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Towards Effective Implementation of Carbon Reduction Strategies in Construction Procurement: A Case Study of New Zealand

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Abstract: In light of climate change, the construction industry plays a crucial part in alleviating carbon emissions and other environmental impacts. The focus on improving the public procurement process poses an important opportunity for the successful implementation of carbon reduction strategies in construction projects. There is a growing body of literature mapping green and sustainable procurement practices in construction. However, previous studies have not treated the implementation of procurement in a particular area, such as carbon reduction, in much detail. This study aims to investigate the implementation of construction procurement incorporating carbon reduction strategies, with a specific focus on the public sector in New Zealand. The research was conducted through 13 semi-structured interviews with construction procurement experts in New Zealand. The results shed light on the current implementation of carbon reduction strategies in construction procurement and its challenges, such as a lack of knowledge and ambiguous procurement guidelines and documents. It also emphasises the importance of (1) well-developed carbon reduction evaluation criteria, (2) specifying a budget for carbon-related initiatives, and (3) the prerequisite of a high level of innovation in the procurement document. The study adds to the rapidly expanding field of carbon reduction construction procurement by providing a deeper insight into the way carbon reduction strategies are effectively implemented in the procurement process.

Keywords: zero carbon; net-zero carbon; carbon reduction; procurement; construction

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1. Introduction

Society is facing significant impacts of climate change, such as sea-level rise, more frequent and extreme natural disasters, and global warming. Greenhouse gas (GHG) emissions from human activity have increased markedly since the beginning of the industrial revolution [1]. The latest Paris Agreement signed in 2016 attempts to limit global warming to no more than 1.5 °C above the pre-industrial level to tackle climate change issues [2]. As such, there is an imperative call to action from a range of private and public-sector organisations to immediately implement strategies to achieve greater carbon reduction [1].

The construction industry plays an important role in alleviating anthropogenic climate change and other environmental impacts as it is responsible for one-third of worldwide GHG emissions [1,3]. The industry must achieve a net-zero carbon target by 2050, but this will require major changes in industry practices, including adopting low-carbon designs and technologies in the planning and implementation of construction projects and increasing levels of integration within the construction supply chain [4,5]. The public sector's contribution to driving changes in the construction industry is substantial, as central and local governments are the most effective driving forces for encouraging carbon reduction initiatives [6,7].

The focus on construction procurement as a policy instrument aimed at achieving a net-zero carbon target by 2050 and sustainable development goals in the public sector has increased in recent years [8,9]. One of the prospects to reduce construction carbon

emissions through construction procurement is encouraging tendering parties to identify opportunities for carbon reductions by offering a bid price advantage tied directly to carbon savings. For example, low-carbon construction materials and processes can be preferred and specified in the tender document. Other important factors include definable targets and functional requirements for operational energy use, transportation of materials to the site and the choice of energy source for construction equipment and activities [10–12].

Research on this area is emerging, with the majority of studies published in green public procurement (GPP) and low-carbon public procurement (LCPP) over the last decade. GPP defines a process where public authorities procure goods and services with lower environmental impacts than alternatives with comparable function and performance [10,13]. In comparison, LCPP means using procurement processes to mitigate carbon emissions from public purchases [12]. Extensive research has concentrated on mapping the practices of green and sustainable procurement in construction globally [13]. However, conditions differ substantially between different sustainability goals and local contexts [9], leading to the inconsistent and ambiguous understanding and analysing of factors that drive procurement development in a particular area, such as carbon reduction. Moreover, "sustainable construction" can be considered a broad term within the general context of holistic sustainability, while "low/zero-carbon construction" focuses specifically on the operational or life cycle carbon-based knowledge area. It is also acknowledged that these terms are used distinctively in different local contexts [7,14]. Therefore, it is pertinent to investigate construction procurement focusing on carbon reduction implemented in a particular local context.

