Designing Scalable SME Decarbonisation: Direct impact, Value-for-Money and Co-benefits in the UK's ERDF and the U.S. Industrial Training and Assessment Centers.

David Shor Sirota

St Cross College

Abstract

This dissertation aims to answer the question: Which policy and programme design features make SME decarbonisation interventions more effective and scalable, in terms of emissions reductions, value for money, and co-benefits (education, innovation, and economic growth)? To address this, the study compares the UK's ERDF-funded SME projects with the U.S. Industrial Training and Assessment Centers (ITAC), analysing audit-level datasets and evaluation reports to quantify emissions impacts, numbers of SMEs supported, and documented co-benefits. Although the policy framings differ, both countries have large SME shares of energy use and emissions; accelerating SME energy-efficiency adoption is pivotal to cost control and competitiveness.

Across 20 ERDF projects offering energy assessments and grants, 5,665 SMEs received support. Reported economic co-benefits include 919 full-time-equivalent jobs (across 10 projects) and average SME cost savings of £5,535 per project-year. In value-for-money terms, ERDF total spending equates to £969 per tCO_2. Student capacity building was comparatively limited: the SiE initiative deployed 86 graduates as sustainability champions in SMEs and trained 500 students in practical carbon management.

Since 2014, ITAC has averaged 507 assessments annually. Assessments identified 9,410 GWh per year of potential energy savings, of which approximately 3,785 GWh per year (40%) have been realised. ITAC's reported value for money is £546 per tCO_2. Financial benefits are tracked consistently: a typical assessment identifies about $150,000 (£117,000) in potential annual savings, with roughly $50,000 (£39,000) realised. Co-benefits are substantial in skills and research: alumni show 72% higher energy-efficiency-related skills, are twice as likely to enter green careers, and earn on average 9% more than comparable graduates. Since 1997, ITAC activities have generated 943 publications across journals, conferences, and technical reports.

The evidence suggests that delivery models integrating audits with systematic implementation follow-up, consistent data reporting, a coordinator or field manager to ensure quality, and strong university engagement could help achieve high value for money while generating scalable talent and knowledge diffusion. Adopting a university-led audit model could shift programmes from one-to-one delivery toward large-scale diffusion by translating audit evidence into actionable guidance, tools, and standards for the wider SME base, increasing additionality, reducing costs, and building the data and skills required for scale.

Acknowledgements

I am deeply grateful to my supervisor, Dr. Sam Hampton, for his exceptional guidance throughout this dissertation. His direction, thoughtful feedback, and encouragement to broaden my perspective on how energy shapes everyday life were vital at every stage. Within the MSc in Energy Systems at the University of Oxford, I also appreciate the teaching and administrative support from the Engineering Department, whose support made the learning experience invaluable.

I gratefully acknowledge COMECYT for its support of this work and for helping to fund my studies.

To my wife, Orly, thank you for walking with me through every step of this adventure and for reminding me why improving our surroundings matters. I hope this dissertation adds at least a small grain to that shared goal. I love you deeply.

To my parents and sisters, thank you for always trusting me and for giving me everything I have, from the values I grew up with to the constant reminders of what really matters, and for making me feel like the luckiest person in the world.

I am indebted to Alejandro Tovar for his help during the application process and for everything I learned while working together at Hartree; I hope he can see his influence reflected in this work.

Finally, I thank Carolina López-Suero, Juan Martínez Gómez and the Universidad Iberoamericana for their support through the application process and for helping me appreciate the value of learning both inside and outside the classroom.

Estoy profundamente agradecido con mi supervisor, el Dr. Sam Hampton, por su guía excepcional a lo largo de esta tesis. Su dirección, sus comentarios reflexivos y su estímulo para ampliar mi perspectiva sobre cómo la energía moldea la vida cotidiana fueron vitales en cada etapa. En el marco del MSc in Energy Systems de la University of Oxford, también agradezco el apoyo de los profesores y administrativos del Departamento de Ingeniería, cuyo acompañamiento hizo que la experiencia de aprendizaje fuera invaluable.

Agradezco sinceramente a COMECYT por su apoyo a este trabajo y por ayudar a financiar mis estudios.

A mi esposa, Orly, gracias por acompañarme en cada paso de esta aventura y por recordarme por qué es importante mejorar nuestro entorno. Espero que esta tesis aporte, aunque sea un poco, a ese objetivo compartido. Te amo profundamente.

A mis papás y hermanas, gracias por confiar siempre en mí y por darme todo lo que tengo: desde los valores con los que crecí hasta los constantes recordatorios de lo que realmente importa, y por hacerme sentir la persona más afortunada del mundo.

Gracias a Alejandro Tovar por su ayuda durante el proceso de aplicación y por todo lo que aprendí trabajando juntos en Hartree; espero que pueda ver su influencia reflejada en este trabajo.

Por último, agradezco a Carolina López-Suero, a Juan Martínez Gómez y a la Universidad Iberoamericana su apoyo durante el proceso de aplicación y por ayudarme a apreciar el valor de aprender tanto dentro como fuera del salón.

Contents

Abstract 2
Acknowledgements 3
Introduction 5
Literature review 6
SMEs and Energy Efficiency 6
Policy Context 12
UK SME decarbonisation efforts 12
US SME decarbonisation effort: ITAC 18
Methodology 22
Findings 23
Results from the ERDF summative assessments and measure-level data 23
Results of the ITAC programme 26
Value for Money comparison 33
Broader Impacts on Education and Economic Growth 35
Discussion: Comparative analysis 37
Conclusion 41
References 43

Introduction

Small and Medium Enterprises (SMEs) are the backbone of the global economy, representing 99% of enterprises and providing around 60% of employment (IEA, 2015). They contribute substantially to GDP, exports, and innovation, and their collective environmental impact is significant, accounting for roughly 40% of industrial pollution, commercial waste, and greenhouse gas (GHG) emissions in Organisation for Economic Co-operation and Development (OECD) countries (Wildnerova et al., 2024). Despite this, regulatory and academic attention has largely focused on large corporations, leaving SME decarbonisation underdeveloped and challenging to scale. Barriers such as high upfront costs, limited access to capital, and reluctance to take on debt, aggravated by the economic shocks of COVID-19, are compounded by time and knowledge constraints, with many SMEs lacking the capacity to assess emissions or identify solutions. Their diversity in size, sector, and energy needs adds further complexity, making tailored interventions the chosen mechanism by energy efficiency programmes. However, energy policy often overlooks SMEs, missing opportunities to address market failures and unlock both cost savings and emissions reductions through targeted, sector-sensitive support.

In pursuit of its Net Zero 2050 goal, the UK must reduce emissions across all sectors, including SMEs, which make up 99.8% of all UK businesses and are responsible for an estimated 43–53% of business-related emissions (Department for business & Trade, 2024). By contrast, recent U.S. policy has prioritised strengthening domestic manufacturing competitiveness and energy supply chains; nonetheless, SMEs, representing about 99% of all U.S. businesses, also require targeted support to improve energy efficiency (The White House, 2025; US Office of Advocacy, 2025). Despite these differing emphases, both countries face a common imperative: accelerating energy efficiency in local SMEs. From 2014 to 2020, the European Regional Development Fund (ERDF) England Operational Programme was the largest funding source for SME decarbonisation, supporting numerous regional projects operated by different institutions. In contrast, the US Industrial Training and Assessment Centers (ITAC) programme, operating since the late 1970s, offers a nationally standardised model, combining technical energy audits, student training, and, since 2021, implementation grants. This dissertation compares these two approaches, assessing differences in design, delivery, and outcomes to draw lessons for UK policy.

This research builds on recent UK government interest in identifying and adapting effective international SME energy efficiency policies. In January 2023, the Department for Energy Security and Net Zero (DESNZ) commissioned Baringa Partners LLP to deliver the International Industrial Energy Efficiency Policy Case Studies report (Greenwood & Goater, 2023). The study examined different OECD policies and identified the US ITAC programme as a transferable example. ITAC was noted for its ability to overcome financial barriers, build local capacity, and reach SMEs that would otherwise not seek energy audits. By comparing ITAC with the ERDF-funded programmes, this dissertation offers evidence-based insights into how SME decarbonisation policy could evolve.

This dissertation seeks to answer the question: *What policy and programme design features make interventions for SME decarbonisation more effective and scalable, in terms of emissions reductions, value for money, and wider co-benefits such as education, innovation, and economic growth?* To explore this, the study compares the UK's ERDF programmes with the US's ITAC. This question is critical because SMEs require solutions that are adaptable and impactful at scale. By focusing on design features such as delivery models, technical support mechanisms, and interactions with SMEs, this study aims to identify the elements that influence effectiveness and scalability. Understanding

these drivers is essential for policymakers seeking to create interventions that not only deliver measurable environmental and economic benefits but can also be replicated and expanded without losing impact.

The study uses a comparative approach incorporating both qualitative and quantitative methods. It draws on data and documents. For ERDF, this includes programme-level evaluation reports and 20 publicly available summative assessments, as well as seven measure-level datasets obtained from project operators. For ITAC, the analysis uses the programme's assessment and recommendation database and relevant evaluation reports. Cross-case comparison focuses on SMEs supported, estimated emissions reductions, value for money, and additional co-benefits, providing a basis for assessing relative effectiveness.

The dissertation is structured as follows: the next section reviews literature on SME decarbonisation challenges and the role of policy interventions. This is followed by an overview and analysis of UK ERDF-funded programmes and their reported results, then a detailed examination of the US ITAC programme's design and delivery model. The methodology section outlines the comparative analytical framework. Findings are then presented for each programme, followed by a discussion of key lessons for designing more impactful SME decarbonisation policies.

Literature review

SMEs and Energy Efficiency

Governments worldwide are increasingly recognising that achieving climate targets requires addressing the unique challenges of decarbonising SMEs. Under frameworks such as the Paris Agreement, countries have begun to integrate SME-focused measures into their national climate strategies, with varying degrees of ambition and success. International initiatives led by organisations like the International Energy Agency (IEA), the OECD, and the United Nations Industrial Development Organization (UNIDO) highlight SMEs as both a vulnerable group and a critical driver of low-carbon transitions (IEA, 2022; UNIDO, n.d.). From targeted subsidies for energy-efficient technologies to regulatory incentives and green financing mechanisms, global policy approaches aim to overcome barriers such as limited technical capacity, restricted access to capital, and fragmented market structures. These efforts underscore the significance of SMEs in achieving emissions reductions while maintaining economic resilience in the face of climate change and energy market fluctuations.

The UK has committed to achieving net-zero greenhouse gas emissions by 2050, with a pledge to reduce emissions by 68% by 2030 compared to 1990 levels (BEIS, 2022). Yet, despite progress over the past three decades, recent assessments show the country is falling behind on key decarbonisation metrics, particularly in the deployment of energy-efficient technologies (CCC, 2025a; Stewart et al., 2025). Improving energy efficiency in SMEs is crucial to addressing this gap, given their significant economic and environmental impact. Defined as businesses with fewer than 250 employees, SMEs account for 99.8% of all UK businesses, around 5.5 million in 2024, while providing 60% of employment and 48% of turnover (Department for business & Trade, 2024; Murray & Hutton, 2025). They also contribute 36% of total national emissions, 43–53% of business-related emissions, and nearly half of the business sector's energy consumption (OECD, 2021; Wilkinson-Dix et al., 2022).

In the industrial and commercial sectors alone, SMEs consume 57% of electricity and 50% of natural gas (OECD, 2021), highlighting the need to prioritise their role in the UK's Net Zero strategy.

In contrast, U.S. policy has recently focused more on strengthening domestic manufacturing and energy supply chains, rather than promoting nationwide decarbonisation and even retreating from the Paris Agreement (The White House, 2025). SMEs in the U.S., defined as firms with fewer than 500 employees, represent 99.9% of all businesses, employ 46% of the workforce and consume 56% of business energy (OECD, 2021; US Office of Advocacy, 2025). Rising energy prices, combined with the Trump administration's opposition to renewable energy development (A. B. C. News, 2025), have left U.S. SMEs vulnerable to energy price volatility. According to 1,000 firms interviewed by the IEA, other productivity benefits from implementing energy efficiency include a 13% reduction in unplanned downtime, increased overall productivity, and less waste of raw materials, leading to a general boost in competitiveness for SMEs, which would help the US accomplish its goals (IEA, 2025). While the political framing of energy efficiency actions differs between the two countries, the role of SMEs in both economies emphasises a common necessity: increasing the adoption of energy-efficient technologies to cut emissions, reduce operating costs, and enhance competitiveness.

In this effort to reduce emissions and increase productivity among SMEs, securing access to affordable and clean energy has become an urgent issue, influenced by decarbonisation objectives and escalating geopolitical challenges. Rising energy prices, caused by supply chain disruptions and international conflicts, have become a major obstacle for businesses. SMEs are especially exposed, lacking the financial reserves, economies of scale, and technical capacity that larger corporations use to mitigate against energy market fluctuations (Fawcett & Hampton, 2020). Reducing energy consumption through energy efficiency improvements is a strategy that SMEs should pursue to mitigate these risks.

Since 2021, energy prices globally have experienced significant increases. The easing of pandemic-related lockdowns reignited global economic activity, increasing demand for gas and electricity. At the same time, fuel supply from key producers became constrained, tensions between Russia and Ukraine escalated throughout 2021, culminating in the full-scale Russian invasion in February 2022, which triggered a spike in energy prices (Sun et al., 2024). In the UK, the energy price cap would have risen by 80% in 2022 without government intervention (Bolton, 2025). Although recent prices are lower than the October 2022 peak, they remain over 50% higher than pre-crisis levels in winter 2021-22, as seen in Figure 1. These high prices have increased operational costs across all sectors, but SMEs, often lacking internal energy expertise, are disproportionately affected (IEA, 2022).

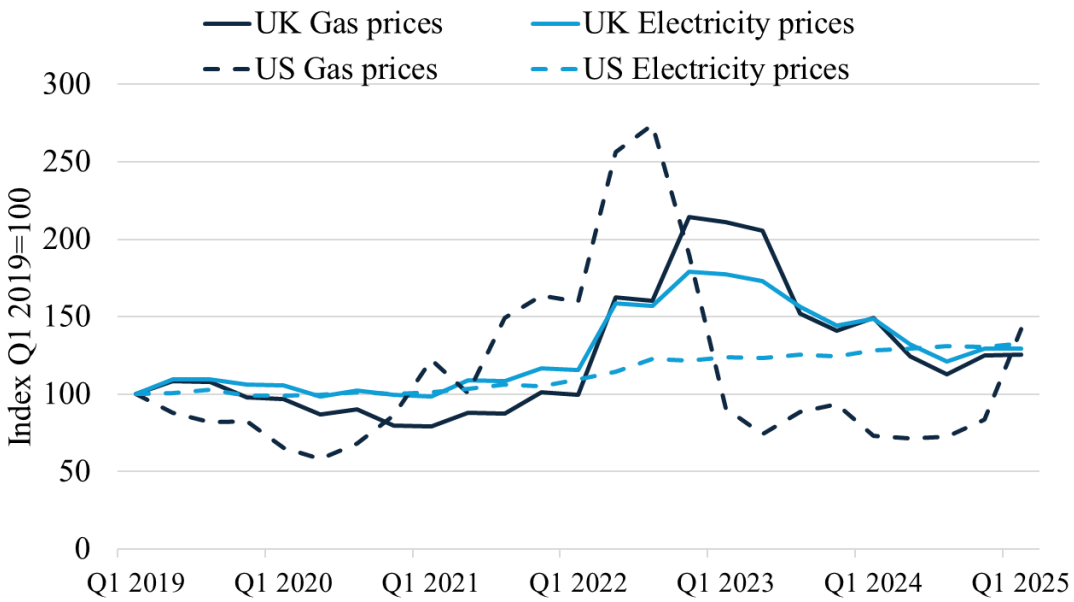


Figure 1. UK and US Energy price indices in real terms(Based on, DESNZ, 2025; eia, 2025; FRED, 2025),

SMEs are often left behind in addressing climate change. They are frequently overlooked in many energy and climate policies (Hampton et al., 2024). This is usually due to its smaller carbon footprint, heterogeneity, and reduced regulatory compliance when compared to larger businesses (Hampton et al., 2024). The decarbonisation and energy efficiency challenge is intensified for many SMEs due to knowledge, time, financial, and resource constraints, which make it challenging to reduce their energy consumption and emissions (Fawcett & Hampton, 2020). These barriers are seen across the world, with OECD and non-OECD countries citing the same limitations (Trianni et al., 2016). While their energy end-uses are often like those of larger businesses, SMEs struggle in their capacity to monitor and manage energy use, respond to policy, plan the needed interventions, and make informed decisions (Hampton et al., 2024; Trianni et al., 2016).

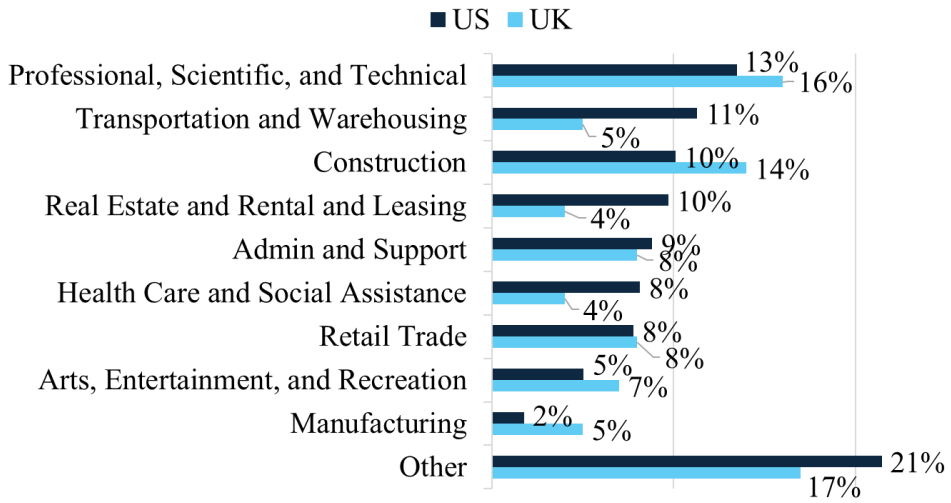


Figure 2. % SMEs by industry type according to SIC letter (based on, Office for National Statistics, 2023; US Office of Advocacy, 2025)

Despite the widely recognised potential of SMEs to cut energy use and emissions, significant evidence gaps persist around their actual consumption patterns, opportunity sets, and decision processes. As Figure 2 shows, SMEs are dispersed across many industry types and diverse activities, end-products, and services, which creates highly varied energy needs and consumption profiles. While fuel use is broadly similar, about 98% use electricity and 41% rely on natural gas, with most using multiple fuels, end-use patterns still diverge even within the same industry; for example, some UK manufacturing SMEs depend on natural gas while others rely on liquid fuels for heating (Figure 3) (DESNZ, 2023). This heterogeneity makes uniform policy design complicated and points to the need for targeted, segment-specific interventions grounded in granular, site-level data, precisely the kind of insight that energy audits can provide to prioritise measures and build credible business cases (Fawcett & Hampton, 2020; Hampton et al., 2024).

