Chapter

AI-Assisted Emission Reporting for Small and Medium-Sized Enterprises (SMEs)

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Abstract

Many Small and Medium-Sized Enterprises (SMEs) from various sectors in Australia are looking for smart, affordable, and user-friendly ways to support their emission reporting. Despite not currently being required by the government due to their small size and limited revenue, many hold the view that emission reporting will eventually become mandatory. Unlike large enterprises, however, SMEs often lack the resources and knowledge to integrate sustainability monitoring and reporting systems into their existing businesses, and are often reluctant to embrace digital transformation as it is complicated and time-consuming to implement changes. However, as forward-thinking SMEs begin to take actions and potentially use sustainability to establish their brand image, SMEs that do not adapt to the changes will quickly fall behind. The advancement of Artificial Intelligence (AI) and Generative AI (Gen-AI) is shifting the way companies solve problems. Advanced sensors and smart algorithms are being used to identify people and objects, while Gen-AI-powered chatbots are replacing human experts in answering questions. Gathering information on the web and synthesizing information has become easier with AI tools. This opens up the possibility of leveraging AI capabilities for more accessible emission reporting and sustainability recommendations. In this chapter, we will discuss the common drivers for emission reporting of SMEs and the difficulties they face, and explore how AI can assist. We will also examine three case studies in detail, which are derived from real-life SMEs.

Keywords: sustainability, emission reporting, small and medium-sized enterprises (SMEs), artificial intelligence (AI), sustainability strategy recommendations

1. Introduction

Australia has officially started mandatory emission reporting in 2025 [1], making it one of the first few nations to make emission reporting compulsory among others such as the EU, the US, New Zealand, and Singapore. Large entities in Australia are now required to publish annual climate statements to disclose their scope one, two and three greenhouse gas emissions and make assumption on how a global

temperature increase of one or two degrees may affect their businesses. Despite not included in this current legislation change, SMEs have also been reminded by the Australian Securities and Investments Commission (ASIC) that the large entities they engage with may need to obtain emissions-related information from them to fulfill their scope three emission reporting obligations [2]. This means that SMEs who cannot provide emission information may become less competitive when collaborating with large enterprises. In the future, carbon footprint accounting and emission reporting are likely to become compulsory for all SMEs.

Large enterprises can afford to have dedicated personnel to work on emission monitoring and reporting, and implement systems and engage consultants when needed. However, this can be hard to achieve in SMEs due to lack of knowledge and awareness, lack of dedicated personnel, lack of data and data collection tools, limited financial resources and time to implement the required systems, etc. [3, 4]. A few commercial tools exist for carbon accounting for households and businesses, such as the CoolClimate calculator [5] developed at the University of California, the Carbon Trust SME Calculator [6] which helps UK-based SMEs to measure emissions from fuel and electricity consumption, and several greenhouse gas calculators published by the Australian Clean Energy Regulator (CER) [7]. Several recent studies have also proposed methods to help SMEs with carbon accounting. Eleftheriadis and Anagnostopoulou developed a carbon footprint calculator for a small Greek Cheese Factory using the Life Cycle Assessment (LCA) method. Hu et al. [8] proposed and implemented a blockchain based software–the CarbonApp–for tracking cows' emissions and feeds in a dairy supply chain. These tools rely on a great amount of detailed data, real-time tracking and continuous monitoring to accurately calculate emissions.

The reality, however, is that many SMEs do not have sufficient knowledge in what data to collect, or enough time to ensure all required data is captured properly into the carbon accounting system, and as a result lose track of their emissions [9, 10]. Integrating advanced carbon metering systems can streamline the process by eliminating manual data entry [11]. However, there are often barriers SMEs face when adopting digital technologies due to lack of knowledge and personnel, and high initial implementation cost.

With the advance in Artificial Intelligence (AI), and how seamlessly it has been integrated in day-to-day life through technologies such as face scanning for identification and Large Language Models (LLMs)-powered chatbots that can answer any questions like a knowledgeable friend, more and more SMEs are seeking ways to leverage AI in their existing business operations to help them understand their carbon footprint and recommend actions they can take to stay sustainable. AI can extract information from various media such as text, audio, images and videos, and has capabilities to think and create. This highlights the potential of using AI in emission reporting and customizing recommendations.