The practical implementation of construction procurement incorporating carbon reduction in New Zealand has not been well-studied. Through advanced searching in the Scopus and Web of Science databases using key words ("zero carbon" or "low carbon" or "zero emissions" or "carbon reduction" or "carbon emissions" and "construction" and "procurement "or "tender" or "contract" and "New Zealand"), it was found that there are no publications regarding carbon reduction construction procurement in New Zealand. The findings from other countries often do not apply to New Zealand due to the distinction between environmental, cultural, political, economic, and social aspects. For example, New Zealand is a small-to-medium developed economy, and its geography is isolated from the rest of the world [15], which may lead to construction supply chain issues. The focus on maximising carbon reduction in the New Zealand construction industry is also new. The late promotion of zero carbon-related legislation results in the delay of zero carbon policies for New Zealand's construction industry [7]. Lagging behind other developed countries has allowed New Zealand to identify lessons learned in the local context. However, this may also lead to several challenges that affect the effective implementation of carbon reduction strategies in construction procurement.

This study responds to this important area by examining carbon reduction strategies in construction procurement in New Zealand, which is the procurement of construction works with lower life cycle carbon emissions. In doing so, a comprehensive literature review was undertaken to identify relevant carbon reduction strategies in construction procurement worldwide and in the New Zealand context. Then, a qualitative research design using semi-structured interviews with New Zealand's construction procurement experts was adopted to investigate the implementation of carbon reduction strategies in construction procurement in New Zealand. After that, the results and recommendations for the effective implementation of carbon reduction strategies in construction procurement were reported following three main themes: (1) the current application of carbon reduction strategies in construction procurement, (2) challenges to implementing carbon reduction strategies in construction procurement, and (3) suggestions for improving the implementation of carbon reduction strategies in construction procurement.

2. Literature Review

2.1. Carbon Reduction Requirements and Related Challenges in Construction Procurement

A considerable amount of literature has been published on green procurement requirements in construction. International scholars have identified many tensions in the development of procurement requirements in construction projects concerning environmental impacts and sustainability. For example, Varnäs, et al. [16] argued that the evaluation criteria related to sustainability were found to not discriminate between tenders. Similarly, Bratt et al. [17] claimed that criteria development processes lacked rigour and consideration of the implementation context. Lately, Cheng, Appolloni, D'Amato, and Zhu [13] further supported previous observations, concluding that the impacts of mandatory environmental requirements needed further assessment under different evaluation criteria. In addition, the tender evaluation method was determined to be of poor design regarding environmentally relevant dimensions and a lack of proper research. Little attention has been paid specifically to carbon reduction procurement requirements in construction. Kadefors, Lingegård, Uppenberg, Alkan-Olsson, and Balian [9] recently provided a deeper cross-country understanding of this specific field by examining the design and implementation of carbon reduction requirements in infrastructure projects in Australia, the Netherlands, Sweden, the US, and the UK. This study identifies factors that should be considered when designing carbon policies and requirements, including ensuring competition, limiting transaction costs for tendering and follow-up, encouraging innovation in projects, encouraging long-term innovation, and considering client capabilities. However, the focus has been on frontrunner projects in Western and developed countries, where carbon reduction-related construction procurement policies have advanced over the last decade compared to non-Western and developing economies.

2.2. Carbon Reduction Procurement Policies, Guidelines, and Tools

Given the numerous barriers hampering the adoption of carbon reduction-related procurement discussed above, there may be opportunities for policies, guidance, and tools to assist. In terms of government policies and guidelines, for example, the UK has set up targets and baselines to measure performance and outcome specifications for carbon impacts in the procurement process. A joint goal is an effective collaboration between clients and contractors [18]. However, the main issues are the balance of low-carbon designs and the strict requirements of high-carbon competence from contractors. In Australia, Transport for New South Wales—a major public agency—has developed sustainable design guidelines with functional carbon reduction requirements in the procurement process [9]. However, there are no penalties for non-compliance.