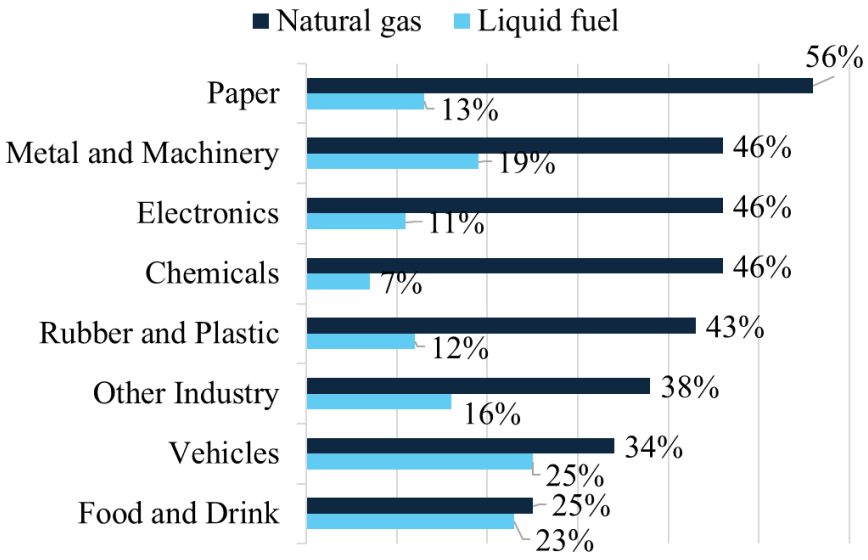


Figure 3. Use of natural gas and liquid fuel by industry (based on, DESNZ, 2023)

Another barrier to SME decarbonisation lies in the lack of clear, reliable, and actionable information on energy efficiency options. Studies highlight that SMEs often face information asymmetries: technology providers may not present options transparently, while SMEs themselves struggle to interpret external advice, because of the lack of internal capabilities (Trianni et al., 2016). The IEA notes that nearly 40% of the 1,282 surveyed SMEs from 13 countries report a lack of awareness as the primary barrier, limiting both their understanding of efficiency opportunities and their ability to develop robust business cases for investment (IEA, 2025). Furthermore, OECD research highlights that information on the environmental footprint of SMEs is scarce, restricting firms' capacity to assess and mitigate their climate impact (OECD, 2021). Data collection difficulties add to the challenge, as many enterprises lack both the systems and skills to generate meaningful internal environmental data, which is crucial for evidence-based decision-making (OECD, 2021).

These issues are compounded by internal data limitations, with SMEs frequently failing to measure or monitor their own energy consumption, efficiency, or emissions. 79% of SMEs do not measure their carbon footprint, while only a minority of manufacturing SMEs regularly track energy use, and even fewer benchmark consumption against peers or across sites (Mazhar et al., 2022). Without these practices, opportunities for identifying inefficiencies and savings remain hidden, reinforcing inaction. Outdated metering infrastructure, lack of sub-metering, and being unaware of their energy costs

further constrain SMEs' ability to generate accurate internal data and slow down decision-making (DESNZ, 2023; Mazhar et al., 2022). Externally, guidance is often too generic or not tailored to SME contexts, leaving many unable to translate broad climate objectives into actionable measures (OECD, 2023). Together, these internal and external barriers create uncertainty, where the absence of reliable data and targeted information limits awareness, weakens the business case for investment, and ultimately slows the adoption of energy efficiency measures critical for SME decarbonisation.

Upfront investment costs remain one of the most cited barriers to SME energy efficiency, with more than half of industry leaders identifying them as the greatest challenge to implementation, particularly for capital-intensive measures in energy-intensive industries (IEA, 2025). SMEs typically operate with limited capital reserves and tight margins, restricting their ability to fund upgrades or adopt new technologies, even if these are cost-effective in the long term(Wilkinson-Dix et al., 2022). Even when opportunities exist, firms tend to prioritise projects with short payback periods, often five years or less, while decarbonisation measures could require longer-term returns, reinforcing underinvestment (IEA, 2025; Trianni et al., 2016).

Access to financing presents an additional hurdle. SMEs are twice as likely as large firms to face capital constraints in the UK (Trianni et al., 2016), and many remain reluctant to take on debt, especially in the post-COVID context, where earlier loans are still being repaid (Wilkinson-Dix et al., 2022). Hidden costs, such as production disruption or administrative burdens in applying for government support, further reduce the attractiveness of efficiency projects (Mole & Ri, 2023; Trianni et al., 2016). Evidence also shows that awareness of support schemes is low: less than 5% of UK manufacturers currently use government or private loans for decarbonisation, while many SMEs report never having heard of relevant programmes or being unsure which ones apply to them (DESNZ, 2023). For firms in rented premises, the lack of authority to upgrade infrastructure compounds these issues, creating a "split incentive" that discourages both tenants and landlords from investing.

As shown in Figure 4, which draws on an IEA survey of 1,282 SMEs conducted in 2024 across 13 countries and three continents (IEA, 2025). Upfront investment costs remain the most frequently cited barrier to energy efficiency improvements, but the lack of workforce capabilities highlights the importance of training and awareness initiatives. In addition, SMEs often perceive energy efficiency projects as disruptive to operations, even though evidence shows that once implemented, such measures tend to reduce unplanned downtime and improve productivity. Without targeted interventions that expand access to reliable information, strengthen workforce capacity, and provide accessible financial support, SMEs are unlikely to engage fully in decarbonisation efforts (Mazhar et al., 2022).

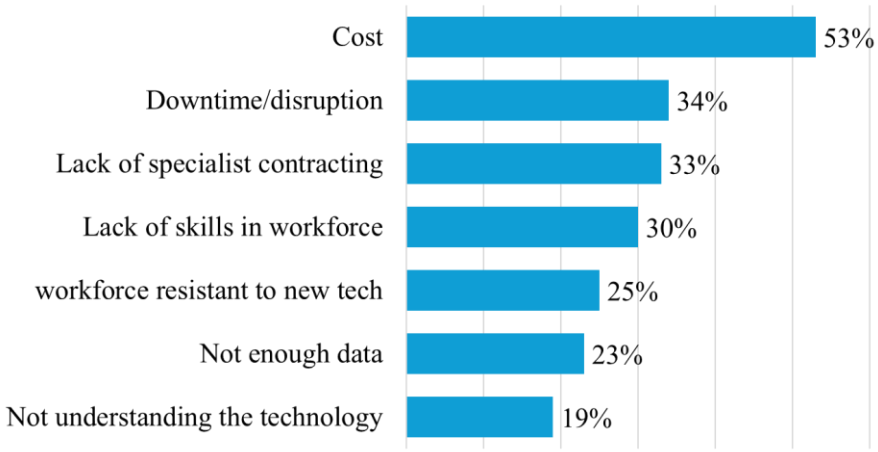


Figure 4. Barriers to energy efficiency (IEA, 2025). (Mole & Ri, 2023)

Policy efforts aimed at supporting SMEs must focus on directly addressing the challenges that limit their ability to act. Effective policies extend beyond isolated or short-term initiatives (Wilkinson-Dix et al., 2022). Regulation is a starting point; governments can introduce clear energy intensity targets, equipment efficiency standards, and workforce upskilling requirements (IEA, 2025). Importantly, SMEs need early and transparent communication of future low-carbon requirements, including clear timelines for phasing out fossil fuel heating systems and for implementing minimum efficiency standards (British Business Bank, 2021). These signals reduce uncertainty, giving SMEs the confidence to plan investments well in advance (Wilkinson-Dix et al., 2022). To promote action, financial support mechanisms are also essential. SMEs consistently identify grants, concessional loans, and tax incentives as among the most effective tools to overcome upfront cost barriers (Wilkinson-Dix et al., 2022).

Complementary support services can amplify these measures. Governments, financial institutions, technology providers, installers, and Energy Service Companies (ESCOs) each have a role in enabling SMEs to adopt energy efficiency solutions (Trianni et al., 2016). Policies can provide accessible awareness programmes, templates, and technical training to build workforce capabilities, particularly in emerging and developing economies (OECD, 2023). Strengthening information flows is equally important; adopting a "make every contact count" approach ensures that all interactions with public agencies, intermediaries, or commercial partners are used as opportunities to share decarbonisation guidance (Hampton et al., 2024). Benchmarking frameworks, sectoral networks, and energy tracking through digital technologies can further improve data availability and allow SMEs to compare performance across peers (IEA, 2025). Subsidised energy audits are tools to raise awareness and identify "quick wins", low-cost measures with short payback periods, such as upgrading lighting to LEDs, repairing insulation, optimising HVAC systems, and installing variable speed drives (IEA, 2025). At the same time, incentives to develop ESCO models, risk-mitigated green loans, and tax relief programmes can lower investment risks and accelerate uptake. Together, these interventions can shift SMEs from recognising barriers to actively engaging in decarbonisation, while also improving competitiveness.

Within this support system, the specialised intervention that energy audits offer can help reduce the barriers to decarbonisation for SMEs. Customised assessments enable the identification of the sources of emissions and energy use, highlight energy-intensive processes, and propose actionable solutions that often reveal previously overlooked low-hanging fruit (Agrawal et al., 2023). Audits not only

evaluate present energy consumption but also serve as entry points to a decarbonisation strategy. They clarify technological choices, provide cost–benefit assessments, and outline the payback periods for investments. Conducted by qualified professionals with communication skills, audits generate trust and encourage action (Agrawal et al., 2023). Despite their value, adoption by SMEs remains limited, mainly due to perceived costs, time constraints, and doubts about the return on investment (IEA, 2025). To address these concerns, audits can be combined with accessible financial support options, such as grants for implementing recommended measures and subsidised audit programmes. Furthermore, these policies can develop beyond a standalone action by integrating additional co-benefits like the development of local capabilities and research that can be utilised to produce a significant impact.

Policy Context

UK SME decarbonisation efforts

The UK has introduced various policies to cut carbon emissions from SMEs and manufacturing, including programmes funded through the ERDF England Operational Programme 2014–2020, which supported energy efficiency, low-carbon innovation, and sustainable practices. This section focuses on ERDF England because, until its closure in 2023, it provided the main structured support for SME decarbonisation and is accompanied by published summative assessments that offer a robust evidence base. ERDF delivered national coverage, long-term funding, and extensive reporting, whereas other initiatives, though important, lack comparable evaluative depth: the UK Shared Prosperity Fund (launched 2022, £2.6 bn) remains in delivery; the Business Energy Advice Service pilot operates only in the West Midlands and has received £15m in new funding to support an additional 1,500 SMEs by 2041 (Business Growth West Midlands, 2025) and as the Community Renewal Fund (2021, £125 m) had a broader, smaller-scale scope (BEAS, 2025; LGA, 2022; MHCLG, 2025b).

This analysis focuses on the England strand, which received the largest UK share of ERDF allocations and was managed separately by the Ministry of Housing, Communities and Local Government (MHCLG). It is the only strand with a comprehensive, publicly available set of summative assessment reports, enabling methodologically consistent evaluation. The devolved administrations managed their ERDF allocations according to different priorities and frameworks, producing outcome data that is not directly comparable. Limiting the scope to England ensures the analysis is based on the most complete and consistent evidence available.

ERDF England channelled EU structural funds into regional economic development, aligning with the EU's strategy for innovative, sustainable, and inclusive growth while addressing regional disparities (MHCLG, 2019). It sought to address market failures, support local strengths, and promote environmentally sustainable and socially equitable growth. By funding low-carbon economy projects, the programme tackled long-term challenges such as rising energy and resource costs while creating opportunities in the low-carbon sector. Requiring matched domestic public and private contributions increased total investment, amplifying the scale and impact of projects. Its three main priorities were research and innovation, SME support, and the development of a low-carbon economy, all

highlighted by cross-cutting principles of sustainable development, equal opportunities, and non-discrimination (Wavehill & MHCLG, 2023).

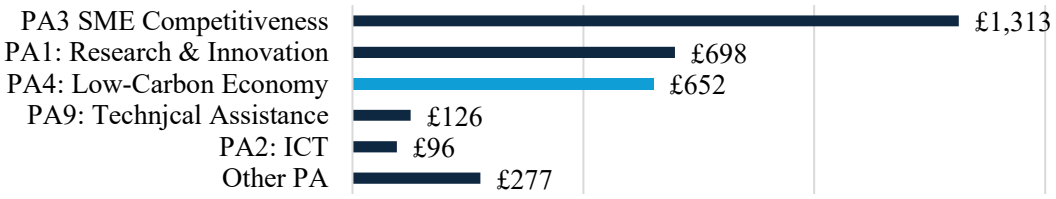


Figure 5. ERDF Programme Financial Performance by PA to July 2022(Wavehill & MHCLG, 2023)

The ERDF England programme allocated £3.2 billion across ten Priority Axes (PAs), with most funding directed to three core areas. Priority Axis 4 (PA4), supporting the shift to a low-carbon economy, accounted for 21.5% of the programme (Figure 5). PA4 aimed to cut greenhouse gas emissions, expand renewable deployment, and stimulate low-carbon growth through smaller, locally tailored projects. Activities included supporting renewable energy production and distribution, improving energy efficiency in buildings and businesses, promoting sustainable transport and low-carbon urban strategies, and advancing innovation in clean technologies. By July 2022, 167 projects valued at £1.17 billion, of which £591 million came from ERDF, had been supported toward PA4 goals (Wavehill & MHCLG, 2023). The strategy rested on the view that emissions are a negative externality and that efficiency can drive growth, justifying intervention to correct market failures. Accordingly, PA4 backed decarbonisation by promoting renewables, efficiency, and research and innovation, especially for small-scale initiatives that might otherwise lack capital, while the wider fund addressed local market failures across England by investing in public and private infrastructure, enterprises, and housing (MHCLG, 2020).

To address market failures in different sectors of the economy, the fund's Operational Programme defined five investment priorities and details specific objectives to promote initiatives in these areas. (Table 1)

Table 1. Decarbonisation Axis Investment priorities (MHCLG, 2020)

Investment priority	Objective
4a: Promoting the production and distribution of energy derived from renewable sources	To increase the number of small-scale renewable energy schemes in England
4b: Promoting energy efficiency and renewable energy use in enterprises	To increase energy efficiency, particularly in SMEs, including through the implementation of low-carbon technologies
4c: Supporting energy efficiency, smart energy management and renewable energy use in public infrastructure, including in public buildings, and in the housing sector	To increase energy efficiency in homes and public buildings, including through the implementation of low-carbon technologies
4e: Promoting low-carbon strategies for all types of territories, in particular for urban areas, including the promotion of sustainable multimodal urban mobility and mitigation-relevant adaptation measures	To increase the implementation of whole-place low-carbon solutions and decentralised energy measures
4f: Promoting research and innovation in, and adoption of, low-carbon technologies	To increase innovation in, and adoption of, low-carbon technologies

Projects under Investment Priority 4b aimed to boost energy efficiency and renewable use, mainly in SMEs, addressing their specific barriers. Selected projects focused on improving energy management, reducing costs, and increasing competitiveness. Key criteria included conducting 'green' diagnostics or energy audits to develop tailored action plans. The process targeted market failures where incentives were lacking, using financial instruments to encourage long-term sustainability and private investment, with grants as a backup (MHCLG, 2020). Overall, SME support under this priority was substantial, with around 43 initiatives receiving a total of £169 million in ERDF funding, as seen in Figure 6 (MHCLG, 2025a; Wavehill & MHCLG, 2023). Many additional projects also aimed to assist SMEs in their decarbonisation process; however, because their main goal was to increase renewable energy generation or promote research and innovation, they do not fall under the 4b investment priority.