In this chapter, we examine how AI can possibly assist SMEs with emission reporting by streamlining the process, reducing costs compared to existing technologies or engaging with human experts, and enabling simple interactions with minimal user input. We analyze sustainability reporting in SMEs using the Technology-Organization-Environment (TOE) framework [12] and find that the drivers are mainly environmental and organizational, such as regulatory requirements, the voluntary carbon market, demands from the SMEs' large enterprise partners, customers, cost-saving opportunities, establishing brand identity and attracting employees. While the barriers are mainly technological and organizational, including challenges with data collection, storage and analysis and high initial capital cost, lack of

expertise in sustainability reporting and technology, and complex reporting format with unforeseen changes. We also conclude that AI can be used to extract and synthesize information to create emission profiles of SMEs, Gen-AI can be used to input missing data, and intelligent recommender systems can be built to suggest sustainability strategies. To apply these AI capabilities in real-life settings, we focus on three case studies based on SMEs in Australia by explaining the specific sustainability issues they face and proposing potential AI-enabled solutions.

The rest of this chapter is organized as follow. Section 2 discusses the drivers and difficulties SMEs face in emission reporting. Section 3 discusses common AI capabilities that can potentially be used in emission reporting and sustainability strategy recommendation. Section 4 takes a deeper look into three real-life scenarios I encountered during the author's teaching and interacting with SME clients, and what AI solutions can be designed to help them. Section 5 outlines other factors to consider when designing and implementing such solutions. Finally, Section 6 concludes the chapter.

2. Drivers and barriers in emission reporting

Emission reporting requires SMEs to understand their carbon footprint, develop the reporting compliant with the required formats, and develop sustainability strategies and monitor the progress. There are companies that provide such services, but they are often expensive to subscribe to, and are limited in their own capabilities as they rely on human expertise and manual accounting. Without leveraging external consultancies, SMEs can also implement and integrate their own sustainability monitoring and reporting systems. However, this is not straightforward as many SMEs lack the expertise in sustainability reporting and face challenges in digital adoption.

Understanding the drivers and barriers SMEs have will guide us on how to effectively design AI-assisted systems for emission reporting. To assess these drivers and barriers, we adhere to the TOE Framework, which is commonly applied to understand how organizations, including SMEs, adopt new technologies. TOE has also been adapted for analyzing sustainability reporting in SMEs [13, 14]. Technology refers to the functionality, complexity, compatibility, and usability of the technology itself. Organization refers to factors such as the size, structure, culture, and resources of the organization. Environmental factors include market conditions, regulatory requirements, and social and cultural conventions.

2.1 Emission reporting frameworks

The International Financial Reporting Standards (IFRS) Sustainability Disclosure Standards by the IFRS Foundation set the global baseline for sustainability related financial disclosures, requiring companies to disclose sustainability-related risks and opportunities that could reasonably affect their financial position, performance, and future cash flows. Different geopolitical regions have their own implementations of the IFRS Sustainability Disclosure Standards. The Australian Sustainability Reporting Standards (ASRS), for example, introduces additional details such as a phased implementation timeline (grouping companies based on their size and financials), and a compliance requirement with the Australian Accounting Standards Board (AASB) S2 Climate-related Disclosures.

Based on the Greenhouse Gas Protocol [15], emissions are classified into–scope one: direct emissions, scope two: indirect emissions from purchased electricity or heating, and scope three: all other indirect emissions from suppliers, product use and employee commuting. Each scope is further divided into multiple categories, with scope three containing 15 categories itself. This imposes challenges in data collection. Moreover, companies are expected to be forward-looking by disclosing their transition plans and climate targets.

2.2 Drivers

2.2.1 Environment

Governments & regulatory bodies: Governments around the world are setting up more stringent, mandatory Environmental, Social, and Governance (ESG) reporting requirements.

Voluntary carbon market: The voluntary carbon market is growing with standardization bodies such as Verra [16] and Gold Standard [17] publishing methodologies for businesses and individuals across various sectors to measure their carbon footprint reduction and claim carbon credits. Many SMEs are seeking ways to reduce carbon footprint and generate a new stream of income by trading carbon credits.