In addition to government policies and guidance, supporting policy instruments, such as standards and labelling programmes, may promote the adoption of carbon reduction-related procurement by providing a clear and structured way to include carbon and/or energy criteria into procurement practices. Examples of standards and labelling schemes include LEED, BREEAM, Green Star, NABERS, CEEQUAL, the IS rating system, Envision, PAS 2080, and the CO_2 Performance Ladder [7,9,19]. These methods provide users with a certification or label that certifies a certain product and/or process is fulfilled according to carbon and energy criteria. Evidence has shown that using instruments such as energy efficiency labelling within the procurement process can reduce procurement costs and time [20]. Yet, due to the relatively recent advent of carbon labelling and the general lack of regulations governing calculation methods and the accuracy of labelling information, prioritising a product with a low-carbon label may not necessarily guarantee legitimate emissions reductions [7,12,21].

Other tools, such as carbon accounting, also have great potential for integration into construction procurement processes. For example, energy modelling tools predict energy performance and associated operational carbon emissions for buildings, optimising the design by allowing users to undertake detailed calculations of the operating energy required to achieve a given performance [22]. Although operational carbon emissions associated

with energy use can be calculated based on the energy model, the whole-of-life embodied carbon function is not included in energy modelling tools. LCA is preferred as a method that seeks to determine the potential environmental impacts of products and services (e.g., building and infrastructure projects) during their entire life cycle [23,24]. Through LCA, practitioners can measure the cumulative impacts of energy and material flow in production systems. These impacts include the environmental and other potential impacts from all stages of a product or service's life cycles, from the extraction of raw materials to final disposal, including all intermediate stages [24]. According to the literature, LCA seems most prevalent in establishing specification and evaluation criteria in the construction industry. However, practical experience using LCA-based award criteria in real life is surprisingly limited [13,25].

2.3. The New Zealand Context

In New Zealand, the New Zealand general construction procurement guidelines outline a pathway for construction stakeholders to implement the best procurement practices successfully [26]. The guide also provides a typical procurement process, including planning, sourcing, and managing. Although this guide does not mention practical examples and information, several key success factors for the procurement process are provided to help achieve project objectives. These factors include strategic priorities, leadership and management, stakeholder engagement, capability and capacity, project team integration, and market understanding.

In response to the climate change emergency, the Ministry of Business, Innovation and Employment (MBIE) has launched the Building for Climate Change programme to reduce GHG emissions within the built environment [27]. The proposed carbon reduction initiatives were discussed among New Zealand's construction stakeholders in late 2020. One of the most important consultation results perceived by New Zealand central government agencies is that more knowledge, resources, and expertise are required to improve carbon reduction procurement practices. Lately, New Zealand Government Procurement published a procurement guide to reducing carbon emissions in building and construction in 2021 [28]. This guide offers construction stakeholders a general and practical guide, including (1) the application of the LCA approach, (2) focused areas for building components for reducing whole-of-life embodied carbon, (3) reducing whole-of-life embodied carbon through on-site activity, (4) tools and data sources for assessment, (5) carbon briefing, assessing, and reporting, (6) responsibilities within the team for reducing carbon impacts, and (7) considerations for procuring the consultant team. The targeted users are government agencies that have a significant ability to effect change to reduce carbon emissions. Similar to the New Zealand general construction procurement guidelines, the procurement guide to reducing carbon emissions in building and construction does not include practical examples. Although various policy initiatives, guidance, and tools have recently become available in the New Zealand construction market, to what extent the construction stakeholders have changed their daily working practices to integrate carbon reduction strategies in construction procurement remains unknown.