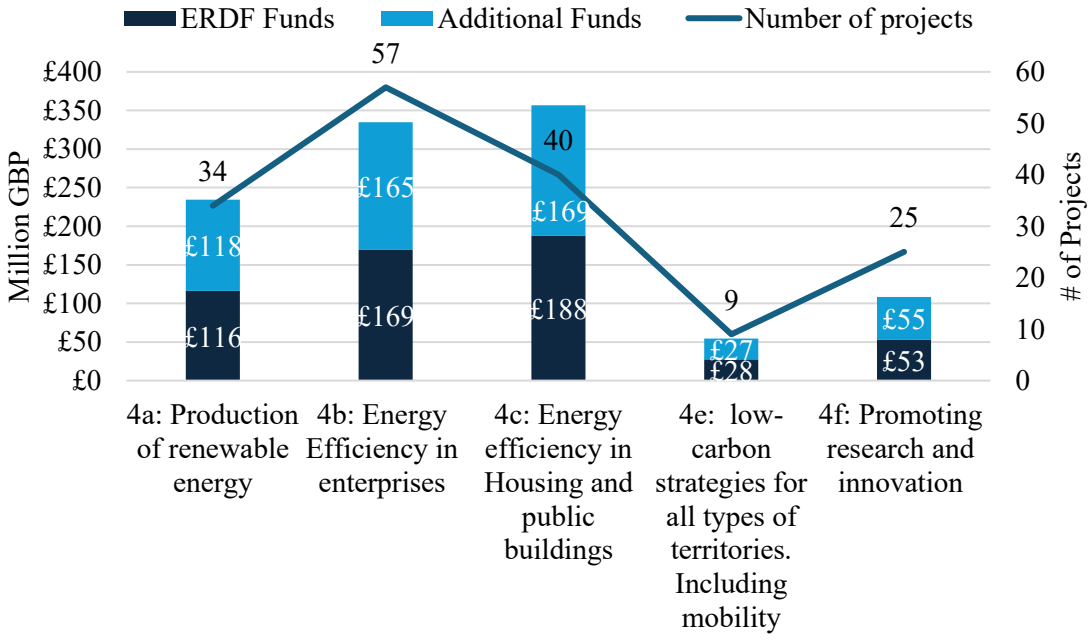


Figure 6. Supported projects and funds by investment priority (MHCLG, 2025a)

Programme evaluation

To evaluate the outcomes, all ERDF-funded projects were required to carry out a summative assessment, typically undertaken by independent evaluators to ensure impartiality and credibility. These assessments followed a common methodological framework while allowing flexibility to adapt to each project's scale, objectives, and intended impacts. The aim was to generate robust evidence on efficiency, effectiveness, and value for money through mixed-methods approaches that combined quantitative performance data with qualitative insights from stakeholder interviews, surveys, and case studies. This enabled evaluators to not only measure outcomes but also examine the factors driving success or underperformance, identifying lessons for future low-carbon support programmes (ERDF, 2020).

The ERDF Summative Assessment Guidance outlines the contractual requirements for all grant recipients, as specified in the grant funding agreement. The guidance provides a common framework for planning and conducting assessments, while supporting recipients in adapting methods to their

projects. It establishes three essential stages: planning, data collection and reporting, and final reporting and communication, and highlights the importance of reliable evidence to inform both project-level learning and the national evaluation programme (ERDF, 2020). Independent evaluators with appropriate expertise were generally expected, although smaller projects could undertake assessments internally if suitably skilled personnel were available. The costs were met from project budgets, with ERDF reimbursement capped at 1% of eligible expenditure (up to £100,000). Interim evaluations were also required in some instances, such as projects with longer-term impacts, where a draft or interim report would precede the final version to allow for quality assurance and to capture early findings (ERDF, 2020). By standardising minimum quality requirements and linking project-level evidence to the national programme evaluation, the guidance ensured that the summative assessments could collectively provide a coherent and credible picture of the ERDF's overall impact (ERDF, 2020).

In addition to project-level assessments, the ERDF England was evaluated at programme level through Phase 2, commissioned to Hatch Regeneris Consulting, and Phase 3, commissioned to Wavehill. The reports draw on evidence from project summative assessments, beneficiary surveys, and counterfactual impact evaluations. These evaluations aimed to meet regulatory requirements, inform continuous improvement, guide the design of successor domestic funds, and support initiatives linked to the Government's Levelling Up agenda. They assessed how project implementation, achievement of outcomes, and overall economic impacts were evaluated, as well as by Priority Axis. The analysis covered cost-effectiveness, financial and output progress, principles like equality and sustainability, and the programme's relevance in changing contexts. Together, these evaluations provided a comprehensive picture of the programme's effectiveness, value for money, and contribution to local and national economic development, while strengthening the evidence base for future SME decarbonisation policy (Hatch Regeneris Consulting, 2021, MHCLG, 2023)

To assess the success of projects supporting SME decarbonisation, the most relevant indicators are the number of enterprises receiving support (C1) and the estimated annual decrease in greenhouse gas emissions (C34) (Wavehill & MHCLG, 2023). These indicators capture both the reach of the interventions and their environmental impact. Quantifying emissions reduction is a key outcome metric, reflecting the decarbonisation impact of ERDF investments. Although reductions in greenhouse gas emissions are often backloaded, particularly for capital-intensive schemes, progress was already evident by late 2021. Other measures of success include the extent of collaboration between SMEs and research institutions (C26), the amount of new renewable installed capacity (C30) and the number of new enterprises supported (C5), all of which point to increased innovation and capacity-building in the low-carbon sector. To support the economic growth objective of ERDF-funded initiatives, some projects also measure additional metrics such as the number of Full Time Equivalents (FTE) created and the Gross Value Added (GVA) resulting from the interventions SMEs. Collectively, these indicators aim to provide policymakers and project managers with information about the progress of the initiatives and the results achieved.

Programme measured results

The programme's impact was delivered through a diverse portfolio of SME-focused decarbonisation projects, which collectively illustrate how ERDF funding was translated into practical support on the ground. These projects offered a mix of services across England, combining technical assessments, financial assistance, and opportunities for collaboration and networking. Interventions ranged from free energy audits with tailored action plans to match-funded capital grants covering 20% to 50% of eligible costs for installing energy-efficient technologies, often linked to recommendations from the

audits. One-to-one expert advice supported SMEs in areas such as product development, life-cycle analysis, legal compliance, and data analytics, while knowledge exchange was promoted through workshops, webinars, and business networks. R&D-focused projects opened up access to university facilities and demonstration sites for low-carbon technologies, and additional mechanisms included graduate placements, supplier vetting support, and carbon reduction certification. Together, these interventions formed a flexible toolkit that could be adapted to the diverse needs of SMEs.

Evaluating funded projects was challenging, mainly due to limitations in impact measurement and consistency in methods. The primary indicator, projected annual greenhouse gas emission reductions (C34), relies solely on a one-year estimate and does not provide information on the long-term sustainability of savings or validation through subsequent monitoring (Wavehill & MHCLG, 2023). Most summative assessments lacked detailed exploration of these projections, and where they did exist, methodologies varied widely, undermining comparability and the potential for aggregate impact analysis (Hatch Regeneris Consulting & MHCLG, 2021). A critical gap was the lack of actual monitoring data on energy and emissions savings, which, due to limited evidence from summative assessments, made a value-for-money evaluation unfeasible (Wavehill & MHCLG, 2023). Additional issues involved inadequate guidance on evaluating low-carbon support effectively, limited evaluation budgets, and a lack of expertise among those commissioning assessments, which resulted in weak methodological choices and decreased transparency (Hatch Regeneris Consulting & MHCLG, 2021). Collectively, these shortcomings reduced the development of strong policy insights and limited the effectiveness of evaluation efforts under PA4.

Table 2. Output target performance under 4b to December 2021 (Wavehill & MHCLG, 2023)

Output	Target	% of target Contracted	% of Target Claimed
C1: Number of enterprises receiving support	11,248	87%	51%
C34: Estimated Annual decrease in GHG (tCO_2eq/y)	60,975	275%	76%

For projects focused on improving energy efficiency in SMEs, the primary result indicator was the number of enterprises that lacked established methods to measure energy efficiency. However, by the time of evaluation, no data had been reported for this indicator. Output data (Table 2) showed that contracting for SME support (C1) had reached 87% of the 11,248 target, reflecting similar patterns to the overall under-contracting of spend in PA4 (91%). Of this, 51% had been claimed, with many projects still ongoing. In contrast, the target for annual greenhouse gas reductions (C34) was over-contracted, with 76% of the goal already achieved, demonstrating progress in decarbonisation outcomes (Wavehill & MHCLG, 2023).

Survey responses revealed that while over 90% of beneficiaries reported making some progress toward their objectives, fewer than 20% felt these had been fully achieved, as seen in Figure 7 (Wavehill & MHCLG, 2023). Nevertheless, the support was seen as crucial: 20% of respondents said that progress would not have happened without it, and an additional 69% believed it would have been slower or less significant. Overall satisfaction was high, with 81% of PA4 beneficiaries expressing they were very or fairly satisfied with the support received, and only 9% reporting dissatisfaction (Wavehill & MHCLG, 2023). Respondents receiving resource and energy efficiency support under the energy efficiency priority were particularly likely to credit the intervention with enabling

progress; 22% said they would have made no progress otherwise, likely due to the provision of direct installations or specialised advice (Hatch Regeneris Consulting & MHCLG, 2021).

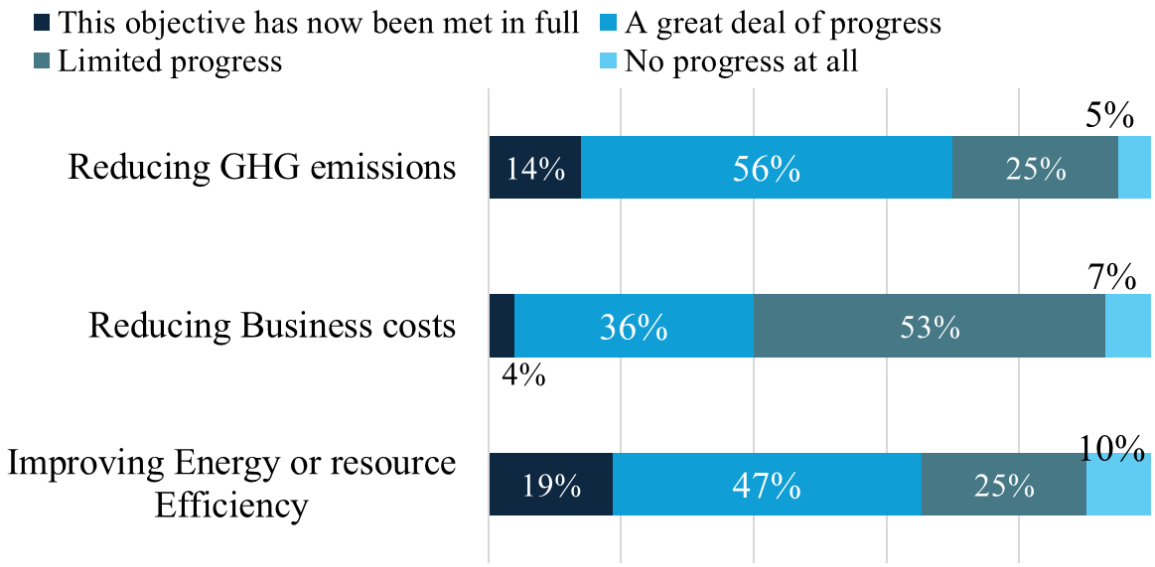


Figure 7. The extent to which PA4 beneficiaries Achieved Goals Following Support (Wavehill & MHCLG, 2023)

Several factors were identified to increase the success rate of the projects supporting the decarbonisation of SMEs. Combining technical advice with grant funding proved particularly effective, helping businesses overcome financial barriers and the inertia that can limit action on energy efficiency recommendations (Hatch Regeneris Consulting & MHCLG, 2021). Advisers who worked closely with SMEs to assess feasibility, costs, and benefits, and who translated recommendations into accessible, practical terms, facilitated smoother implementation and stronger outcomes (Wavehill & MHCLG, 2023). The phase three evaluation report identified different characteristics of successful projects. These reduced administrative burdens and made support easy to access, recognising that carbon reduction was not always a top business priority. Demonstrating clear business benefits, particularly financial gains, and sharing relatable case studies helped build trust and engagement. In energy efficiency initiatives under Investment Priority 4b, incorporating educational and communication components alongside technical installations helped encourage behavioural change, thereby maximising long-term savings in costs, energy, and carbon (Wavehill & MHCLG, 2023).

Projects supporting SME decarbonisation faced several significant challenges. External economic factors, such as the COVID-19 pandemic, disrupted delivery, limited face-to-face interactions, and delayed capital projects due to supply chain disruptions and revised site protocols (Wavehill & MHCLG, 2023). Broader economic uncertainty, including the impacts of Brexit, also weakened business confidence, causing many SMEs to postpone or scale back green investments (Hatch Regeneris Consulting & MHCLG, 2021). Engaging clients proved difficult, as carbon reduction was not always a top priority for them, even among sustainability-conscious firms. This increased the need for a more compelling value proposition and for support to be both time-efficient and easily accessible. Additionally, the retention of skilled project staff emerged as a consistent challenge across all Priority Axes. In PA4 specifically, keeping teams up to date with the fast-evolving environment

of low-carbon technologies required ongoing investment in professional development and technical expertise.

UK efforts to draw lessons from international policies

Since its creation in 2023, DESNZ has taken the lead from MHCLG in decarbonisation efforts and has included the decarbonisation of SMEs as a policy priority. One of their objectives has been to draw lessons from other countries as part of this transition. In January 2023, DESNZ commissioned Baringa Partners LLP to deliver the International Industrial Energy Efficiency Policy Case Studies study to inform the design and improvement of schemes to improve SME energy efficiency (Greenwood & Goater, 2023). Focusing on OECD countries, the research examined policies in five categories relevant to UK SMEs: funding, knowledge and awareness, conditional tax relief and subsidies, regulation, and monitoring energy use. A Rapid Evidence Assessment identified 115 policies, from which 14 were selected for detailed case studies based on design, implementation, and outcomes. Findings aim to help the UK adapt effective international approaches to strengthen SME energy efficiency policy (Greenwood & Goater, 2023).

Among these, the ITAC programme in the United States was identified as particularly relevant. Falling under the category of knowledge and awareness, it provides free SME energy audits conducted by university students through centres funded by the US Department of Energy (DOE). It was selected for its strong evidence base, high transferability, and capacity to address UK policy gaps. The programme merges financial accessibility with capacity-building efforts, eliminating cost barriers. As a result, 75% of participating SMEs indicated they would not have pursued an audit otherwise, while also providing training for future energy professionals. At the time of the study, most G7 countries subsidised SME audits, but the UK lacked a national scheme. The IAC model, along with examples such as Switzerland's ProKilowatt and Austria's National Environmental Support, demonstrates how targeted funding, technical support, and regulatory alignment can be integrated to improve SME energy efficiency outcomes in the UK. The following section builds on this effort and provides an overview of the ITAC policy, including its objectives, delivery model, and measurable impacts (Greenwood & Goater, 2023).

US SME decarbonisation effort: ITAC

The US ITAC program partners with universities across the country to generate energy savings at SME facilities, with a special focus on the manufacturing sector (Stephen et al., 2022). This policy has two main goals. The first is to generate energy savings in SMEs while cutting costs. The second goal is to develop valuable skills in engineering students and those in related disciplines, preparing them for careers related to energy efficiency roles through hands-on experience and keeping faculty connected with technological and industry challenges (Stephen et al., 2022). The program has assessed over 21,900 businesses since 1981 and given more than 163,357 recommendations (ITAC, 2025c). The ITAC programme contributes to the US government priorities of increasing competitiveness in the manufacturing sector.

The ITAC initiative aims to achieve its primary objectives by conducting no-cost assessments of energy, waste, and productivity at the facilities of SMEs. A team of faculty and students from a registered university carries out these evaluations; these 37 universities can be seen in Figure 8. The assessments produce reports containing specific recommendations for SMEs, including estimated costs, energy savings, and cost savings. This process results in energy savings once the assessed SMEs implement the recommendations, while the hands-on experience gained by students translates into practical skills for future roles in the manufacturing sector (Stephen et al., 2022). To implement these

recommendations, SMEs can apply for grants provided by the DOE, offering up to $300,000 USD with a 50% cost share, to help fund the installation of energy efficiency projects identified in an ITAC assessment. Grant support was introduced in the 2021 budget and was not previously considered (U.S. DOE, 2024).



Figure 8. Industrial Assessment Centers (IAC) (ITAC, 2022)

The programme operates through 5-year cooperative agreements with U.S. universities and is funded by the 2021 Infrastructure Investment and Jobs Act, authored by Representative Peter DeFazio. Between 2022 and 2026, $550 million USD was allocated, $150 million for operations, including $30 million annually for centres of excellence, training, and energy assessments, and $400 million for implementation grants, distributed at $80 million per year until expended (Rep. DeFazio, 2021). This marks an increase from 2014–2020, when $59.7 million USD was allocated, with $7–9 million spent annually on assessments and training (SRI International et al., 2022).

Currently, 37 universities deliver the programme regionally, led by ABET-certified engineering faculty with industry links to ensure high-quality assessments (SRI International et al., 2022). The DOE oversees delivery, with third-party performance reviews and coordination by a central Field Manager at Rutgers University, who ensures technical consistency, organises training, and liaises with IAC directors. Each director leads a student team conducting assessments, combining flexibility at the centre level with national quality control and alignment to decarbonisation priorities (SRI International et al., 2022; U.S. DOE & West Virginia University, 2016).

Each IAC is led by a Director and an Assistant Director, both tenure-track professors committing at least two full days weekly to IAC tasks (U.S. DOE & West Virginia University, 2016). The Director serves as the strategic and operational leader, training students, managing deadlines, and mentoring the assessment team. Many centres also employ full-time professional staff to support operations. Students are selected based on their academic performance, engineering skills, and professionalism. Graduate students typically receive research assistantships, while undergraduates are paid hourly (U.S. DOE & West Virginia University, 2016). Each IAC establishes its own specific selection criteria, and student compensation reflects the individual's role and experience. Students are generally recruited from a strong engineering background to perform assessments. A tiered recruitment

approach ensures experienced students assist in onboarding new team members, maintaining continuity and quality in assessment delivery (U.S. DOE & West Virginia University, 2016).

Students complete a structured training programme to prepare for high-quality energy assessments, beginning with safety instruction and exercises using sample utility bills to understand energy billing, rates, and usage patterns. They then conduct mock assessments of energy-intensive campus facilities, learning to operate data collection instruments, interpret results, and develop recommendations. Guidance from directors and lead students ensures recommendations are feasible and accurate, while mentoring supports new students through all stages, from utility bill analysis to client engagement, maintaining consistent quality. Training also emphasises recognising best manufacturing practices, integrating individual contributions into final reports, and uploading them to the Field Manager platform (U.S. DOE & West Virginia University, 2016).

The program primarily targets SMEs in the manufacturing sector that meet specific eligibility criteria. While 98% of assessments have historically been conducted in manufacturing, other industries have increasingly been included in recent years. Eligible businesses must have gross annual sales under $100 million, fewer than 500 employees at the plant site, annual energy bills between $100,000 and $2.5 million, and no dedicated in-house energy assessment personnel (Stephen et al., 2022).