Large enterprise partners: The pressure may come from the large-enterprise business partners of SMEs, as they need emission information from the SMEs to satisfy their own reporting requirements.

Customers: In some cases, the pressure also comes from customers, as a large portion of consumers are willing to pay a premium for sustainable products and change their purchasing habits to reduce negative environmental impact–this is especially true for Gen Z [18].

Competitors: When an SME's competitors are capable of emission reporting and are taking actions to reduce emissions, the SME is automatically impacted.

Investors: There is also an increasing emphasis on sustainability in the financial sector, with investors such as venture capitals and banks encouraging voluntary reporting [19].

2.2.2 Organization

Discovering cost-saving opportunities: Tracking emissions often reveals energy or material inefficiencies, and allows businesses to identify cost-saving opportunities.

Establishing brand identity: Some SMEs may adopt a sustainability-focused approach and use carbon neutrality as a brand principle, such as KeepCup [20]–a company that sells reusable coffee cups and water bottles, and Allbirds [21]–a brand for sustainable shoes and clothing.

Attracting employees: To some extend, employees, especially the younger ones also increasingly value working for environmentally responsible companies [22].

2.3 Barriers

The transformation, however, is not easy, as there are difficulties SMEs face when integrating emission reporting processes and systems into their usual business practices [23]. Several studies have reported on the barriers SMEs face in emission

reporting in a systematic manner [3, 23], with the most frequently mentioned barriers being lack of resources, high initial capital cost of implementing sustainability measures, and lack of expertise [3].

2.3.1 Technology

Advanced and dedicated sustainability tracking and reporting systems are seldom part of SMEs' core businesses. Sometimes, the only digital system an SME has is an accounting system. Comprehensive carbon accounting requires a large amount of data collected from all significant sources of Greenhouse Gas (GHG) emissions across energy usage, water usage and transport. The *data collection, storage and analysis* all impose major difficulties to SMEs.

Collection: Sensors are needed to collect various data. In a dairy supply chain, simple temperature sensors can measure and track the temperature of fridges during the transport of fresh milk. This is an essential part of the supply chain as milk should be kept cold for freshness. The temperature data can also be used to calculate energy usage of the fridges. However, other emissions produced in the supply chain, such as the methane emissions from livestock, and emissions from fossil fuel usage require much more specialized sensor systems to measure and record. These systems are often absent as they are not required to for the business to sustain.

Storage and access: For SMEs with advanced sensor systems and corresponding IT systems for data collection, they may still lack the ability to make use of the data and may not have been properly storing historical data. Continuing with the dairy supply chain example, some farmers may have installed commercially-available, advanced dairy management systems that are capable of measuring animal health, breeding activities, milk production, and inventory. Despite the fact that much of this data can be used to (indirectly) calculate emissions, it is often overlooked by farmers, as their main focus is on milk test results, i.e., protein levels and milk volume–the factors that determine the milk price. Additionally, as the dairy management software is proprietary, data access for the farmer is only limited to importing and exporting data manually at a limited frequency. This makes it difficult to enable API integration with other software that could use the same data for emission calculations.

Analysis: Even when SMEs have full access to their data and have been storing historical records, they may still lack the expertise to calculate carbon footprint using that data. The options are to work with carbon accountants or use specialized carbon accounting software–both of which can be expensive and inefficient.

2.3.2 Organization

High initial capital cost: Many SMEs are used to manual work [24], and depend heavily on tacit knowledge–unwritten, experience-based knowledge held by individuals–which includes memorization of product details and processes [25]. Setting up new IT systems and adopting technologies can be complicated and costly. As a real-world example, a small manufacturing business may store hundreds types of products in their warehouse, and still rely on manual counting to keep track of their stock levels. Implementing a new product management system requires placing barcodes on all products and entering each one of them into the system, which can take up to six months of manual work. This will interrupt the normal business operations, and hence the business owner is reluctant to adopt such changes due to the time and financial costs.