3. Research Method

A qualitative research design was adopted to examine the implementation of carbon reduction strategies in construction procurement in New Zealand. The qualitative research approach was considered appropriate as it provides reliable and comparable qualitative data when working with a complex issue [29]. Given that this study is exploratory, the qualitative approach offers opportunities to probe incredible views and gain an in-depth understanding as opposed to the quantitative method, which often uses generalisable facts about the research context [30,31]. Moreover, many studies have applied the qualitative approach to mapping and analysing current green public procurement, focusing on identifying the barriers under the current regulatory framework. It was found that the case study was the dominant data collection method in the research field. However, only a

few studies used detailed interviews, which are necessary to adopt in future studies to analyse the results and identify the main issues in a better way [13]. Thus, semi-structured interviews with construction experts involved in the procurement process were selected to explore the current practices of integrating carbon reduction strategies, related challenges, and suggestions for improvement.

Participants were purposively recruited from the construction supply chain actors categorised into three main groups: clients, consultants, and contractors. Expert sampling was used to ensure the desired outcomes [32]. Thus, participants were required to have relevant knowledge and expertise in carbon reduction and construction procurement. Participants under the client category were selected from New Zealand's central/local government specialised in construction procurement with focused areas, including significant carbon reduction capital projects. Participants in the consultant group were identified as carbon specialists involved in carbon reduction construction projects. The contractor representatives were chosen from well-known suppliers that provided carbon reduction services and products.

Between October 2021 and December 2021, 13 interviews were undertaken online and in-person, each less than 1 h. Participants received an invitation via email and were then asked to carefully read the project information and sign the written participant consent form following standard ethics protocols. The interviews included questions about: (1) participants' background, (2) the current practices of integrating carbon reduction strategies in construction procurement, (3) challenges to implementing carbon reduction strategies in construction procurement, and (4) suggestions for improvement. Table 1 illustrates an overview of the participants.

Table 1. Interviewees' profiles.

Category	Number of Interviews and Codes	Positions
Clients (Government agencies)	Client #1, Client #2, Client #3, Client 4, Client #5	Senior construction procurement specialists/managers
Consultants	Consultant #1, Consultant #2, Consultant #3, Consultant #4,	Senior carbon specialists/carbon reduction programme leaders
Contractors	Contractor #1, Contractor #2, Contractor #3	Regional project directors

The number of interviews was considered appropriate due to several reasons. First, this study was exploratory and/or phenomenological, offering an insight into the problem and contrasting with grounded theory research. According to Creswell and Poth [33], a grounded theory requires interviews with 20–30 participants, while there is a need for up to 10 people in phenomenological research. The number of interview participants can vary between 5 and 30 participants based on two main reasons: (i) their advancement in the knowledge of the research problem under investigation and (ii) the semantic saturation points of the interview's emerging themes. Umar and Egbu [34] further support this view, opining that six interview participants are adequate for a qualitative study when the participants give useful facts about the subject area. In this research, the participants were experts in construction procurement areas. In addition, the saturation point of the data was reached after interviewing 10 participants. After that, three more interviews were conducted to confirm no new themes emerged, following Francis et al. [35]'s recommendation.

The interviews were audio recorded with permission from the participants and then transcribed. Transcripts and notes were logged and coded for thematic analysis, a foundational qualitative analysis method [36]. NVivo software was used to support the analysis process. International researchers highly recommended the software because it opened up new ways of determining the missing data when managing the information without software and generated efficient, multiple, and transparent data analyses [37].

Three strategies were adopted to confirm the validity and reliability of the findings. First, the interview protocol including a detailed plan of actions and interview questions peer-reviewed by academic researchers in the authors' institution; peer reviewers provided valuable feedback, criticism, and suggestions for improvement before conducting the interviews [38]. Second, an interview database represented all sources of evidence using the computer-aid qualitative data analysis software NVivo 12, word-processing tools (e.g., Word, Excel files), and cloud storage, which was created to improve the reliability [38,39]. Third, member checking was undertaken to test the emerging findings. Regular contact with the participants was maintained throughout the period of data collection and analysis to identify missing data and verify certain interpretations and themes resulting from the data analysis. For example, the interview transcript and initial data analysis was returned to the interviewees to validate and revise if necessary [40,41]. The key findings were discussed in the following sections. The key findings were discussed in the following sections.