SME engagement

To identify and engage potential clients, IAC Directors employ various methods. These include consulting regional manufacturers' directories, attending professional organisation meetings, and leveraging longstanding industrial contacts developed through their academic and professional network experience (SRI International et al., 2022). Some IACs also proactively reach out to businesses by coordinating with local utilities or attending industry conferences and seminars. Leads are often generated through referrals from previous clients or via channels such as the U.S. DOE Office of Energy Efficiency and Renewable Energy (EERE) and the Industrial Technologies Programme (ITP). Additionally, IAC websites serve as tools for client outreach, frequently updated to showcase case studies, student involvement, and director activities.

Pre-assessment

Once a client is identified, the IAC team initiates contact with a company representative, such as a plant or engineering manager, to confirm eligibility and begin information gathering. It is essential to the assessment that relevant plant personnel, such as the plant manager and maintenance staff, are involved in the process. The company is asked to provide 12 months of energy bills and data on waste disposal with energy implications (U.S. DOE & West Virginia University, 2016). A detailed questionnaire is also sent to better understand the production level, operating hours, description of the most relevant processes, and utility-related information (IAC, 2022). The IAC team reviews the data in advance to analyse for trends, calculate the unit cost of energy and identify key energy systems (IAC, 2022). One student prepares energy measurement equipment and assembles a standard assessment packet. Team members also use the IAC database to identify preliminary energy-saving opportunities based on similar facilities(U.S. DOE & West Virginia University, 2016).

Assessment

On the day of the visit, the IAC team reviews the facility's energy bills and holds a meeting to outline the process and confirm operations reflect a typical day (IAC, 2022). The team receives an overview of the manufacturing process, inventory, defects, and waste before touring the plant in line with production flow, noting energy systems and operational practices (IAC, 2022). They then identify

potential energy-saving opportunities, assign data collection tasks, and conduct measurements on key systems, including heating and cooling, water use, compressed air, and building systems. A closing meeting shares initial findings, explains next steps, and introduces DOE best practices, software tools, and demonstration materials (U.S. DOE & West Virginia University, 2016).

After the visit, student team members develop the report, covering energy bill analysis, plant operations, data visualisation, and detailed recommendations with estimated energy and cost savings, implementation costs, and payback periods. Directors and lead students review progress through regular meetings and multiple edits (U.S. DOE & West Virginia University, 2016). The final report, delivered within 60 days, is shared with the client, uploaded to the programme's database, and accompanied by follow-up calls and technical assistance as needed, with confidentiality maintained throughout (U.S. DOE & West Virginia University, 2016).

Post-assessment follow-up

After delivering the report, the IAC follows up within two weeks to confirm receipt and understanding, and about nine months later, conducts a phone survey to track adoption of recommendations (U.S. DOE & West Virginia University, 2016). Clients report on implementation status, realised energy and cost savings, and incurred costs. These results are summarised in an implementation report submitted to the Field Manager, with additional follow-ups as needed to capture further savings (U.S. DOE & West Virginia University, 2016).

The ITAC Implementation Grants programme provides funding for businesses evaluated by an IAC or approved third-party to carry out recommended measures. Administered by ENERGYWERX, applications are reviewed quarterly, with opportunities to reapply, and manufacturers may receive technical assistance (Energywerx, 2024). Funding is reimbursed post-implementation, and recipients must meet reporting, labour, and sourcing requirements (Energywerx, 2024).

Evaluation of the programme

After the assessment process, data is entered into the IAC database, a publicly accessible resource that helps train new students, inform energy efficiency recommendations, and analyse programme impact. By recording detailed, standardised data on plant operations, energy consumption, and specific technologies, IAC teams can identify patterns, benchmark performance, and customise suggestions for similar facilities. This centralised data source, maintained by the IAC Field Manager, improves the consistency and quality of assessments across centres and enables data-driven decisions for small and medium-sized manufacturers (Muller, 2011). Additionally, implementation data uploaded to the database track the adoption and effects of recommendations, providing feedback for future improvements. The approach to documentation, validation, and sharing enhances the credibility of IAC outputs and supports initiatives like grant programs, where verified recommendations and savings estimates are necessary for funding (U.S. DOE & West Virginia University, 2016).

The 2022 follow-up evaluation of the programme, conducted by SRI International for Rutgers University and DOE's Advanced Manufacturing Office, assessed the programme's continued effectiveness in meeting its dual goals: improving energy efficiency in small- and medium-sized manufacturers and developing skilled energy efficiency engineers through applied student training (SRI International et al., 2022). Building on a 2015 evaluation, the study analysed data from FY2014 to FY2020 for energy savings and from 2014 to 2020 for student outcomes, using quantitative assessments, interviews with faculty and students, and exploratory research on the skilled technical

workforce. The methodology combined the impact analysis of implemented recommendations with workforce development tracking, supported by stakeholder insights. The evaluation also examined opportunities for expanding the programme's reach within the skilled technical workforce, ensuring recommendations were grounded in both performance data and sector needs. In addition, each IAC must prepare a report at the end of its funding cycle summarising activities, student involvement, publications, and goals. These centre-level reports are primarily descriptive, offering limited operational insight into the functioning of individual IACs.

Methodology

In this study, I adopt a comparative case study design to examine SME-focused energy efficiency programmes in the United Kingdom and the United States, specifically the ERDF England Operational Programme and the ITAC programme. Both are large-scale, mature and well-documented interventions to improve SME energy efficiency and support decarbonisation, making them suitable for comparative analysis. The ITAC programme was selected for its national coverage, long operational history and combination of technical assessments, workforce training and, since 2021, large-scale implementation grants (Rep. DeFazio, 2021). It offers a mature institutional framework, a public database of recommendations and outcomes, and an evaluation of its capacity-building role (SRI International et al., 2022). The ERDF England strand was chosen because, until its conclusion in 2023, it was the largest single funding source for SME decarbonisation in England, with national coverage, substantial funding and comprehensive evaluation through publicly available summative assessment reports.

For ITAC, I used the public assessments and recommendations databases to obtain reported energy and cost savings and implementation rates, complemented by US DOE materials on scope and funding. For ERDF England, I reviewed 20 summative assessments and analysed seven measure-level datasets. Some assessments were public; for the remainder, and for all measure-level data, my dissertation advisor (Dr Sam Hampton) and colleagues requested anonymised datasets from project managers and shared them with me. I compiled these sources by manually reviewing differing report formats, extracting comparable variables and reconciling terminology. To my knowledge, no prior academic synthesis has combined ERDF SME decarbonisation evidence at project- and measure-level granularity to assess impacts on SMEs energy efficiency; this dissertation provides that consolidated evidence base.

Originally, I planned to complement document and data analysis with semi-structured interviews to assess the transferability of ITAC policy features to the UK. Delays in obtaining ethics approval precluded this, so I adopted a fully document- and data-based scope focused on comparing programme-level outcomes and synthesising reported co-benefits and implementation learning. As a result, the study privileges measurable outcomes over stakeholder perspectives; future work should address this.

To ensure comparability, I standardised datasets by mapping project-specific labels to a common measure taxonomy and aligning spend categories (ERDF: revenue vs capital; ITAC: operational vs grants). Because ERDF expenditure is not reported by year, monetary values are reported in nominal terms. For cross-country comparisons, I converted GBP to USD using the 2023 average rate of 1 USD = 0.80 GBP (Exchange rate UK, 2023). ERDF emissions reductions were taken directly from summative assessments or operator datasets. As ITAC does not report emissions, I estimated them

from reported energy savings using an electricity factor of 366 tCO_2/MWh (EIA, 2025) and standard factors for natural gas and other fuels (EIA, 2025).

I structured the analysis around two sets of indicators: (i) direct outcomes and value for money; and (ii) reported co-benefits. Direct outcomes comprise the number of SMEs supported and total emissions reductions; value for money is measured as cost per SME supported and cost per tonne of CO_2 reduced. For ERDF, total public expenditure aggregates revenue and capital spending where reported. For ITAC, I distinguish operational expenditure and implementation grants; where splits are unavailable, I infer the public contribution from DOE cost-share statements. I also calculate the simple payback for implemented ITAC measures (the implementation cost divided by the expected annual cost savings). Reported co-benefits, educational impact, workforce development, economic growth and additionality are drawn from ERDF summative assessments and ITAC evaluation materials and inform the Discussion.

Important limitations remain. ITAC and ERDF differ in eligibility definitions, funding mechanisms, and delivery structures, which complicates direct comparison; for example, the UK's SME definition and sectoral scope differ from ITAC's manufacturing-focused eligibility criteria (ITAC, 2022). Performance data are primarily self-reported by delivery teams for ERDF and by participating IACs and firms for ITAC. The ITAC implementation status relies on follow-up calls, typically six to nine months after assessments, and does not capture the long-term persistence of measures or changes made after the assessment. ERDF evaluations differ in methodological rigour and scope, which impacts the reliability and comparability of results within the programme and also in the ITAC comparison.

Findings

Results from the ERDF summative assessments and measure-level data

To assess the effectiveness of the ERDF-funded programmes, this subsection examines the outcomes reported in the summative assessments of multiple projects supported between 2016 and 2023. These evaluations provide aggregated data on SME engagement, carbon and energy savings, and the financial support allocated through grant schemes. In addition to this overview, the analysis draws on more granular data from seven selected projects to understand the types of decarbonisation measures that were implemented with grant support. This approach allows for a more comprehensive assessment of the programmes' overall impact on UK SMEs and highlights the specific strategies that proved most effective. By identifying key patterns and barriers, the findings aim to inform the design of future decarbonisation initiatives and contribute to a broader understanding of how public funding can best support SME sustainability transitions.

Impact of the programme, SMEs supported, energy and emission reductions

Across the 20 ERDF-funded projects analysed, each offering both energy assessments and grants to incentivise the implementation of decarbonisation measures, a total of 5,665 SMEs received support. However, this figure excludes additional businesses that received limited assistance falling short of the 12-hour engagement threshold required to qualify as a fully supported SME under ERDF definitions. Unlike the ITAC programme, which focuses on manufacturing, the ERDF initiatives targeted a broader range of sectors, as seen in Figure 9. While manufacturing remained the most

frequently supported industry, a significant share of beneficiaries came from wholesale and retail, as well as accommodation and food services. Despite this diversity, only 11 of the 20 summative assessments provided any form of sectoral breakdown, limiting the ability to compare outcomes across industries or understand sector-specific needs. This inconsistency in reporting highlights a wider challenge in assessing programme reach and delivering more targeted support in the future.

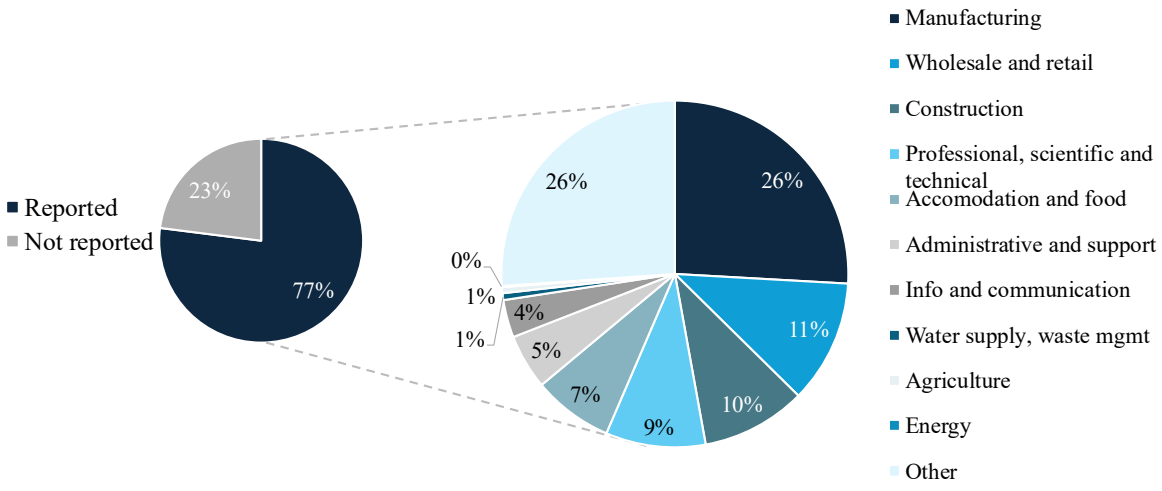


Figure 9. Sectors supported by ERDF-funded projects

Analysis of more granular data from seven projects reveals that a significant share of grants were awarded to support mature, commercially proven technologies, most notably LED lighting and solar PV systems. These two measure types alone represent 32% and 23% of all supported interventions, respectively, reflecting a strong preference for solutions with well-established performance records and attractive economic returns, even without public subsidies, as seen in Figure 10 (Department for Business, Energy & Industrial Strategy, 2023; Mandys et al., 2023). This trend raises important considerations about additionality, as grants might be supporting decisions that SMEs would have made anyway, favouring lower-risk, cost-effective options. Besides lighting and solar, process energy and machinery optimisation are also significant, highlighting the operational and productivity priorities of manufacturing SMEs. However, the findings may be partially skewed, as the dataset overrepresents manufacturing firms.

Across the seven projects, 52% of the funded measures focus on building energy efficiency, including LED lighting, HVAC upgrades, heat pumps, insulation, and glazing, an area identified by the Climate Change Committee as vital for achieving national decarbonisation targets, with buildings expected to account for 20% of emissions reductions between 2025 and 2037 (CCC, 2025b). The absence of data on non-implemented recommendations limits a deeper understanding of SME decision-making and barriers. Given the prevalence of leased commercial properties among SMEs, where tenants often lack incentives to invest in efficiency improvements, building-related measures present an opportunity to enhance additionality, particularly if future programmes address split incentive barriers and intent to reduce building-related emissions.

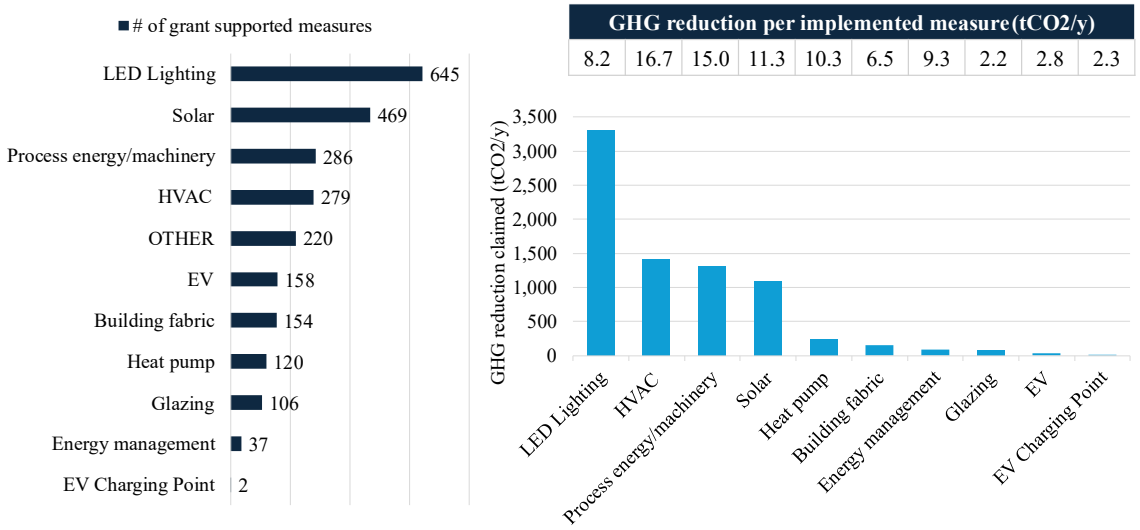


Figure 10. Number of grant-supported measures and claimed emission reductions (C34) by 7 ERDF projects

Inconsistencies in how GHG savings are reported across ERDF-funded projects raise concerns about the comparability of claimed outcomes. For example, BEE Anglia reported 0.106 tCO_2 saved per £1,000 of project cost in LED lighting measures, while Durham BEEP claimed over 1.89 tCO_2 for the same intervention type, as shown in Figure 11, without providing a clear explanation of whether these differences stem from methodology or other factors. This variation in claimed emissions is evident across all measure types, with some projects consistently reporting lower GHG reductions and others consistently reporting higher ones. Overall, the summative assessments estimate a total reduction of 98,714 tonnes of CO_2. However, the reported effectiveness of individual projects varies significantly, ranging from an average of 2 to 68 tCO_2 saved per SME supported. When normalising by project capital cost, as seen in Figure 11, the variability remains even when considering the amount of investment required. The absence of standardised methods or verification protocols makes it challenging to assess the accuracy of these figures. Moreover, no clear link is evident between GHG reductions and the level of capital or revenue expenditure per SME, or between emissions savings and the sectors supported, partly due to incomplete reporting. These differences emphasise the need for more detailed and uniform guidance and reporting frameworks to ensure dependable and comparable emissions accounting across projects.