Lack of expertise: SME owners and staff are specialized in their business domains and often find the need to outsource digital transformation projects or to license and white-label other products. However, many SMEs struggle to find people with the right skill set or the right technology due to a lack of knowledge in sustainability and technology themselves and limited financial resources. For instance, having a customer-facing website is the choice of many businesses. SMEs outside of the technology industry tend to develop their initial website through another company, and sometimes they do not own it. This may work as a short-term solution, but after a few years, their hosting services may become unavailable due to changes within that company. Just to update their websites and to modernize the User Interface (UI), they have to find other software houses or freelancers, and may even consider using overseas developers to reduce costs. Some collaborate with universities and engage students to develop the software; however, without professional supervision, students may only produce prototypes that are not ready for use. Moreover, SMEs have unique features and needs and are often looking for bespoke solutions, which are not easily accessible or can only be accessed at a high cost.

2.3.3 Environment

Emission reporting is often required in *complex formats*, which evolve as policies change. For example, with the adoption of the Corporate Sustainability Reporting Directive (CSRD) in 2022, the European Union (EU) mandated that companies meeting certain criteria must use the European Sustainability Reporting Standards (ESRS) starting in 2024 instead of the previously-used Global Reporting Initiative (GRI) Standards. Many businesses faced significant difficulties as ESRS imposes an increased reporting complexity, and the businesses lacked the suitable IT systems and internal expertise to interpret and apply ESRS. A 2024 PwC survey showed that more than 60% of EU-listed companies expected moderate to significant increases in compliance costs and needed major overhauls to meet the updated requirements [26].

3. AI capabilities

AI makes many aspects of life easier through automation, the reduction of manual work, and the ability to analyze large volumes of data. It is used in systems such as smartphone assistants like Siri and Google Assistant, which leverage Natural Language Processing (NLP) to understand voice commands, send texts, and set reminders. Maps also use AI to suggest optimal routes and assist with navigation. Modern chatbots like ChatGPT understand questions in various formats and generate responses based on information extracted from multiple sources. Many of these capabilities can potentially help SMEs with emission reporting and developing sustainability strategies.

3.1 Information extraction and synthesis

When multiple sources of data exist and can be directly used for emission calculation, smart algorithms and streamlined systems can be designed to automatically calculate emissions and aggregate results across these sources to develop a holistic view of the SME;s emissions, creating an emission profile.

If the data cannot be directly used to calculate emissions or if there are no advanced and dedicated sensor systems in place to capture all required data, AI can also estimate and predict emissions based on the context [27] through various types of inputs such as text, images, videos, etc. Saez et al. proposed to use transformers for CO_2 emission prediction in self-driving vehicles using various vehicle telemetry data collected by the self-driving system, such as speed, acceleration, throttle position, engine load, etc. [28]. Hua et al. proposed to use AI to infer emissions in construction industry based on factors such as material choices, energy consumption patterns, and operational behaviors [27].

3.2 Creativity

A complete dataset can be difficult to obtain, and when it is unavailable, AI can enable smart data collection from messy inputs and impute missing data [29, 30]. Chen et al. [31] showed that machine learning models perform better than traditional linear models in computationally estimating missing data of industrial consumption and pollution based on information collected from 701 Chinese cities between 2006 and 2018. Mekki et al. [32] demonstrated that simple linear regression models can predict missing values using the 2020 Carbon Disclosure Project (CDP) dataset, which contains environmental data from various organizations.

In cases where business owners are not tracking the emissions from their operations, a Gen-AI-powered chatbot can be used to have conversations with the business owners around their operations to infer the emissions, leveraging information on the business sector, the number and usage of appliances, utility costs, purchases of raw materials, waste management, etc.

3.3 Recommendation

The purpose of emission reporting is likely to go beyond reporting itself. Very often through emission calculation, businesses may recognize the need to reduce emissions and seek guidance on what actions they could take. There are commercial services that provide such advice, but they also require continuous monitoring of progress and charge a high premium for bespoke advice, as they rely on human expertise. The consultants themselves may have limited understanding in specific business domains, and interacting with consultants can result in delays. When engaging with these services, SMEs may become over-reliant on external advisors and fail to build internal capacity (just like outsourcing website development to software houses). This can hinder long-term sustainability if the service is discontinued.