4. Results and Discussion

4.1. The Current Application of Carbon Reduction Strategies in Construction Procurement

The first set of analyses from the interview findings explored the current application of carbon reduction strategies in construction procurement in New Zealand. When participants were asked to provide perspectives on this matter, most responses (28 references) indicated that several carbon reduction strategies had been adopted in the current construction procurement. This aspect is illustrated in Table 2, which collates several quotes from the research participants about their understanding and perceptions.

Table 2. The perceptions of research participants regarding the current implementation of carbon reduction strategies in construction procurement.

Participants	Illustrative Quotes
Client #1	"Two procurement agencies have applied carbon strategies in the tender document. This document included the specifications and life cycle cost (LCC), which refers to the total cost of ownership over the life of an asset, such as a building asset."
Client #3	"Some organisations have adopted the carbon reduction strategies. We are working with a public organisation to develop an integrated embodied and operational carbon reporting tool."
Contractor #1	"In the education sector's construction procurement process, there are a lot of tender documents that incorporate carbon reduction strategies, such as upgrading LED lighting tender, school design and construction tender."

To further explore the current application of carbon reduction strategies in construction procurement, the participants participating in the interviews were asked to share their experiences applying carbon assessment methods and tools. Most participants (22 references) referred to several common methods and tools available in the construction market. For example, one participant commented: "Principles and guidelines of Life Cycle Assessment (LCA), defined by ISO 14040 and 14044, are used to calculate carbon footprint" [Client #2]. In the same vein, the interviewee [Contractor #3] expressed that "a Life Cycle Assessment (LCA) approach is typically used to calculate the whole-of-life embodied carbon emissions of a construction project". Besides LCA tools, Green Star was acknowledged as another method to identify carbon reduction strategies for buildings. As [Client #4] mentioned, "there are tools available in the market such as Green Star". In addition, the interviewees in the contractor category recognised an energy and utility management cloud platform named Carbon EMS, which provided the total energy and operational carbon performance of buildings. According to the participants, this tool was usually used in the facility management and building operation stages.

These findings have revealed several common carbon strategies, assessment methods, and tools available in New Zealand's construction market are adopted in the procurement

process. Although many have been found in the literature, only a few have been adopted widely in the current practices. The LCA method is acknowledged as the most appropriate for carbon-related procurement. An explanation is that the LCA method allows practitioners to measure whole-life carbon impacts [42]. Through LCA, clients can uncover how changes in their decisions at one point in the design and construction processes affect the overall carbon performance, while contractors can identify essential life cycle-based information to provide appropriate solutions [24,43]. Therefore, integrating a carbon calculation and reporting tool in the procurement process is necessary to determine a more accurate procurement outcome.

4.2. Challenges to Implementing Carbon Reduction Strategies in Construction Procurement

Challenges to implementing carbon reduction strategies in the procurement process were identified during the interviews. Follow-up questions were also asked to encourage the participants to elaborate on their viewpoints on the barriers to integrating zero-carbon strategies in the tender document. Table 3 shows some main challenges to reducing carbon emissions in the construction procurement process mentioned by research participants.

Table 3. The main challenges to reducing carbon emissions in construction procurement mentioned by research participants.

Participants	Illustrative Quotes
Client #5	"Two procurement agencies have applied carbon strategies in the tender document. This document included the specifications and life cycle cost (LCC), which refers to the total cost of ownership over the life of an asset, such as a building asset."
Consultant #2	"Some organisations have adopted the carbon reduction strategies. We are working with a public organisation to develop an integrated embodied and operational carbon reporting tool."
Contractor #2	"In the education sector's construction procurement process, there are a lot of tender documents that incorporate carbon reduction strategies, such as upgrading LED lighting tender, school design and construction tender."