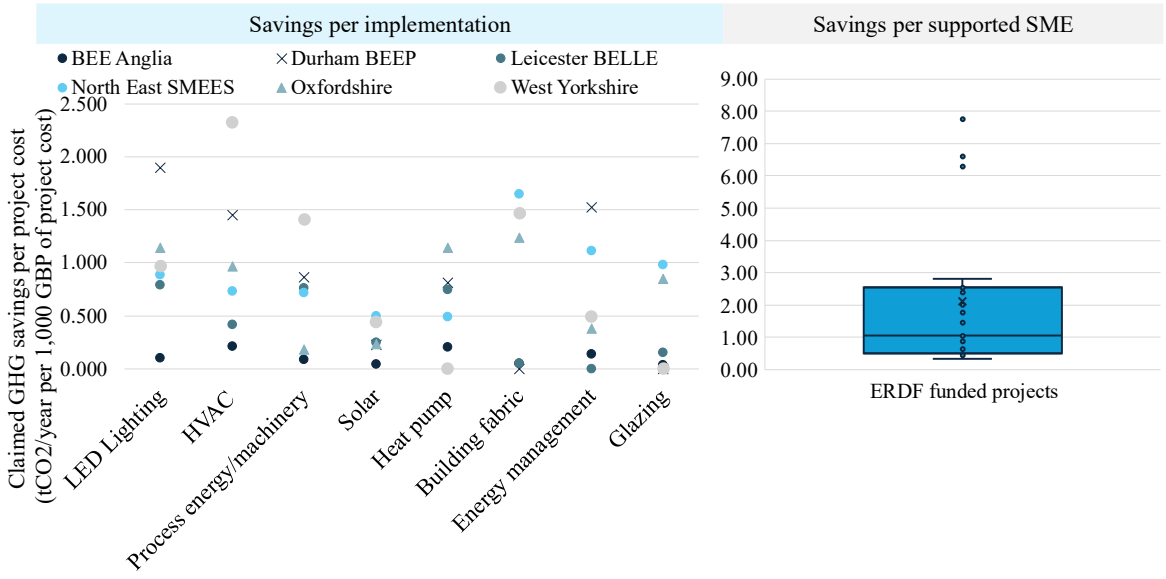


Figure 11. Reported data variability by the analysed ERDF projects

In summary, these projects provided support to thousands of SMEs across multiple sectors, with a clear emphasis on promoting mature, low-risk technologies such as LED lighting and solar PV. While these interventions align with national climate targets and provide economic benefits, the evidence raises questions about additionality and whether public funding is effectively enabling change or should be directed towards higher emission reduction technologies, such as phasing out natural gas for heating processes. The scale of these initiatives remains limited, and less than 1% of SMEs have received support, highlighting the need for a scalable intervention. Inconsistent reporting practices limited sectoral breakdowns, and variation in GHG savings per measure further complicate the assessment of programme impact. To improve the effectiveness and transparency of future initiatives, a clear need exists for standardised methodologies, improved data collection and reporting, and targeted support that addresses specific barriers, particularly for higher-impact measures and sectors currently underserved.

Results of the ITAC programme

To understand the effectiveness of the ITAC programme, this chapter analyses the direct outcomes of the energy assessments conducted between 2014 and 2024. While the programme's main aim is to offer free audits to SMEs that lack in-house energy expertise, its success depends on whether the recommendations are implemented and result in energy and cost savings. The publicly accessible ITAC database functions as a repository for monitoring these outcomes, providing detailed information on implementation rates, projected savings, and the types of measures recommended. Besides these quantitative indicators, the programme's impact is evaluated in the following sections by its contributions to student training and workforce development, as well as the knowledge it generates, as evidenced by the academic and technical publications produced from the assessments. These dimensions collectively provide an understanding of the programme’s effectiveness and policy value for money.

Impact of the programme, SMEs supported, energy and emission reductions

As noted in the ITAC policy overview, the programme primarily targets SMEs within the manufacturing sector that meet specific eligibility criteria. Historically, around 98% of all

assessments have been conducted in manufacturing, although recent years have seen a gradual inclusion of businesses from other sectors (ITAC, 2025a). Within manufacturing, food processing facilities represent the most frequently assessed industry, followed by metal and rubber product manufacturers (ITAC, 2025a). Since 2014, the programme has completed an average of 507 assessments annually, with each IAC conducting approximately 17 audits per year, as seen in Figure 12.

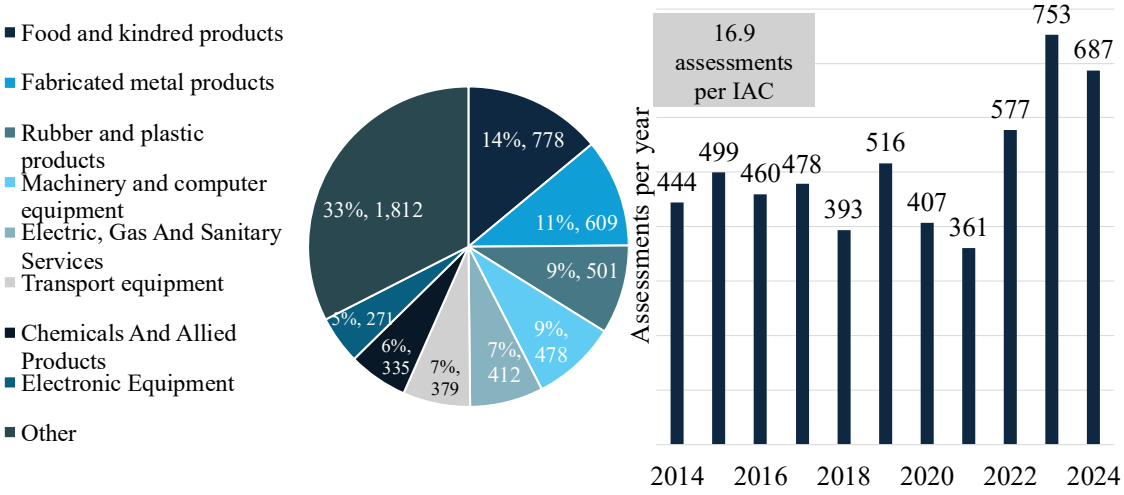


Figure 12. Assessments per year and assessments by sector

The assessments conducted through the ITAC programme yield recommendations aimed at enhancing the operational efficiency of SMEs. While most suggestions focus on energy management, particularly reducing electricity and natural gas consumption, areas such as productivity improvements and waste reduction are also addressed. The most common measures include enhancing the efficiency of air compressors and lighting systems, which are implemented at rates of 48% and 51% respectively (Figure 13). Air compressor measures are primarily operational in nature, most often involving the elimination of leaks, reducing system pressure to the minimum required, and positioning air intakes in cooler locations. These types of improvements illustrate how manufacturing SMEs can enhance energy efficiency without investing in new equipment. Better heat management is another key focus, with boiler upgrades, heat recovery systems, and heat containment frequently advised. Notably, heat recovery measures and general recommendations—most of which relate to solar generation (53%), but also include practices such as metering recycled water (7%) and reducing water consumption (6%)—tend to have the lowest implementation rates.

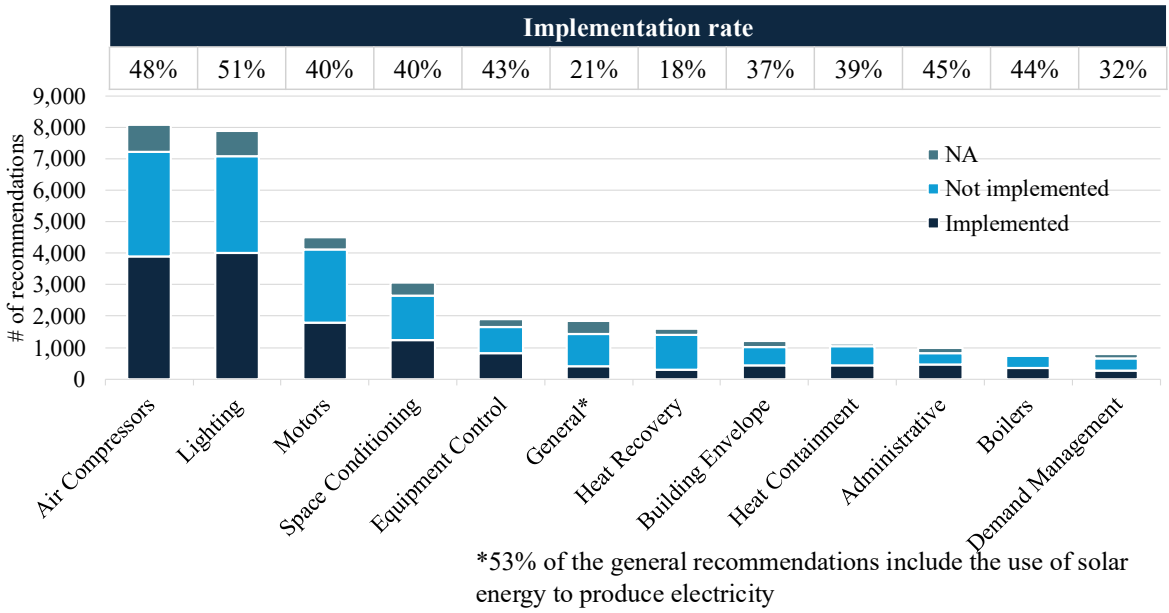


Figure 13. The most common measure types recommended and their implementation rate.

Across the programme, the average implementation rate of recommended measures stands at 41%, with 20 IACs reporting rates above this threshold and 26 falling below. Several of the lower-performing IACs, such as the CC IAC, appear to have underreported implementation data, which contributes to their low implementation rates (Figure 14). This pattern may be explained in part by the fact that many of these IACs began operations in 2021 and have conducted fewer assessments overall. As a result, a greater share of their recommendations were issued in 2024, meaning follow-up interviews may still be pending or implementation updates have yet to be reported. These differences suggest that some IACs may be more consistent in conducting follow-up interviews, offer stronger cases when supporting recommendations or that regional variations influence SME engagement and willingness to adopt recommended measures.

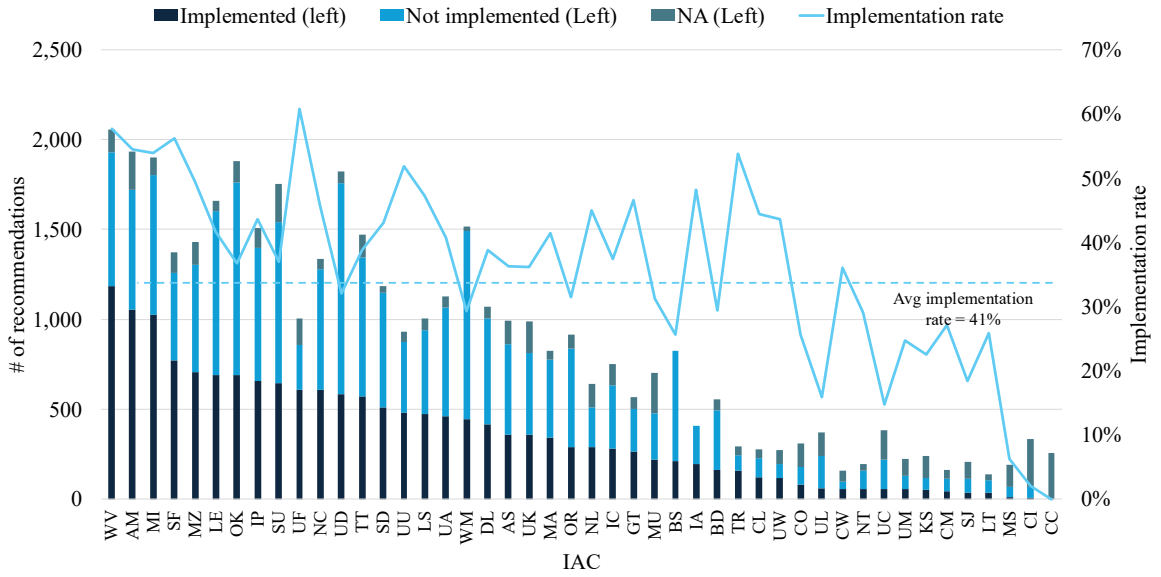


Figure 14. Implemented and not implemented measures, implementation rate by IAC

Each recommendation includes an estimate of the annual energy savings and specifies the type of energy source expected to be reduced. Between 2014 and 2024, the programme identified a total of 9,410 GWh per year in potential energy savings, of which approximately 3,785 GWh per year, or 40%, have been realised through implemented measures. Recommendations targeting the optimisation of heating processes, which primarily reduce on-site natural gas consumption, account for the highest energy savings per implementation. Electricity-saving measures, although producing smaller savings per case, are recommended more often and implemented at higher rates, significantly contributing to the programme's overall impact (Figure 15). This indicates that supporting SMEs requiring heating services with natural gas presents the greatest opportunity to reduce emissions per measure implemented.

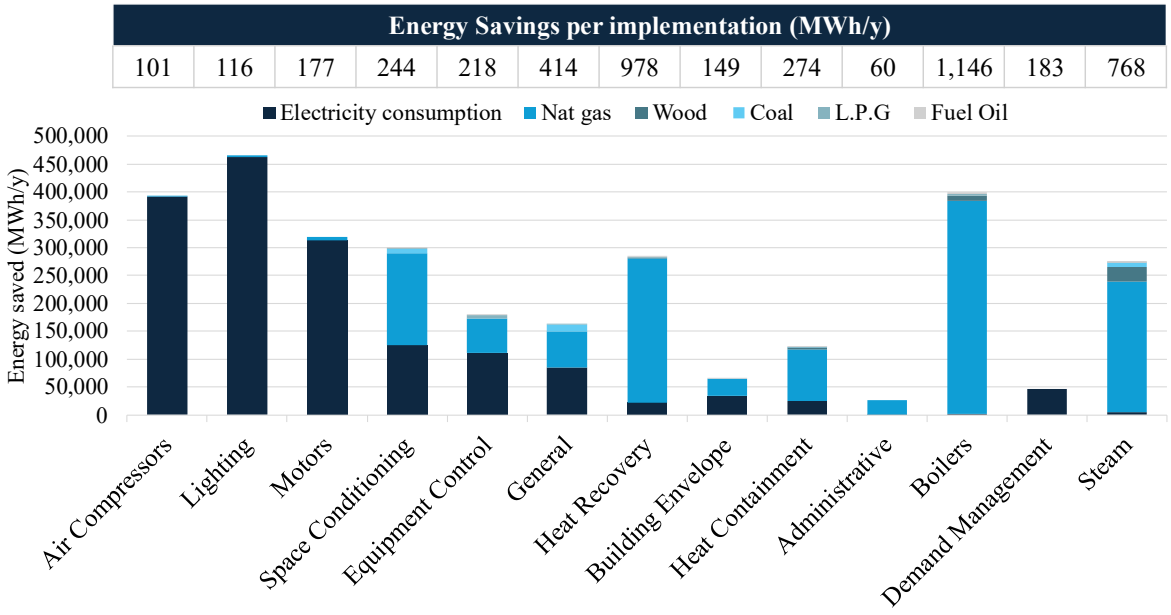


Figure 15. Energy savings from implemented recommendations.

Emission savings were estimated based on the projected energy savings from each recommended measure. As seen in Figure 16, among the implemented measures, lighting upgrades have contributed the most to actual GHG reductions, mainly due to the high volume of recommendations and their relatively high implementation rate. Of the total potential emission reductions identified for each measure, 57% from lighting and 48% from air compressors were successfully captured. Heat recovery processes alone represent the largest source of untapped reductions, with only 15% of their potential emissions being captured, while measures regarding boilers captured only 32%. These measure types highlight where targeted support could generate more environmental benefits, especially considering the higher capital costs typically associated with such measures. By facilitating the adoption of these higher-impact but less frequently implemented technologies, the programme could increase its additionality, helping SMEs pursue projects they might otherwise forgo and significantly increasing overall emissions reductions.

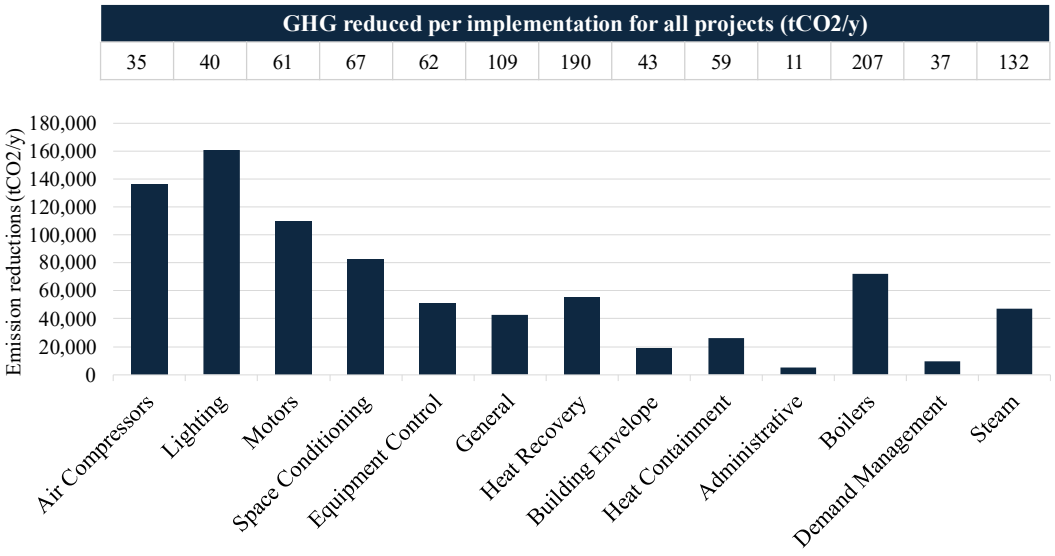


Figure 16. Estimated emissions reductions by implemented measures

Each data point in the analysis represents the estimated emissions reductions reported by individual IACs. As shown in the Figure 17, there is significant variability in the reported emissions savings per measure across centres. This variation is consistent even when normalising by project implementation cost. It may stem from differences in the methodologies used to calculate energy and emissions savings, or from the types of SMEs each IAC typically assesses, resulting in measures with differing impacts. The lack of consistency suggests there is currently no uniform approach to reporting energy savings across the programme. This represents an important area of opportunity: adopting a standardised methodology could improve the comparability and reliability of reported outcomes, enhancing the programme's overall effectiveness and credibility.

