literature in providing a comprehensive guide on 'how' SMEs can achieve net zero. We reviewed the academic and grey literature on this topic and identified four frameworks that have been proposed for net zero implementation in the grey literature

that should be incorporated into the academic literature. The key stages involved in these grey literature frameworks are provided in Table 3.

Table 3. Key frameworks for the implementation of net zero strategies in the grey literature (Source: Authors' analysis).

Framework Used	Key Stages in the Framework
Bank of Scotland: From Now to Net Zero: a practical guide for SMEs [10]	1. Starting the process 2. Short wins and engaging employees 3. Measure, Mobilise, and Monitor 4. Future processes 5. Best practice cases
Institute of Environmental Management and Assessment (IEMA): Pathways to Net Zero: Using the IEMA Green House Gas (GHG) Management Hierarchy [42]	1. Eliminate 2. Reduce 3. Substitute 4. Compensate
Carbon Trust: The Journey to Net Zero for SMEs [2]	1. Make commitments 2. Calculate emissions 3. Renewable energy tariffs 4. Carbon reduction planning
World Economic Forum: The "No-Excuse" Framework to Accelerate the Path to Net-Zero Manufacturing and Value Chains [27]	1. Develop a net zero strategy 2. Create internal changes 3. Drive external improvements through collaboration 4. Develop a net zero culture

5. Discussion and Development of Net Zero Implementation Framework

The analysis of the limited academic literature and grey literature on net zero implementation identified the drivers for SMEs to embark on this journey. The drivers as discussed previously in the paper focused on aspects of cost reduction through green energy procurement, the market demand for zero emissions, brand image, and the requirement to meet government regulations around net zero. Although the analysis identified that it will be beneficial for SMEs to implement net zero capability, the papers have also identified challenges that impede this capability. The challenges identified through the literature analysis have focused on the reduction of short-term profits when implementing sustainable practices, lack of support from the supply chain and government for implementation, and lack of training. An important aspect to consider for SMEs is their position in the supply/value chain and the influence of the consumer/customer to overcome the challenges. The position of the SME in the value chain and the position of power will also determine whether the SME can access funding, support, and skills training.

Although several frameworks have been proposed in the grey literature, this paper is unique because it proposes an implementation framework for SMEs to implement their net zero strategies based on the academic and grey literature. Based on our analysis of the key stages in the existing frameworks as shown in Table 3, we propose that some crucial elements from the academic and grey literature on SMEs and net zero activities can be incorporated into a holistic conceptual framework to help SMEs attain net zero and present these elements and the framework in Figure 2.

Figure 2 depicts the conceptual framework for SMEs to achieve net zero capability. It provides a clear pathway for SMEs to embark on their net zero journeys and acts as a progressive decision-making framework as well as a continuous improvement framework. The framework comprises eight stages: (1) Understanding the position of the SME in the value chain; (2) Understanding the pressures from stakeholders; (3) Undertaking greenhouse gas accounting to measure current levels of carbon emissions; (4) Undertaking internal changes towards the net zero agenda; (5) Undertaking external facing changes towards the net zero agenda; (6) Uncoupling, Reduction and Substitution; (7) Us over Me; and (8) Updating regularly. Next, we explain each of these stages.