4.2.1. Lack of Knowledge

All interviewees (n = 13) agreed that construction stakeholders involved in the procurement process had inadequate knowledge of the up-to-date zero-carbon initiatives, including the government policies and guidelines, construction-related industry support, and education programmes. The traditional procurement method was still dominant, followed by the design-build procurement method. It was observed that the tender document was stereotyped. Most of the tender documents were traditionally formatted, including a background introduction, the rationale of procurement, and the timeframe. There were no innovative strategies and initiatives related to carbon reduction. More importantly, participants recognised that a knowledge of carbon accounting was an important basis for setting procurement requirements. However, carbon literacy has been immature within the New Zealand construction industry. In line with general research on green public procurement, this finding suggests the need for the education of procurement professionals regarding carbon-related evaluation criteria [44,45].

4.2.2. Ambiguous Procurement Guidelines and Documents

It was observed that the current procurement guidelines issued by the government agencies were not specialised enough for the industry to provide carbon-related input, as agreed upon by all participants under the contractor category. A few carbon reduction strategies have been recognised in construction procurement, such as using LCA tools to quantify life cycle carbon emissions of products and services. However, all participants claimed that there was still a limited number of process and strategy frameworks that provided clear and consistent guidance on integrating carbon reduction strategies in the

tender document. Furthermore, some interviewees opined that the tender documents addressing carbon reduction objectives varied among individual organisations, and there was no standardised process or method to follow. On the one hand, some government agencies, including the Ministry of Transport (MOT) and the Ministry of Business, Innovation and Employment (MBIE), have established zero-carbon policy agendas for the procurement process related to capital investment as part of the broader fit-for-purpose initiative. On the other hand, other organisations have focused on developing in-house policies and guidelines for early-stage assessment work to understand the carbon reduction requirements with significant capital projects, especially the feasibility of projects in terms of embodied carbon emissions associated with construction materials and products and operational carbon emissions emitted from the operation stage of the project. The current inconsistent and ambiguous procurement guidelines may be due to the immaturity of carbon reduction-focused construction procurement in New Zealand as the construction industry is in its infancy of the transition to a net zero-carbon future [7,46]. In driving carbon reduction in construction procurement, the process and strategy frameworks that provided clear and consistent guidance on integrating carbon reduction strategies in the tender document are expected to be well-established in future work.

Moreover, there was a lack of carbon reduction measurements in the procurement document. First, some participants believed that the evaluation criteria in the tender document included only the information regarding fit-for-purpose and the capability and capacity of the contractor to deliver the project. No specific carbon reduction-related criteria and measurements for carbon performance were recognised. Second, it was observed by the majority of participants that the description of design requirements was often insufficient. The current tender document provided a standard specification detailing some basic design requirements. The information on energy efficiency and whole-of-life carbon reduction was not addressed. Third, the pricing information section of the tender document may not specify any budget relevant to the carbon reduction plan and implementation. Several participants said that even though some tender documents provided standard pricing information, including the LCC method, there was no reflection on the cost associated with carbon-related calculations and measurements. These results reflect those of Cheng, Appolloni, D'Amato, and Zhu [13] and Bratt, Hallstedt, Robèrt, Broman, and Oldmark [16] who have found that the tender document and its evaluation criteria must be better designed to support the successful implementation of carbon reduction procurement strategies.

4.3. Suggestions for Improving the Implementation of Carbon Reduction Strategies in Construction Procurement

The suggested support mechanisms for successfully implementing carbon reduction strategies in construction procurement identified by the interviewees generally focused on addressing the abovementioned challenges. However, it was believed that the key support mechanism that could be measured by construction professionals involved in the procurement process was improving the tender document. In particular, the tender document should clarify additional costs associated with applying carbon assessment methods and tools and following up on carbon performance estimations. This approach, which has not been widely recognised in the literature, helps set a budget for carbon-related initiatives and limits unexpected costs during project planning and implementation. In addition, the development of carbon reduction evaluation criteria in selecting stakeholders and proposed solutions to meet carbon reduction procurement requirements should be considered. This finding is consistent with experiences implementing procurement requirements for carbon reduction in other countries such as the US, the UK, Netherlands, Sweden, and Australia [9]. However, the participants in this study have determined significantly more detailed carbon reduction evaluation criteria in which the implementation of carbon reduction strategies in construction procurement could be better improved compared to those found in the literature.