Given the unique emission profile of an SME, AI can recommend realistic sustainability strategies based on insights from other SMEs with similar profiles. Unlike human expertise, which is often limited to specific fields, AI can efficiently process information from a wide range of sources. AI models can also be updated with new data and adapt to recent changes, making them suitable for supporting long-term sustainability goals. Furthermore, when regulatory reporting formats change, AI can be used to customize reports to meet different formatting requirements. In contrast, human experts are typically limited by their existing knowledge and require more time to learn and adapt to changes.

4. Case studies

In this section we discuss three SMEs in Australia that are either seeking sustainability solutions or are sustainability service providers themselves looking to enhance their offerings through AI. We discuss the problems they want to solve and the difficulties they face, and explore how the above-mentioned AI capabilities can be leveraged.

4.1 SME A: Emission reduction through feed additives in agriculture

SME A is a dairy manufacturer that contracts dairy farmers and collects milk from them daily to make dairy products. The company is looking to reduce emissions in its dairy supply chain, and claim carbon credits with the emission reduced. One aspect they have considered is reducing methane emissions from dairy cows, as cows produce a significant amount of methane during digestion, and methane is a powerful greenhouse gas that traps 25 times more heat than CO_2 [33]. The solution they are experimenting with involves introducing a feed additive for the cows, which interferes with their digestion process and reduces methane emissions.

A blockchain-based data collection software was proposed in [8], allowing farmers to register feed types and amount for each cow at milking times twice a day and accepting real-time methane measurement data from a methane sensor system. These data can be used to calculate the cows' methane emissions, and be further converted into carbon reduction and hence carbon credits. The application currently requires manual data entry of feed types and amount.

Without redesigning the application, AI can be used to streamline data entry. For example, we can design the user interface to accept file uploads–such as receipts for feed additive purchases–and use AI to extract relevant information like feed quantity and purchase date, and apply the calculation over the entire herd instead of individual cows. This approach improves the reliability of data registration by reducing human error and increases efficiency.

4.2 SME B: Energy usage reduction in electric appliances

SME 2 is a busy coffee shop that servers local customers. They have typical coffee shop appliances such as a commercial coffee machine, two customer-facing fridges, two internal fridges, several toasters, a dish washer, some lights, etc.

They noticed several thousand dollars in monthly energy spending and decided to reduce that cost. However, when speaking with an energy assessor, the only information they could provide was their total energy bill, which gave no insight into the actual usage of each appliance, which is not sufficient to identify the cause of the high electricity consumption.

When energy assessors visited the facility in person, they found that the fridges were placed in direct sunlight As a result, the fridges consumed more energy than necessary to maintain the cool temperature–especially during the summer months when daylight is strong.. This example shows that details such as the fridge's power rating, location, and usage are important for identifying energy-saving opportunities, but these details are often overlooked by business owners and typically only discovered through in-person assessments.

Rather than explicitly asking business owners to keep track of and disclose every aspect of their energy usage, we could potentially incorporate AI-based

image analysis to identify and count appliances, determine their placement, and assess whether they are being used appropriately. This would only require business owners to provide photos or videos of their shops.

4.3 SME C: Gen-AI to infer carbon footprint, generate sustainability reporting, and recommendations on sustainability strategies

SME C helps other businesses with emission reporting and recommends ways to reduce emissions. Currently, business information is collected through a series of questions on a web form to understand the motivation for emission reduction, size of the business, sourcing of materials, etc. Generic recommendations are provided for free based on these basic information, while customized recommendations are only accessible to clients with subscriptions. However, solutions recommended to the paying clients are often around installing solar panels and using batteries to store unused electricity, which does not meet the needs of SMEs that demand more specialized emission reduction solutions.

On the one hand, SME C wants their system to be smarter in understanding the large number of continuously evolving tender requirements, so they can easily produce reports that meet specific formatting standards. By using LLMs, we can efficiently extract requirements from these tender documents and build report-generating engines that produce reports aligned with them. On the other hand, SME C considers leveraging AI to improve their sustainability recommendations.