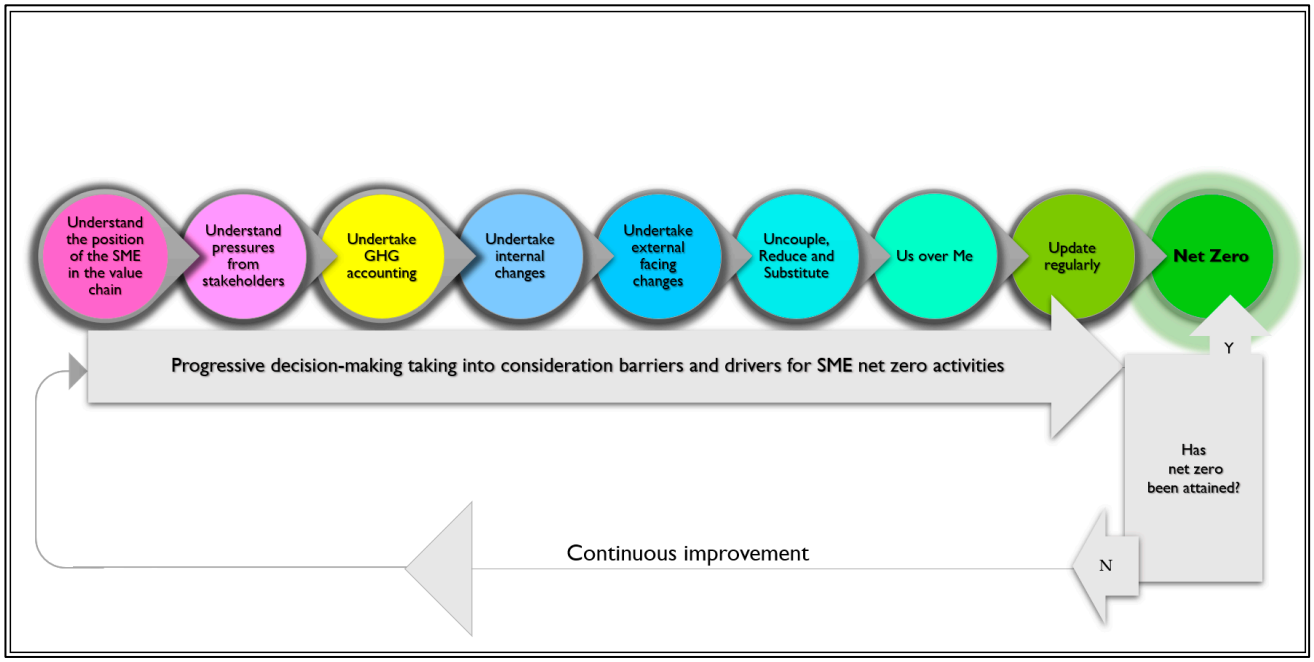

Figure 2. Framework for SMEs to achieve net zero capability (Source: Authors' analysis).

Stage 1: Understand the position of the SME in the value chain. The position in the value chain determines the level of engagement with the focal firm in the value chain that sets the performance targets for other entities in the chain [10,27]. This is essential because the activities and decisions of other entities within the value chain could affect the SME. The position of the SME in the value chain also determines the baseline business and operating model for the SME and the various strategies that it can engage in. For example, an SME that is high in the value chain will have more flexibility to adopt net zero activities and such an SME could more readily influence other entities. Conversely, if the SME occupies a low position in the value chain and can only stay profitable by engaging with firms higher up the value chain that are substantial carbon emitters, it will be hard to engage meaningfully with the net zero agenda [27,75].

Stage 2: Understand pressures from stakeholders. The position of the SME in the value chain not only sets the proximity of the SME to the focal firm, but also the proximity to the customer and other stakeholders. These stakeholders exert different types and levels of pressure on the SME and the SME needs to be aware of it. The typical transaction relationships (business to business or business to consumer) in which the firm typically engages must also be understood. If consumers are not sensitive to increases in price due to engagement in net zero practices, this can be a driver for the SME to engage in such practices [30,31].

Stage 3: Undertake greenhouse gas accounting to measure current levels of carbon emissions. SMEs need to create or invest in platforms that can monitor their GHG emissions and inform them about their emission levels [2,10,27,42]. This is a shared thread that runs across all of the grey literature. The importance of this has also been reported in the academic literature [33,55]. This can help SMEs to set targets that they can use to benchmark their carbon reduction efforts. SMEs at this stage can also start to decide on short-term outcomes that will be a step towards longer-term net zero capabilities. By engaging in this process, SMEs could also identify what activities they engage in that contribute most to GHG emissions.

Stage 4: Undertake internal changes towards the net zero agenda. After the previous stages have been achieved, SMEs can engage in changes within their businesses to reduce their GHG emissions. These do not have to be large changes. Little steps such as engaging in the training of employees so they are more conscious of the carbon footprint of the busi-

ness, conducting energy-intensive activities at certain hours, and using more information communication devices to reduce travel and the need for paper can help [2,27,33]. It is easier to make changes within the organisation before trying to make changes outside the organisation, the issue we turn to next.

Stage 5: Undertake external facing changes towards the net zero agenda. Altering how SMEs engage with the external environment is an essential requirement for SMEs if the net zero target is to be reached by 2045 or 2050 in the case of some countries [10,42]. This however will depend on the previous stages; for example, pressures from value and supply chain entities as well as the financial health of the SME could impact the SMEs' ability to procure energy from renewable sources because these could be more expensive [2,27]. Thus, activities at this stage will largely depend on Stage 1 and Stage 2 evaluations. At this stage, the scope of decisions will also be heavily influenced by the barriers and drivers to implementing net zero activities that we have shown in Table 2 [30,31].