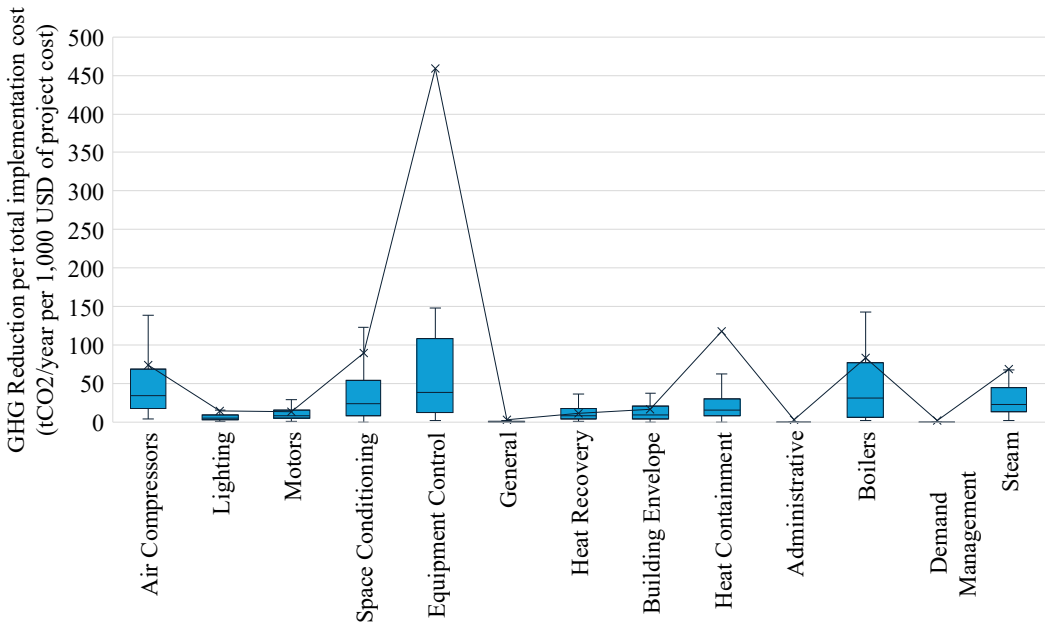


Figure 17. Variability of emission reductions per measure as reported by each IAC

In addition to estimating potential energy savings, each recommendation includes an expected cost for implementation and the projected annual financial savings. This allows for the calculation of simple payback periods, providing insight into the cost-effectiveness of each measure. For the 13 most frequently recommended measure types, the average expected payback period was 1.8 years for implemented measures and 2.0 years for those not implemented. These relatively short payback periods suggest that the average implemented recommendation is more financially attractive. Administrative measures and equipment control improvements typically offer the quickest returns, often within a year, as seen in Figure 18. These measures involve minimal capital investment and focus on operational optimisation, such as reducing leaks, lowering pressure to necessary levels, or turning off equipment when not in use. The most common administrative strategies include applying for tax-free status and paying utility bills on time.

Air compressor measures, as noted above, also focus primarily on operational improvements and typically require only small capital inputs. This contributes to their relatively high implementation rates, as firms can achieve energy savings with reduced upfront expenditure. By contrast, general recommendations tend to involve a higher cost per implementation, driven mainly by the capital-intensive nature of installing on-site solar generation systems. These measures, therefore, have some of the longest payback periods, making them less attractive for SMEs despite their potential for long-term energy savings.

When comparing the average payback period, implemented recommendations tend to have shorter payback periods than those that have not been implemented. This suggests that SMEs may be discouraged by higher initial costs and longer payback periods, despite the greater environmental benefits. The fact that implemented measures show an average payback period 11% shorter than non-implemented ones supports the idea that SMEs focus more on economic factors than environmental impact when making decisions, as can be seen in Figure 18.

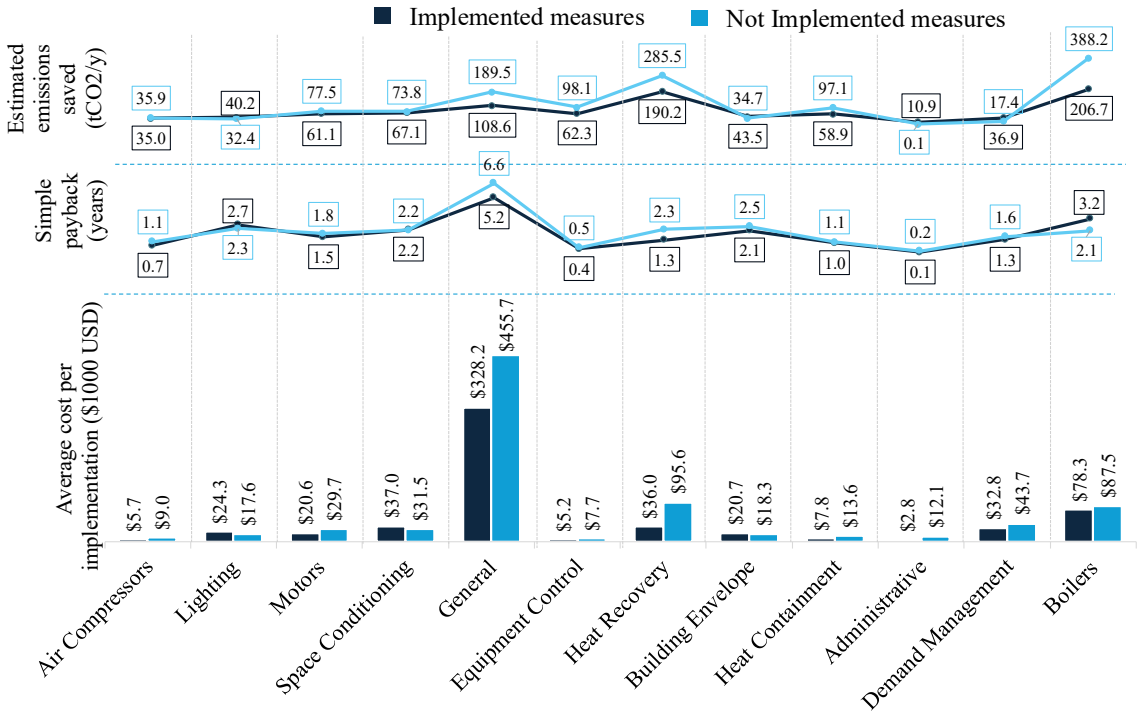


Figure 18. Implemented vs recommended but not implemented measures, estimated emissions saved, simple payback and average implementation cost

Interestingly, non-implemented measures are associated with 44% higher expected CO_2 savings per year compared to those that have been implemented, according to the assessment data. This trend suggests that SMEs may prioritise measures with stronger economic returns, even when these deliver lower environmental benefits. Another possible explanation is that larger projects, which typically achieve greater emissions reductions, also require higher upfront investment and are therefore less likely to be adopted. For example, within the category of general measures, which includes solar electricity generation, implemented recommendations have, on average, a 27% shorter payback period but achieve 75% lower emissions reductions than those that remain unimplemented (Figure 18). This implies that SMEs might be hesitant to adopt environmentally impactful projects when they involve longer payback periods or higher upfront costs. However, when considering the cost per tonne of CO_2 abated, the implemented measures on average prove 10% more cost-effective, delivering emissions savings at a lower cost (Figure 19). This indicates that while SMEs may be prioritising cost-effectiveness, they are still achieving relatively efficient environmental outcomes for the money invested. The data, therefore, suggests that SMEs are making economically rational decisions that align, to some extent, with environmental performance goals.

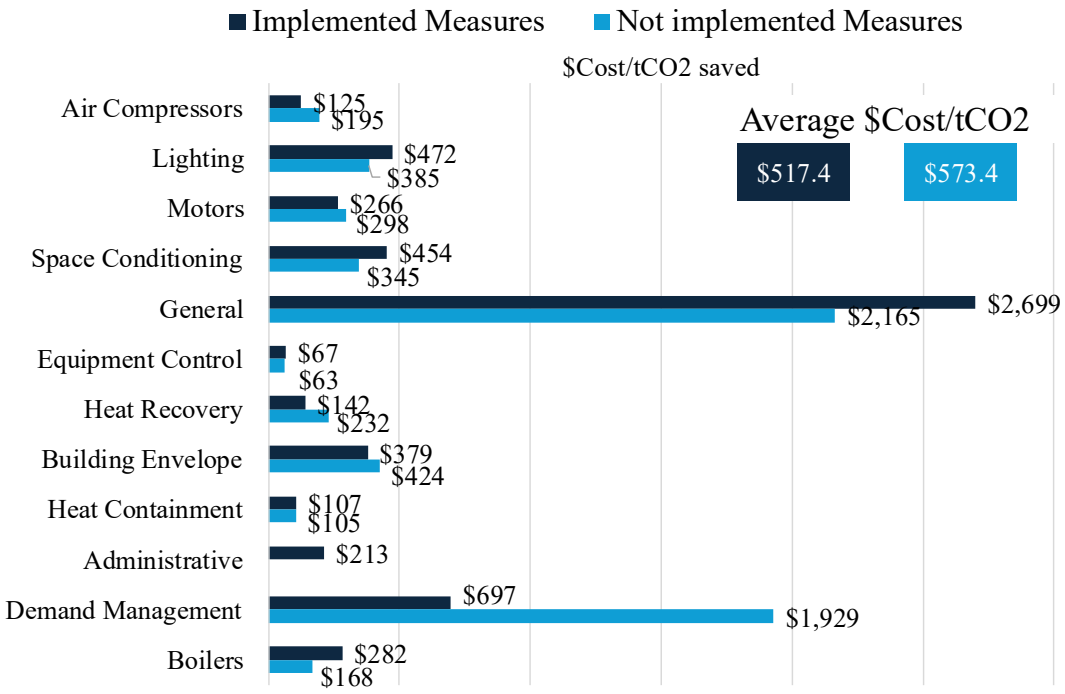


Figure 19. Implementation cost per expected tCO2 saved

Overall, data from 2014 to 2024 demonstrates both the significant impact and the key limitations of the ITAC program. The substantial number of assessments conducted and the resulting potential energy and emissions savings highlight the program's direct influence on the U.S. manufacturing sector but its limited reach when considering the total number of SMEs in the country. The discrepancy between implemented and non-implemented measures offers valuable insight into how SMEs prioritise and make decisions. Additionally, inconsistencies in data reporting practices among IACs present a clear opportunity for improvement. By refining follow-up procedures and promoting consistency in data collection, the program can enhance its effectiveness, improve its credibility, and unlock greater environmental benefits.

Value for Money comparison

This section benchmarks the cost and cost-effectiveness of ERDF-funded projects against the U.S. ITAC programme. It compares operational/revenue costs per assessment or SME, spending per tCO_2 reduced, the measure mix and additionality, and private capital leveraged. It also flags comparability limits arising from COVID-period disruptions and differences in eligibility/scope between programmes.

The ITAC programme presents higher estimated operational costs per assessment when compared to ERDF-funded projects, as seen in Figure 20. Since 2021, each IAC has incurred average annual operational costs of $811,000 USD (£637,000 GBP), with previous federal estimates indicating an average cost of $18,000 USD per audit (£14,200 GBP). The current post-2021 average cost per audit is closer to $43,000 USD (£33,800 GBP). However, assessment costs in 2021 may have been affected by COVID-19-related restrictions that limited the ability to conduct on-site visits, constraints that similarly impacted ERDF-funded assessments during the same period. It is important to note that results may not be directly comparable due to the differing scope of assessed businesses.

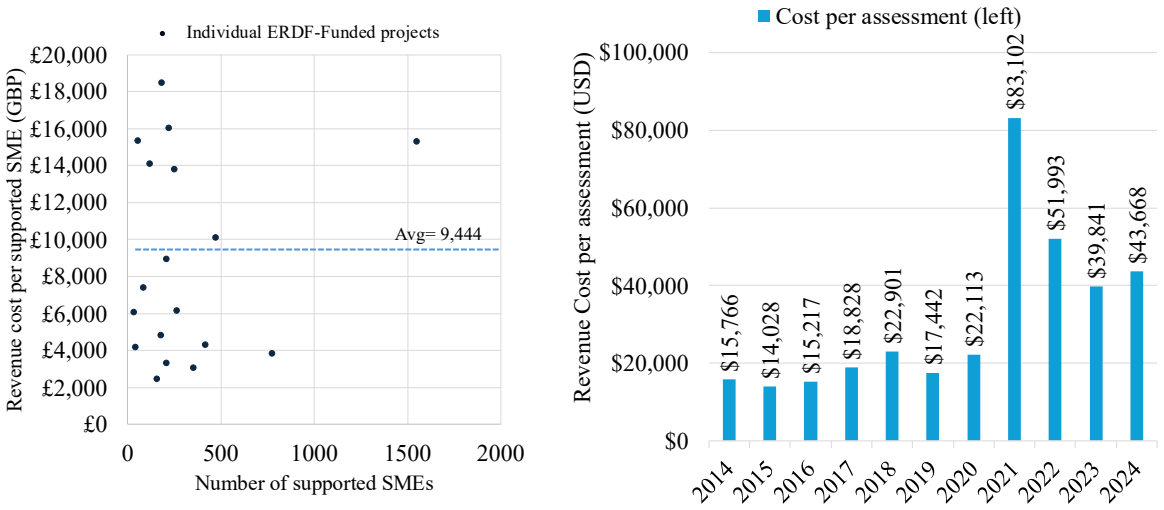


Figure 20. ERDF and ITAC revenue cost per assessment

In contrast, ERDF-funded projects reported an average revenue cost of £9,444 per supported SME across the 2016–2023 period. Here, revenue cost refers to the project cost excluding capital expenditure. Capex was excluded from this metric because many SMEs that received support only underwent an assessment and received recommendations; many did not proceed with implementation, while others carried out measures independently without drawing on capital grant funding. This analysis is based on the stated project costs and the reported number of supported SMEs. Reported figures vary widely between local projects, with the Low Business Support project reporting the lowest cost per SME at £2,439, and the Growing Oxfordshire's Low Carbon Economy project reporting the highest. These differences may reflect variation in the types of support offered, the size of grants awarded, or the intensity of engagement provided to each business.

Some projects, such as the Sustainability in Business (SiE) initiative, operated by Nottingham Trent University (NTU), reported high revenue costs, up to £16,000 per supported SME. In this project, education was a significant focus, as students were directly involved in conducting the assessments in a model similar to the ITAC programme. Decarbonisation assessments, therefore, represented only one part of a broader set of interventions, which also included graduate placement schemes,

consultancy support, and the establishment of a sustainability community lab. This is an example of an ERDF project where the decarbonisation strategy was broader than simply supporting SMEs and reducing emissions, aiming instead to deliver wider educational and institutional benefits and increasing the cost of supporting individual SMEs. These broader perspectives generated value that is harder to quantify than straightforward emissions reductions, and an effort to capture and assess these additional impacts is made in the next section.

Across both ITAC and ERDF-funded projects, lighting upgrades and solar PV installations emerged as the most commonly supported measures, as seen in Figure 21. While these technologies deliver measurable emissions reductions, their widespread adoption and favourable payback periods suggest that public funding may have supported investments that could have proceeded without intervention. In contrast, measures such as heat recovery, boiler upgrades, and motor efficiency improvements, particularly under the ITAC programme, have shown lower implementation rates despite offering higher emissions savings per intervention. Redirecting grant support toward these under-implemented but high-impact technologies may offer a more effective path to maximising carbon reductions. Solar generation projects, while capital-intensive, also deliver significant emissions savings and could still warrant support where additionality can be demonstrated. Given the maturity of the solar market, further research is needed to assess the extent to which grants for solar PV deliver outcomes that would not otherwise occur, both in the UK and the US contexts.

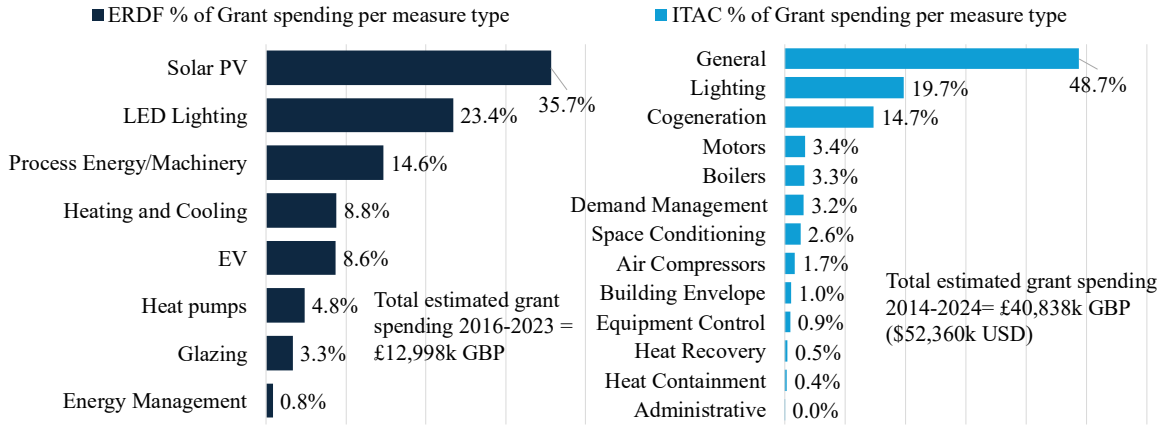


Figure 21. Grant spending by 7 ERDF projects and the ITAC programme

The ERDF-funded projects collectively reported estimated annual savings of 98,714 tonnes of CO_2, achieved at an average total cost of £969 per tonne reduced (Figure 22). This value includes both revenue and capital spending and falls well below the ERDF's benchmark of £2,000 per tonne of CO_2 abated (Nottingham Trent University, 2023), indicating that the programme delivered emissions reductions within acceptable cost thresholds. Compared with ITAC, the ERDF projects appear broadly similar in cost-effectiveness over the long run: ITAC's 10-year programme average is about $700 USD (£546) per tonne, as shown in Figure 22. By contrast, post-2021 ITAC reductions are estimated at $1,102 USD (£859) per tonne, reflecting the introduction of an annual grant budget and increase in revenue spending since 2021; only disbursed grant funding is counted in this calculation. Considering only public funding, the 10-year average for ITAC is $242 USD (£189) per tonne, versus $538 USD (£419) per tonne in the post-2021 period, both numbers remaining below the ERDF spending per emission reduction.