AI can be used to understand a business emission profile and suggest a range of concrete actions to take, utilizing existing data for similar businesses. Since the completeness and quality of data are the keys to accurate emission reporting and sustainability strategy recommendations, in cases where an owner cannot provide detailed receipts, spending records, or all the required information, they can instead provide their usual business operations in terms of hours of operation and number of staff, energy, water and transport usages–and use chatbots trained on relevant datasets to synthesize the available information and generate customized reports and recommendations.

5. Other factors

Accuracy: Despite several prior studies showing promising results of using AI in imputing missing data and predicting emissions, due to the lack of complete datasets, the prediction accuracy remains low for certain scope three categories [34], such as Category 9: Downstream Transportation and Distribution, and Category 11: Use of Sold Products. Moreover, without quality datasets, it is also hard to develop reliable AI models. Future research should aim to collect more relevant data and determine the minimum percentage of data required for AI models to achieve an acceptable accuracy in data imputation, and emission calculation or prediction.

User-friendliness and integration with existing systems: For wider adoption, the AI-assisted emission reporting solutions need to be user-friendly, especially for non-technical users. The solutions should also be low-cost and easy to integrate into SMEs' regular business operations. This means that any AI-powered systems should seamlessly interoperate with existing systems for data collection and other relevant processes.

Data storage, access, usage, privacy and security: The AI solutions will require an increased amount of data to be collected and shared by SMEs, naturally triggering concerns around data collection, storage, access permissions, and how the data is shared, analyzed and protected. For instance, images of a shop's interior setup may accidentally capture biometrics of customers or staff members. Therefore, how we ensure data privacy and guard the data from malicious access need to be considered when developing and deploying such solutions.

Government support and policy implication: Governments around the world are increasingly recognizing the importance of sustainability and are taking steps to support businesses in meeting emission reporting requirements. The Australian Government offers several grants and funding opportunities, such as the grants administered by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) and the Australian Carbon Credit Unit (ACCU) Scheme which is managed by the CER, to assist SMEs in monitoring their carbon footprint, reporting emissions, and transitioning to sustainable practices. The Artificial Intelligence (AI) Adopt Program [35] was also developed to establish AI Adopt Centres to support SMEs in adopting responsible AI-enabled services, particularly in sectors such as renewables and low-emissions technologies.

With targeted grant schemes or funding opportunities, as well as tax incentives dedicated to applying AI in sustainability related processes, the development and adoption of the technology can be accelerated. To ensure proper use of AI, regulatory bodies also need to set clear rules around ethics and privacy of data collection, security of data storage and transparency and auditability of AI-generated data.

6. Conclusion

This chapter highlights the drivers and barriers in emission reporting for SMEs with respect to the TOE framework, and explored how AI capabilities such as information extraction and synthesis, creativity, and recommendation can be used to help SMEs with emission reporting. In general, these AI capabilities can be leveraged to better understand the operations of a SME and generate a holistic emission profile for it. Leveraging AI's capability of collecting and analyzing a large amount of information, AI can be used to customize sustainability strategy recommendations based on the unique emission profile of the SME. This chapter also discusses three case studies based on Australian SMEs to demonstrate how these AI capabilities can be used to address real-life challenges. Finally this chapter points out other aspects to consider when developing such solutions and before rolling them out. As the performance of AI models largely relies on the size and quality of the training datasets, we can expect more data to be collected from SMEs, which naturally raises concerns about data privacy and security. User-friendliness and ease of integration are also important to consider when deploying such solutions in real-life settings. Governments play an important role in supporting these initiatives, regulating AI usage and accelerating technology development and adoption.

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Abbreviations

AASB	Australian accounting standards board
ACCU	Australian carbon credit unit
AI	artificial intelligence
ASIC	Australian securities and investments commission
ASRS	Australian sustainability reporting standards
CDP	carbon disclosure project
CER	clean energy regulator
CSRD	corporate sustainability reporting directive
DCCEEW	climate change, energy, the environment and water
ESG	environmental, social, and governance
ESRS	European sustainability reporting standards
EU	European union
Gen-AI	generative AI
GHG	greenhouse gas
GRI	global reporting initiative
IFRS	international financial reporting standards
LCA	life cycle assessment
LLMs	large language models
NLP	natural language processing
SME	small and medium-sized enterprise
TOE	technology-organization-environment
UI	user interface

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