In terms of stakeholder selection, participants suggested the following carbon reduction evaluation criteria that should be considered when selecting consultants, contractors, subcontractors, and suppliers:

- Experience in managing carbon-related issues in the procurement process;
- Ability to draw up specifications of carbon reduction strategies;
- Ability to work with clients and other stakeholders in terms of carbon-related functional characteristics;
- Experience in carbon reduction design and construction and whole-of-life carbon calculating and reporting;
- Ability to develop innovative design and construction strategies;
- Relevant qualifications and experiences in construction projects that focus on reducing carbon emissions;
- Reflections of carbon reduction measurements and management in the proposal and contract agreement.

Regarding the evaluation criteria for assessing proposed solutions to meet carbon reduction procurement requirements, participants recommended that these criteria reflect the procurement outcome regarding carbon reduction, which should be specified in the request for the proposal and procurement plan. Including a comprehensive list of evaluation criteria in the tender document helps create a clear and consistent pathway for selecting ideal solutions. Several solutions that support the project team in making decisions to reduce carbon emissions can be defined in the tender documents as follows:

- Describe solutions that will enable the project team to calculate and compare carbon impacts;
- Describe solutions that facilitate the consideration of design and construction options incorporating carbon reduction;
- Describe solutions that simplify the LCA method and process for non-expert users;
- Describe any other provision and support solutions related to carbon reduction design and construction (e.g., user guidelines);
- Describe how the solutions simplify LCA calculation and minimise input while delivering robust outputs;
- Describe how the solutions can integrate with our internal and external systems to minimise interruption;
- Describe the flexibility of the solutions to the LCA analysis and LCC method (if applicable).

Another suggestion for improving the implementation of carbon reduction strategies in the procurement process is the need for a high level of innovation in the construction procurement process in New Zealand. This finding is in line with the studies by [9,10,47], confirming that the procurement strategies and requirements should encourage innovation as it creates benefit and value for all actors in the procurement process towards providing environmental improvement solutions. Carbon reduction innovations are new technologies, processes, and products in design and construction. These innovations are widely available in the construction market, but their successful implementation requires significant changes in design, management, and construction practices [48]. Therefore, promoting carbon reduction innovations throughout the procurement process can create innovative responses and solutions that contribute to effective carbon reduction project delivery.

5. Conclusions

The main goal of the current study is to investigate the implementation of construction procurement with carbon reduction in New Zealand using semi-structured interviews with construction procurement experts. Three main themes that emerged from the findings were discussed, including (1) the current application of carbon reduction strategies in construction procurement, (2) challenges to implementing carbon reduction strategies in construction procurement, and (3) suggestions for improving the implementation of carbon

reduction strategies in construction procurement. Overall, the results of this investigation have shown that New Zealand's construction stakeholders are aware of and willing to adopt carbon reduction strategies in the procurement process. However, employing carbon reduction strategies has been found ineffective in construction procurement due to a lack of knowledge and ambiguous procurement guidelines and documents. The findings from this study make several theoretical contributions to the current literature. First, the study confirms the requirement of well-developed carbon reduction evaluation criteria in tender documents. More importantly, a budget and/or additional costs for carbon-related initiatives must be set and specified in the procurement documents to limit unexpected expenses during the project planning and implementation. This study also strengthens the idea that a high level of innovation in the construction procurement process is needed to support the transition of the global construction industry to a net-zero carbon future. Besides theoretical implications, the study has also suggested ways to improve the tender document that can be applied through New Zealand's construction procurement practices. Although the scope of this study is limited in terms of the New Zealand context, its practical implications, including strategies and recommendations for effective implementation of carbon reduction construction procurement, can apply to the construction industry worldwide.

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