Stage 6: Uncouple, Reduce and Substitute. Some SMEs might need to disengage from certain activities or even leave some markets altogether to help achieve net zero [27,42]. The literature is clear that to achieve net zero, certain practices will need to be eliminated, others reduced, and others substituted with cleaner technologies [2,10,42,60]. These can easily be identified from Stage 3. It must be noted that there could be unavoidable residual emissions that can only be offset via greenhouse gas removal (GGR) offsets from either nature-based projects such as reforestation and soil management, or through engineered methods including carbon capture and storage [2,42]. Offsetting can be used to make an organisation or product carbon neutral, where the sum of greenhouse gas emissions produced is compensated for by carbon offsets, also called carbon credits [2,6].

Stage 7: Us over Me. SMEs can drive external improvements through collaboration and help to build communities of climate-conscious SMEs [27,57]. Such communities have the potential to magnify the activities of individual SMEs and the combined efforts of such communities will be more effective at contributing to the net zero agenda. SMEs could also seek valuable partnerships and embed themselves in supply and value chains that are more environmentally friendly or seek to contribute to the greater climate good. There are many ways in which SMEs can help themselves and each other through vital collaboration in building not just sustainable companies, but sustainable supply chains and business communities [10,28].

Stage 8: Update regularly. Continuous improvement and innovation processes will be required to achieve the net zero agenda. SMEs will need to consistently be on the lookout for cleaner and more efficient technologies and practices. They will also need to find out ways to embed such technologies and practices into their business activities. However, engaging in communities and with stakeholders that are concerned with the net zero agenda (as discussed in Stage 7) can help in this regard.

SMEs start from Stage 1 and progressively make decisions until they reach Stage 8. If they have not achieved net zero at this point, they can return to Stage 1 and continuously improve their performance. This process should be repeated as many times as possible until net zero is eventually attained by the SME. Continuous improvement can also be implemented until the SME is carbon negative. This occurs when an entity reduces its carbon footprint to less than neutral so that the entity has a net effect of removing carbon dioxide from the atmosphere rather than adding it. Based on the discussion so far, we have inferred a model which we summarized in Figure 2 to emphasize several dimensions. The combined framework from the academic and grey literature indicates that for SMEs to effectively contribute to the net zero agenda, a holistic and long-term approach that incorporates the eight stages we have identified should be encouraged. It also suggests that SMEs should engage in progressive decision making as well as continuous improvement using our framework to actualise net zero.

6. Conclusions

The journey to net zero is urgent, but complex, and there are both challenges and huge opportunities for SMEs [10]. SMEs collectively account for a significant proportion of greenhouse gas emissions and so there is a need for urgent action to be taken by SMEs in the journey to achieve net zero. Lip service must not be paid in this context, but action needs to be taken. All hands must be actively on deck because, for example, research shows that Vietnamese listed firms have been found to engage in "green talks" in their corporate reporting rather than "green actions" in their daily practices [76]. The framework we have derived from the academic and grey literature is a helpful tool for SMEs as they plan and undertake activities to contribute to the net zero agenda.

Like all other research, this paper has some limitations, yet it provides vital opportunities for future research. First, like other studies that derive conceptual frameworks from the existing literature, we might have missed some useful literature. However, our incorporation of the grey literature takes into consideration the latest industry perspectives concerning our research questions. Future studies can aim to incorporate the literature we might have missed into our model. Secondly, most of the literature we have reviewed is from the context of the UK and so our framework should be applied with caution in different contexts. However, we were careful to try to incorporate as much of the literature as possible and not only the literature from the UK. The paper has also identified specific variables such as the position of the SME in the value chain, the power position, and the pursuance of net zero capability within short- and long-term timescales. There is therefore scope for the various aspects in this scope to be tested empirically in the future to ascertain the relationship between the variables examined as SMEs generate net zero capability.

A key theme across the entire academic and grey literature we have reviewed is the need for SMEs to understand their carbon footprint, otherwise known as greenhouse gas (GHG) accounting, and then seek to reduce it via several methods. SMEs need to actively engage in activities in the framework we have elucidated to limit global warming to 1.5 °C. Furthermore, achieving net zero implies that value chain emissions across the entire supply chain be reduced. When this has been done, any remaining emissions that remain uneliminated could be offset via greenhouse gas removal (GGR) offsets. To strengthen SMEs' role as change agents for net zero, policymakers should reconsider this framework we have developed and ensure flexible and targeted incentives to support SMEs. SMEs should also be helped in the acquisition of green assets, knowledge and skills, which they can in turn share with their customers and communities.

From a scientific perspective, the novelty of our study is the use of academic and grey literature. Previous literature on SMEs and net zero have focussed on the academic perspective and have employed empirical measures taken to justify such perspectives. By introducing the grey literature, this paper explicates the academic and grey literature dimensions of SMEs and net zero to synergise multiple actors and develop a conceptual framework to contribute to the net zero agenda.

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