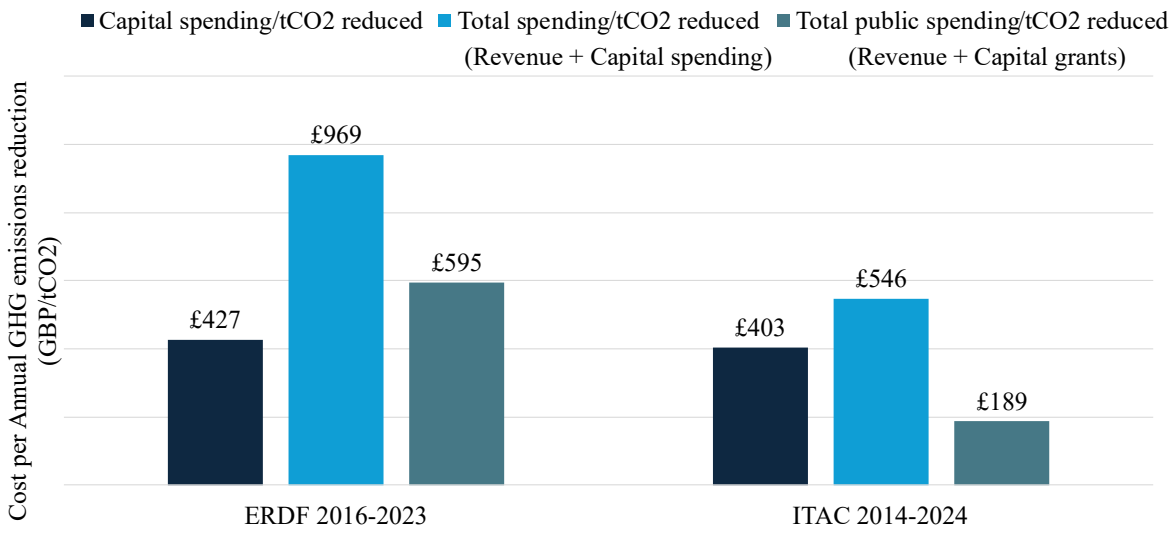


Figure 22. ERDF and ITAC spending per claimed tCO2/y reduced

Overall, these figures suggest that ITAC has been more cost-effective than ERDF in terms of reduced GHG emissions, particularly when considering the actual expenditure per tonne reduced. However, the difference between the two programmes should not be overstated. The methodologies used to calculate emissions reductions differ across the two contexts, making direct comparisons more indicative than definitive. As a result, while ITAC appears to deliver reductions at a lower cost on average, both programmes can be regarded as achieving broadly comparable levels of effectiveness within their respective policy and funding frameworks.

Since its inception, ITAC has also demonstrated strong mobilisation of private capital, with $1.89 of private investment leveraged for every dollar of public funding. However, this ratio has declined significantly in recent years. Between 2014 and 2020, ITAC leveraged $3.67 of private capital per dollar spent by the DOE, whereas in the post-2021 period, this figure fell to just $1.05. The ERDF programme, by contrast, has leveraged £0.63 of private capital for every pound of public funds spent, based on data from summative assessments, typically in the form of grant match capital. Taken together, these figures indicate that both programmes have mobilised private investment that likely would not have occurred absent public intervention. Differences in programme design help explain variation in leverage: ERDF support typically required implementation to receive a grant, whereas in ITAC, only around 11% of implementations were grant-supported, with most proceeding without direct grants, which could explain the higher private-to-public spending ratio. This raises the question of whether grants are necessary for these programmes to be effective or if a more selective approach to their roll-out is advisable.

Broader Impacts on Education and Economic Growth

Both the ITAC and ERDF-funded programmes extend their impact beyond direct SME decarbonisation by contributing to other objectives, including economic benefits and capacity building in the clean energy workforce. The ITAC programme provides both undergraduate and graduate students with practical experience in energy auditing and technical reporting within manufacturing settings, enhancing their technical and professional skills (SRI International et al., 2022). Students analyse utility bills, industrial processes, and building performance. This hands-on experience helps them stand out among their peers: alumni show 72% higher energy efficiency-related skills, gain valuable communication and leadership abilities through client interaction, and are

twice as likely to enter green careers, earning on average 9% more than comparable graduates (SRI International et al., 2022; US DOE, n.d.).

By contrast, student capacity building through ERDF programmes has been more limited, with the main initiative being the SiE programme. This deployed 86 graduates as sustainability champions in SMEs and trained 500 students in practical carbon management (Nottingham Trent University, 2023). Under academic supervision, students delivered carbon audits, diagnostic reports, and action plans for SMEs, directly contributing to GHG and cost reduction strategies. Survey results show that 98% of participants gained confidence in assessing sustainability within organisations and 95% felt better equipped to communicate ideas to drive change (Nottingham Trent University, 2023). Beyond technical training, students helped SMEs build awareness, skills, and policies, while also benefiting from networking opportunities. This demonstrates how involving students can create lasting impacts for both businesses and the future workforce as these graduates move into leadership roles.

The ITAC programme also supports workforce integration and faculty development. According to survey data, 72% of alumni report that the programme helped them secure their first job, and 53% work in energy efficiency-related roles (US DOE, n.d.). To further support alumni, the programme provides a job-matching platform connecting them with employers in the manufacturing and energy sectors. This creates a path from university to employment, reinforced by the practical skills developed through assessments. Additionally, IACs are embedded in universities and provide funding for faculty to engage in energy systems work. Many IAC directors use the programme to develop new teaching content; it is estimated that for every student directly involved, three others are exposed to energy topics through coursework (Trombley & Amann, 2010). The programme's contribution to research is also significant. Since 1997, it has produced 943 publications, including publications in peer-reviewed journals, conferences and technical reports, which are a secondary outcome of the assessments and are authored by IAC personnel. These publications aim to improve energy efficiency in the manufacturing sector by identifying operational improvements, optimising industrial processes, developing new techniques for conducting energy audits, and supporting SMEs in making informed investment decisions through cost-effectiveness analysis of new technologies (ITAC, 2025b). While ERDF-funded projects do not systematically report research output, they do promote collaboration between academia and business. Across the reviewed projects, 175 SMEs worked with research institutions (C26 metric), promoting innovation transfer and co-creation of new low-carbon services.

The ERDF-funded projects demonstrated economic co-benefits, including reported job creation and cost reduction. Ten of the twenty assessed projects claimed impacts on employment, with a total of 919 full-time equivalent jobs created, providing a visible contribution to local labour markets. Seven projects also reported potential cost reductions, with average SME savings of £5,535 per project year. However, evaluation evidence suggests that job creation data should be treated cautiously. For example, the Phase 2 evaluation of Priority Axis 4b indicated that beneficiaries actually reported a decline of 0.6 FTEs per business (a 9% reduction), with the counterfactual analysis instead showing a 20.4% employment growth, 89% of which was additional (Hatch Regeneris Consulting & MHCLG, 2021). This discrepancy highlights the challenge of attributing employment effects to energy efficiency interventions, suggesting that reported job creation impacts may not be entirely reliable. This data was also impacted by the COVID-19 pandemic and its effect on the job market.

By comparison, ITAC does not report job creation figures but tracks financial savings in a more consistent manner. Each assessment identifies potential annual savings of around $150,000 USD (£117,000), of which approximately $50,000 USD (£39,000) is typically realised through implemented measures. The scale of these opportunities points to a potentially larger contribution to

firm competitiveness, even if indirect employment impacts are not quantified. In both programmes, SME economic growth is evident and demonstrates that employment and cost savings related to energy audits are regarded as inherent to efficiency-focused measures.

Both programmes demonstrate strong additionality, addressing barriers that prevent SMEs from pursuing energy improvements independently. In the ITAC programme, 75% of clients would not have sought an audit without the programme, and 87% of recommendations were not previously planned (SRI International et al., 2022). Similarly, several ERDF projects demonstrated that their interventions led to actions that might not have occurred without support. For example, in the BEE Anglia programme, only 16.7% of SMEs would have taken action without grants, and in the CSA project, 76% of beneficiaries either would not have acted or would have delayed investment. These findings demonstrate that both ITAC and ERDF-funded projects effectively addressed market failures, whether through grant schemes, advisory services, or technical support, enabling SMEs to act earlier or more ambitiously than they would have otherwise. Additionally, 148 new enterprises were supported through the ERDF programme, a goal that the ITAC programme cannot meet, given the requirements for reporting annual electricity bills and revenue. This would improve energy efficiency for SMEs since its inception by helping them avoid locked-in investments in less efficient technologies and creating an on-site team better prepared to address future decarbonisation challenges.

Discussion: Comparative analysis

This section examines similarities and differences between ERDF-funded projects in the UK and the ITAC programme. The comparison focuses on what characteristics of each programme could dictate future policies to achieve the most impact. By reviewing both models, the analysis identifies where decentralised approaches benefit from local flexibility, where centralised models offer efficiency and consistency, and how each can inform the other's design to improve impact, scalability, and cost-effectiveness.

Fragmented approach vs. one standardised programme

ERDF projects used multiple regionally tailored initiatives, aligning with local priorities but resulting in variation in delivery methods, data collection, and performance metrics, which complicated comparison. ITAC operates as a single nationally standardised programme with consistent audit methods, reporting formats, and metrics across centres. A central coordinating role, for example, ITAC's Field Manager at Rutgers, supports quality assurance, methodological alignment, and uniform data reporting across sites. This is an important operational element that other schemes could replicate by appointing a national coordinator to align partners, standardise tools, deliver training, and oversee data quality.

Fragmentation in ERDF increased local responsiveness but could reduce national visibility of results and limit system-wide learning. Standardisation in ITAC enables long-term benchmarking and planned adjustments, though coordinating changes across all parties can be complex. This coherence has enabled clearer national reporting of cumulative impacts. The DE-carbonise summative assessment (Shaw et al., 2022) also notes the value of expertise built over time. This illustrates the advantages of implementing long-term initiatives over temporary ones.

Sector focus differs. ITAC targets manufacturing, which concentrates technical expertise, simplifies assessment tools, and facilitates engagement with industry, useful for issues such as process heat

recovery and motor system optimisation. The trade-off is a narrower reach. ERDF projects spanned more sectors, broadening coverage but often with less sector-specific depth and making it harder to draw standardised measures.

Project marketing and reach

ERDF projects recruit SMEs through local networks, chambers of commerce, and partners, using email, telesales, cold calls, and online ads. Reach depends on each partner's resources, leading to uneven uptake and weak programme recognition; minimal branding can further limit trust beyond immediate networks.

ITAC's national brand and long-standing presence enable direct outreach to SMEs and associations. Consistent materials, a central website, and active alumni networks sustain visibility across sectors and regions without requiring redesign of engagement. While ITAC leans on reputation and direct contacts, ERDF projects were more active, using networking and targeted campaigns.

A hybrid of ITAC's brand strength and ERDF's multi-channel outreach could maximise visibility and highlight economic benefits. Both models face a common gap: SMEs receive audit reports but lack support to act. Providing follow-up, vendor identification, technical guidance, and links to certified suppliers, and, with consent, sharing data with pre-vetted suppliers while maintaining impartiality could boost implementation. As noted in the Phase Three ERDF evaluation, showcasing successful case studies would build trust by emphasising tangible benefits.

Are energy audits necessary?

The strong presence of lighting and solar PV projects in both ITAC and ERDF-supported recommendations suggests that specific efficiency measures are a common need across SMEs. Some of these quick-win measures can be found in the majority of facilities, especially in smaller organisations: an analysis of industrial firms in the United States found that more than 70% of facilities could implement quick-win upgrades to lighting and air compressors, and that around 45% of facilities have the potential to achieve savings through upgrades to motors (IEA, 2025). In such cases, making an audit a prerequisite for grants can add unnecessary complexity, delay implementation, and exclude businesses that already know which measures they need to take. It can also discourage new businesses, as they cannot be audited before operations start, risking lock-in to inefficient equipment. Given that they are in the investment period, early financial support can help them acquire energy-efficient technologies. Against this, audits are essential for uncovering less obvious, high-impact opportunities and for navigating complex changes; SMEs often cannot anticipate in advance whether their needs will be simple or highly complex.

Audits help identify opportunities that are not immediately apparent, such as process optimisation, motor efficiency improvements, and heat recovery systems, with significant GHG reduction potential. They also support complex improvements such as electrification and phasing out natural gas in favour of electricity, which can pose challenges and require sustained support. Programme-funded professional auditors, involved in ERDF initiatives, can enhance SME trust and provide tailored, detailed recommendations. Meanwhile, student-led audits in ITAC, with support from academic experts, not only bring these advantages but also help build a pipeline of future energy efficiency professionals and increase sector capacity beyond immediate results. In addition, audits generate consistent data on SME energy consumption patterns and measure implementation, helping programmes to understand trends and creating an evidence base that can be leveraged for large-scale impact.

As programme experience grows and common SME energy patterns become clearer, it may be more effective to provide a standardised manual of proven measures, such as LED lighting, solar PV generation, and operational best practices (e.g., for air compressors), so simpler operations can act without a full audit, reserving audits for more complex opportunities. Programmes should develop sector-specific expertise to identify which SMEs are most likely to benefit from an audit and target support towards firms that would gain the most from addressing more complex problems. Leveraging emerging tools, such as AI-powered agents for simple, remote, self-performed assessments that draw on historical assessment data to generate tailored recommendations, could widen reach and accelerate impact.

Are grants necessary?

Both the ERDF and ITAC programmes allocate funding for grants, often covering around 50% of the implementation cost for qualifying measures. Analysis shows that lighting and solar PV dominate grant allocations in both contexts, despite being mature technologies that can deliver positive economic returns without public support. This raises questions about the additionality of grants in these cases, especially when such investments might have occurred without subsidy.

The repeated support for lighting and solar PV across programmes, despite differences in geography and sector, suggests the need to reassess the marginal value of grants for SMEs seeking these measures. While solar PV's high upfront costs and substantial GHG reduction potential may justify continued support, further analysis of project additionality is needed to ensure public funds are accelerating adoption rather than subsidising inevitable investments. For mature, low-risk measures like LED lighting, alternative financing models such as low- or zero-interest loans could reduce upfront costs while limiting public expenditure. For example, Scotland's Public Sector Energy Efficiency Loan Scheme offers 0% interest loans repayable over 10 years, linking funds to a maximum cost of £278 per tCO_2 reduced over the project's lifetime to ensure cost-effectiveness (Salix Finance Ltd, 2020).

Redirecting grant funding towards measures with high GHG reduction potential but low market uptake, such as heat recovery, efficient motors, and advanced heating systems, could yield greater climate impact per public pound or dollar spent. In ITAC, such capital-intensive measures have some of the lowest implementation rates yet some of the highest unclaimed emissions reduction potential. Grants could also play a strategic role in supporting the phase-out of natural gas by accelerating the adoption of low-carbon heating technologies, including high-efficiency boilers and heating process upgrades.

In future programme design, a more targeted grant allocation strategy could combine support for select high-cost, high-impact measures with alternative financing options for mature technologies. This would maximise GHG reductions, improve cost-effectiveness, and ensure that public funds are directed towards interventions that would not otherwise be implemented without financial support.

University involvement and the outsized impact of the programmes

Embedding ITAC within universities has generated benefits beyond direct SME support. The programme serves as a training platform for engineering students, with alumni reporting faster job placement, higher salaries, and stronger energy efficiency skills compared to peers. Faculty engagement expands its reach, with an estimated three additional students exposed to energy topics for each directly involved participant. The ITAC evaluation by SRI International found that faculty often integrate these topics into lectures, further disseminating knowledge.

Given the relatively small scale of SME audit programmes, "massifying" their impacts is key to maximising policy outcomes. The ITAC programme illustrates how university-led audits can generate broader knowledge from SME decarbonisation, much of which can be distilled into tools and publications that benefit firms outside the programme. Since 1997, ITAC personnel have produced 943 peer-reviewed and non-peer-reviewed publications, largely derived from audits, focusing on operational improvements, process optimisation, and the cost-effectiveness of technologies.

For this knowledge to influence adoption, however, it must be translated into actionable guidance—ranging from lighting upgrades to operational improvements identified as recurring patterns across firms. An early example was ITAC's 2003 self-assessment workbook for small manufacturers, which outlined a four-step method to reduce operational costs. This framework included utility analysis, identification of high-consumption equipment, process efficiency reviews, and cost-saving measures with payback estimates. However, the workbook has not been updated to reflect current technologies, prices, and processes. Importantly, the recurrence of recommendations targeting operational rather than capital-intensive measures (e.g. optimisation of air compressors) signals that many SMEs continue to overlook on-site opportunities. Such findings suggest that standardised guidance on low-capital, high-impact measures could yield substantial benefits without requiring major investments.

Beyond direct measures, networking and knowledge-sharing mechanisms have proven important. ITAC's university setting enables collaboration between students, academics, and SMEs, while the ERDF programme incorporated networking centres in many projects, allowing SMEs to work with research institutions. These local cooperation environments can build trust, stimulate demand for energy efficiency measures, and amplify the wider impacts of audit programmes. Additionally, ERDF experience shows that embedding educational and communication components alongside technical installations encourages behavioural change, thereby maximising long-term cost, energy, and carbon savings.

These efforts are an example of how a programme can be scaled to achieve impact outside of the SMEs that have been audited and directly supported, which constitute just a small fraction of the existing SMEs. Creating an environment of collaboration and centres where knowledge can be developed and packaged in actionable measures for SMEs to follow, along with networking efforts to expose success among businesses, can help decarbonisation grow and reach SMEs that have not been directly involved with an audit or a decarbonisation initiative.

Evaluation and data reporting

Both the ERDF and ITAC programmes mandated evaluations at both the individual project/IAC level and for the overall programme. While the ERDF programme required individual summative assessments at project close-out, covering impacts, marketing challenges, additionality, and value for money, these evaluations were not uniform, and the Phase 3 review concluded it was impossible to calculate a reliable value for money for the decarbonisation priority axis. In contrast, the individual IAC level reports covered only high-level data. However, it was the more detailed assessment and recommendation database that enabled comprehensive programme evaluations, such as the one presented in this dissertation and those carried out by SRI International in 2015 and 2022. These evaluations combined quantitative data with stakeholder interviews to monitor progress over time, providing stronger evidence of the programme's overall impact. Nevertheless, ERDF's summative assessments still provided valuable qualitative and operational project-level insights and lessons, which ITAC lacked in its reports.

A limitation of ERDF projects was the lack of publicly available assessment and measure-level data. Information on recommendations, implementation rates, grant allocation, and impact was often stored privately in spreadsheets. This restricted wider learning and limited the ability to benchmark performance. By contrast, ITAC operates under a centralised data reporting system where every audit feeds into a standardised database. This allows tracking of long-term trends, estimation of cost-effectiveness, and year-on-year benchmarking.

For both programmes, a common gap is the lack of a granular evaluation of implemented measures. Tracking whether a recommendation was adopted is not enough; assessing if it was implemented correctly and delivered the projected savings is essential to verify GHG reductions. Wide variation in reported savings for similar measures across operators suggests inconsistent delivery or measurement. Equally important is understanding why recommendations are not implemented, as this provides insight into barriers SMEs face and informs the design of more effective interventions.

An optimal evaluation framework for SME decarbonisation programmes would combine standardised data collection with transparent public reporting. Every project should feed into a cumulative, central database capturing SME characteristics, recommendations made, implementation rates, grant allocations, measured impacts, and reasons for non-implementation. This would allow consistent benchmarking, facilitate academic and policy research, and create generalised, actionable guidelines that SMEs can adopt without external support. Follow-up evaluations should verify actual performance and identify success factors for each measure, enabling continuous improvement. By embedding these practices, programmes could move beyond one-off impact tracking to building a lasting knowledge base that accelerates SME decarbonisation at scale.

Conclusion

This dissertation investigated which policy and programme design features make SME energy efficiency interventions effective and scalable, focusing on emissions, value for money, and co-benefits in education, innovation, and growth. Comparing England's ERDF projects with the US ITAC highlights four drivers: structural design, competence building, knowledge diffusion, and delivery scheme.

ITAC's central, university-led model standardises audit methods, data, and branding, enabling benchmarking and clearer impact. Its manufacturing focus deepens technical capability but narrows sectoral reach. ERDF's decentralised model widened coverage and provided tailored support; however, inconsistent methods and reporting obscured the overall picture. A hybrid architecture is followed: a national backbone that sets protocols, metrics, and a recognisable brand, combined with local delivery by universities and accredited providers tailored to regional needs.

Across both programmes, LEDs and solar PV dominate recommendations and grants, mature options with limited additionality. ITAC data point to under-adopted, higher-impact thermal and process opportunities (e.g., heat recovery, advanced heating) with greater emissions cuts per dollar spent. Future schemes should tier support by fast-tracking simple, familiar measures through standard guidance and light-touch finance, while directing deeper audits, technical help, and capital toward complex, under-implemented opportunities.

Embedding students and universities in delivery, as in ITAC, creates durable benefits without sacrificing audit quality: a workforce pipeline, curriculum integration, and research outputs that diffuse beyond directly supported firms. ERDF networking centres likewise built trust and demand.

A joined-up model would fuse these strengths: student–industry teams operating within local networks under national standards.

Both programmes mandated evaluation, but only ITAC's granular central database enabled programme-wide value-for-money assessment. Heterogeneous ERDF reporting prevented like-for-like aggregation, even as individual summative assessments yielded useful qualitative insight. Best practice is a standard data scheme, public measure-level reporting of costs and realised savings, and systematic follow-up to verify persistence and diagnose barriers.

Policy context matters for feasibility. In the US, ITAC faces a funding renewal in 2027. The current US administration signals support for local manufacturing but is also committed to government efficiency, showing little interest in decarbonisation initiatives. Therefore, future funding may hinge on how the programme is perceived at the time of allocation. In England, ERDF has no like-for-like successor: in April 2025, the West Midlands BEAS pilot received a £15m extension, aiming to reach only about 1,300 additional firms by 2041, roughly 0.02% of UK SMEs, on top of around 2,400 already supported by that programme. Given these constraints, the recommendation is not simply to reinstate broad capital grants and energy audits but to work through universities within a, standardized framework: mandate standard audit scopes, savings estimation and with a shared recommendations database; fund universities to deliver audits while training students and anchoring regional SME networks; and couple audits with rapid, grants or rebates prioritising higher-impact thermal and process measures with low uptake.

Adopting this design shifts the focus from one-to-one delivery to large-scale diffusion: the aim is to leverage university capabilities, research, innovation, and the evidence generated by auditing a small share of SMEs, into clear, actionable guidance, tools, and standards that the broader SME base can implement. This increases additionality and cost savings while building the knowledge, data, and skills required for scale.

References

A. B. C. News. (2025, August 21). *Trump blames renewable energy for rising electricity prices. Experts point elsewhere*. ABC News. https://abcnews.go.com/Business/wireStory/trump-blames-renewable-energy-rising-electricity-prices-experts-124860028

Agrawal, R., De Tommasi, L., Lyons, P., Zanoni, S., Papagiannis, G. K., Karakosta, C., Papapostolou, A., Durand, A., Martinez, L., Fragidis, G., Corbella, M., Sileni, L., Neusel, L., Repetto, M., Mariuzzo, I., Kakardakos, T., & Güemes, E. L. (2023). Challenges and opportunities for improving energy efficiency in SMEs: Learnings from seven European projects. *Energy Efficiency*, *16*(3), 17. https://doi.org/10.1007/s12053-023-10090-z

BEAS. (2025). *Business Energy Advice Service is providing energy saving grants to small businesses.* Business Growth West Midlands. https://www.businessgrowthwestmidlands.org.uk/support-programmes/business-energy-advice-service-beas/

BEIS. (2022). *United Kingdom of Great Britain and Northern Ireland's Nationally Determined Contribution: Updated : September 2022*. The Stationary Office.

Bolton, P. (2025). *Gas and electricity prices during the 'energy crisis' and beyond* (No. 9714). House of Commons Library. https://researchbriefings.files.parliament.uk/documents/CBP-9714/CBP-9714.pdf

British Business Bank. (2021). *Smaller businesses and the transition to net zero*. https://www.british-business-bank.co.uk/sites/g/files/sovrnj166/files/2023-03/J0026_Net_Zero_Report_AW.pdf

Business Growth West Midlands. (2025, April 1). *New funding to help hundreds more businesses cut energy costs and carbon emissions*. Business Growth West Midlands. https://www.businessgrowthwestmidlands.org.uk/articles/new-funding-to-help-hundreds-more-businesses-cut-energy-costs-and-carbon-emissions/

CCC. (2025a, February 26). The Seventh Carbon Budget. *Climate Change Committee*. https://www.theccc.org.uk/publication/the-seventh-carbon-budget/

CCC. (2025b, June 25). Progress in reducing emissions—2025 report to Parliament. *Climate Change Committee*. https://www.theccc.org.uk/publication/progress-in-reducing-emissions-2025-report-to-parliament/

Department for business & Trade. (2024, October 3). *Business population estimates for the UK and regions 2024: Statistical release*. GOV.UK. https://www.gov.uk/government/statistics/business-population-estimates-2024/business-population-estimates-for-the-uk-and-regions-2024-statistical-release

Department for Business, Energy & Industrial Strategy. (2023, January 10). *Leading the world in lighting efficiency lightens the load on energy bills*. GOV.UK. https://www.gov.uk/government/news/leading-the-world-in-lighting-efficiency-lightens-the-load-on-energy-bills

DESNZ. (2023). *Energy efficiency in the manufacturing sector*. https://assets.publishing.service.gov.uk/media/657f754783ba380013e1b6a5/energy-efficiency-in-the-manufacturing-sector-2021.pdf

DESNZ. (2025, May 29). *Domestic energy price indices*. GOV.UK. https://www.gov.uk/government/statistical-data-sets/monthly-domestic-energy-price-stastics

eia. (2025). *Henry Hub Natural Gas Spot Price (Dollars per Million Btu)*. https://www.eia.gov/dnav/ng/hist/rngwhhdm.htm

EIA. (2025). *U.S. Energy Information Administration—EIA - Independent Statistics and Analysis*. https://www.eia.gov/environment/emissions/co2_vol_mass.php

Energywerx. (2024). *ITAC Implementation Grants FAQ | DOE Energy Assessment Program*. https://www.energywerx.org/itac/faqs

ERDF. (2020, July 1). *Summative Assessment Guidance*. European Regional Development Fund. https://www.gov.uk/guidance/england-2014-to-2020-european-structural-and-investment-funds

Exchange rate UK. (2023). *British Pound to US Dollar History: 2023*. https://www.exchangerates.org.uk/GBP-USD-spot-exchange-rates-history-2023.html

Fawcett, T., & Hampton, S. (2020). Why & how energy efficiency policy should address SMEs. *Energy Policy*, *140*, 111337. https://doi.org/10.1016/j.enpol.2020.111337

FRED. (2025, August 12). *Average Price: Electricity per Kilowatt-Hour in U.S. City Average, Federal Reserve Bank*. https://fred.stlouisfed.org/series/APU000072610

Greenwood, N., & Goater, A. (2023). International Industrial Energy Efficiency Policy Case Studies. *Baringa Partners LLP for the Department of Energy Security & Net Zero*. https://assets.publishing.service.gov.uk/media/657f6a581c0c2a000d18cebd/international-industrial-energy-efficiency-case-studies-report.pdf

Hampton, S., Eadson, W., Blundell, R., & Sugar, K. (2024). *Where Next for SMEs and Net Zero?* https://doi.org/10.5286/UKERC.EDC.000976

Hatch Regeneris Consulting & MHCLG. (2021, January 1). *National Evaluation of English ERDF Programme 2014-20: Phase Two Report: Interim Impact Evaluation*. The Ministry of Housing, Communities & Local Government. https://assets.publishing.service.gov.uk/media/631a0c0cd3bf7f77cacb6d58/ERDF_National_Evaluation_Phase_2_Report_-__Interim_Impact_Evaluation.pdf

IAC. (2022). *IAC Assessment Protocol*. https://iac.university/assessmentProtocol

IEA. (2015). *Accelerating Energy Efficiency in Small and Medium- sized Enterprises*. https://c2e2.unepccc.org/wp-content/uploads/sites/3/2016/03/sme-2015.pdf

IEA. (2022). *Coping with the Crisis: Increasing Resilience in Small Businesses in Europe through Energy Efficiency: Proposed Energy Saving Strategies*. OECD Publishing. https://doi.org/10.1787/104e00aa-en

IEA. (2025, June 1). *Gaining an Edge the Role of Energy Efficiency in Industrial Competitiveness*. https://www.iea.org/reports/gaining-an-edge

ITAC. (2022). *Industrial Assessment Centers*. https://iac.university/#centers

ITAC. (2025a). *IAC: Search IAC Assessments*. https://iac.university/searchAssessments

ITAC. (2025b). *IAC: Search IAC Publications*. https://iac.university/publications

ITAC. (2025c). *IAC: Search IAC Recommendations*. https://iac.university/searchRecommendations

LGA. (2022, September 19). *Learning from the Community Renewal Fund Programme | Local Government Association*. https://www.local.gov.uk/publications/learning-community-renewal-fund-programme

Mandys, F., Chitnis, M., & Silva, S. R. P. (2023). Levelized cost estimates of solar photovoltaic electricity in the United Kingdom until 2035. *Patterns*, *4*(5), 100735. https://doi.org/10.1016/j.patter.2023.100735

Mazhar, M., Domingues, A. R., & Bull, R. (2022). *Small and medium-sized enterprises: Hard to reach, data-poor but rich in creative potential as agents of change for decarbonisation*. Nottingham Trent University.

MHCLG. (2019). *European Regional Development Fund: England operational programme 2014 to 2020 Executive Summary*. Ministry of Housing, Communities & Local Government.

MHCLG. (2020). *European Regional Development Fund: England operational programme 2014 to 2020*. Ministry of Housing, Communities & Local Government.

MHCLG. (2025a, January 31). *List of Beneficiaries of the ERDF and ESF*. GOV.UK. https://www.gov.uk/government/publications/european-structural-and-investment-funds-useful-resources

MHCLG. (2025b, June 5). *UK Shared Prosperity Fund: Frequently asked questions*. GOV.UK. https://www.gov.uk/government/publications/uk-shared-prosperity-fund-prospectus/uk-shared-prosperity-fund-frequently-asked-questions

Mole, K., & Ri, A. (2023). *Actionable Information enables SMEs to Journey towards Net Zero* (No. 109). ERF. https://www.enterpriseresearch.ac.uk/wp-content/uploads/2023/09/ERC-ResPap109-Actionable-Information-enables-SMEs-to-Journey-towards-Net-Zero-Mole-Ri.pdf

Muller, M. (2011). *IAC Assessment Database Manual Version 10.2*. U.S. DOE. https://iac.university/technicalDocs/IAC_DatabaseManualv10.2.pdf

Murray, A., & Hutton, G. (2025). *Business statistics*. https://commonslibrary.parliament.uk/research-briefings/sn06152/

Nottingham Trent University. (2023, April 1). *Sustainability in Enterprise (SiE) Project ERDF Summative Assessment*.

OECD. (2021). *No net zero without SMEs: Exploring the key issues for greening SMEs and green entrepreneurship* (OECD SME and Entrepreneurship Papers No. 30; OECD SME and Entrepreneurship Papers, Vol. 30). https://doi.org/10.1787/bab63915-en

OECD. (2023). *Assessing greenhouse gas emissions and energy consumption in SMEs: Towards a pilot dashboard of SME greening and green entrepreneurship indicators* (OECD SME and Entrepreneurship Papers No. 42; OECD SME and Entrepreneurship Papers, Vol. 42). https://doi.org/10.1787/ac8e6450-en

Office for National Statistics. (2023, May 18). *SME by region and industry—Office for National Statistics*. https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/adhocs/1136smebyregionandindustry

Rep. DeFazio, P. A. [D-O.-4. (2021, November 15). *Text - H.R.3684 - 117th Congress (2021-2022): Infrastructure Investment and Jobs Act* (2021-06-04) [Legislation]. https://www.congress.gov/bill/117th-congress/house-bill/3684/text

Salix Finance Ltd. (2020, May 1). *Scotland Energy Efficiency Loans Application Notes*.

Shaw, P., Mycock, K., & Clementson, J. (2022, July 19). *Summative Assessment Report: ERDF Project DE-Carbonise*. Institute for Innovation in Sustainable Engineering, University of Derby. https://assets.publishing.service.gov.uk/media/66b621f0fc8e12ac3edb0d81/ERDF_Final_Reports_PA4.zip

SRI International, Stephen, R., Bouverot, K., Lee, M., Lecomu, C., & Ebert, W. (2022, June 1). *Saving Energy, Building Skills*. Center for Innovation Strategy and Policy. https://iac.university/file/technical/Industrial%20Assessment%20Centers%20Impact%202022%20SRI%20International.pdf

Stephen, R., Bouverot, K., Lee, M., Lecomu, C., & Ebert, W. (2022). *IAC Technical Documents*. Rutgers University. https://iac.university/technical-documents

Stewart, I., Burnett, N., Tyers, R., Hinson, S., & Malik, X. (2025). *The UK's plans and progress to reach net zero by 2050*. https://commonslibrary.parliament.uk/research-briefings/cbp-9888/

Sun, M., Cao, X., Liu, X., Cao, T., & Zhu, Q. (2024). The Russia-Ukraine conflict, soaring international energy prices, and implications for global economic policies. *Heliyon*, *10*(16), e34712. https://doi.org/10.1016/j.heliyon.2024.e34712

The White House. (2025, January 20). *Putting America First In International Environmental Agreements*. The White House. https://www.whitehouse.gov/presidential-actions/2025/01/putting-america-first-in-international-environmental-agreements/

Trianni, A., Cagno, E., & Farné, S. (2016). Barriers, drivers and decision-making process for industrial energy efficiency: A broad study among manufacturing small and medium-sized enterprises. *Applied Energy*, *162*, 1537–1551. https://doi.org/10.1016/j.apenergy.2015.02.078

Trombley, D., & Amann, J. (2010). *How Building Assessment Centers Can Leverage the Success of the Industrial Assessment Centers to Train the Next Generation of Efficiency Experts*. ACEEE.

UNIDO. (n.d.). *SME Business Portals*. UNIDO. Retrieved 11 August 2025, from https://www.unido.org/investing-technology-and-innovation/competitiveness-business-environment-and-upgrading/information-and-communications-technology/programmes/sme-business-portals

US DOE. (n.d.). *Connect with ITAC Graduates | Better Buildings Initiative*. Better Buildings US DOE. Retrieved 18 July 2025, from https://betterbuildingssolutioncenter.energy.gov/connect-itac-graduates

U.S. DOE. (2024, May 30). *Industrial Training and Assessment Center Implementation Grants*. Energy.Gov. https://www.energy.gov/mesc/industrial-research-and-assessment-center-implementation-grants

U.S. DOE & West Virginia University. (2016). *Industrial Assessment Center (IAC) Operations Manual*.

US Office of Advocacy. (2025). *2025 Small Business Profile*. US Small Business Administration. https://advocacy.sba.gov/wp-content/uploads/2025/06/United_States_2025-State-Profile.pdf

Wavehill & MHCLG. (2023, March 1). *National Evaluation of English ERDF Programme 2014–20 Phase 3 Evaluation Report*. Ministry of Housing, Communities & Local Government. https://assets.publishing.service.gov.uk/media/6761acfd1ca3ec0a49e19073/European_Regional_Development_Fund_2014-2020_-_Phase_3_Evaluation_Report.pdf

Wildnerova, L., Menon, C., Dehghan, R., Kinne, J., & Lenz, D. (2024). *Which SMEs are greening? Cross-country evidence from million websites*. OECD. https://www.greenindustryplatform.org/sites/default/files/downloads/resource/Which%20SMEs%20are%20greening.pdf

Wilkinson-Dix, J., Weatherall, D., Emma Bill, Trevor Wilkinson, Richard Blundel, Sam Hampton, & Stew Horne. (2022). *How can policy better support SMEs in the pathway to Net Zero? Energy Saving Trust*. https://www.theccc.org.uk/publication/how-can-policy-better-support-smes-in-the-pathway-to-net-zero-energy-saving-trust/