Study Report SR477 [2023]

The future of work: Equipping construction professionals with the skills to transition to zero carbon – a national survey

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BRANZ Funded from the Building Research Levy

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ISSN: 1179-6197

Preface

This is the first of a series of reports related to the project *Future of Work: What do we know, what do we need to know to transition to zero-carbon construction?* within the *Transition to a zero-carbon built environment* research programme.

Acknowledgements

This research project was funded by the Building Research Levy, and we appreciate the support the Levy provides in helping us undertake this important research.

We would like to thank our research partners in assisting us with this research, especially Teresa Poli from ConCOVE (the Construction Centre of Vocational Excellence) and Mark Williams from Waihanga Ara Rau | Workforce Development Council for Construction and Infrastructure.

We would also like to thank members of the Construction Workforce Research Consortium and Construction Sector Accord who have assisted with recruitment.

Finally, we would like to thank those construction professionals who took the time to fill in our survey. We appreciate the time and effort you gave to complete the survey and your desire to assist industry with the important transition to zero-carbon construction.

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Reference

Lockyer, O. & MacGregor, C. (2023). *The Future of Work: Equipping construction professionals with the skills to transition to zero carbon – a national survey*. BRANZ Study Report SR477. BRANZ Ltd.

Abstract

The threat of climate change and the transition to a net-zero carbon economy is one of the greatest challenges facing the world. A transition to a net-zero carbon economy requires the construction sector to focus on how the building and construction industry will respond to climate change and the transition. Specifically, the sector needs to ask these questions: Does the building and construction industry have the expertise at scale needed for zero-carbon construction? What are the values and practices that motivate people to act on climate change? A nationwide survey of the building and construction industry was undertaken to examine and understand the knowledge, skills, competencies and education and training requirements of industry in relation to the transition to zero-carbon construction. The survey found that the building and construction industry is ready for a change and largely supportive of efforts to address climate change and transition to zero-carbon construction. However, the survey also identified that, while there is a desire for change, there is very little knowledge or experience across industry around zero-carbon skills and competencies. The current training available to industry in this space is also limited so any upskilling will require a significant push from the education sector to provide resources in the channels that suit each of the various professions across the sector. More importantly, the survey shows that there are other challenges the sector needs to consider outside of training specific to zero-carbon construction. The current make-up of the construction workforce, how it works together and the lack of underpinning knowledge outside of zero carbon are all concerns that need to be addressed to enable zero-carbon construction.

Keywords

Skills, competencies, knowledge, training, vocational education, building, construction, transition, zero carbon, climate change.

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Executive summary

This report outlines a nationwide survey that sought to gain an understanding of the building and construction industry's knowledge and experience in relation to zero-carbon construction. The research was guided by three central research questions:

- What expertise (knowledge, skills and competencies) are required for delivery of zero-carbon buildings across their life cycle?
- Does the building and construction industry have available the existing expertise, knowledge and competencies to deliver zero-carbon buildings? If not, what are the barriers to developing and deploying the delivery of zero-carbon buildings across industry?
- How will the expertise need to be provided?

This research study is the first in Aotearoa New Zealand to examine the knowledge, skills, competencies and education and training requirements of the building and construction industry in relation to the transition to zero-carbon construction.

A survey comprising 34 questions was developed and conducted through Qualtrics. The survey covered:

- participant demographics and occupational information
- awareness of climate change
- knowledge and practical experience of skills in relation to zero carbon
- preparing for the transition to net-zero carbon such as training preferences
- an invitation to enter a prize draw and participate in future research.

A total of 308 valid survey responses were received (95% confidence level, 5.58% margin of error).

These are the key results from the survey:

- The largest proportion of the sample (45%) identified as being in a construction trade. These participants primarily worked on residential stand-alone buildings, and there was an even split between builders and carpenters. The next most-represented professions were architects and designers (24% of the sample).
- We sought to test the survey participants' knowledge about greenhouse gas (GHG) emissions across a building's life cycle. Participants rightly identified the significant impact embodied carbon has on GHG emissions. However, participants scored operational carbon (energy use from plug-in appliances, space heating, etc.) lower than expected. Operational carbon (ranked fourth by our participants) is normally the greatest source of GHG emissions in most building typologies.
- Over half of the survey participants were not aware of some or all of the changes proposed by the Ministry of Business, Innovation and Employment (MBIE) *Building for climate change* programme. Despite this, 86% of participants were supportive of MBIE making changes to address climate change.
- The key areas that survey participants identified as important or very important new skills and knowledge for industry were:
  - knowledge of how your work connects with the work of other trades (96%)
  - knowledge of general building, architectural and engineering principles (93%)
  - overall understanding of sustainable construction strategies (90%)
  - understanding the environmental impact of GHG emissions (83%)
  - broad awareness of climate change (83%)

- The areas where survey participants had no knowledge at all were:
  - calculating GHG emissions (68%)
  - transition planning such as retrofitting an existing building to be zero carbon (50%).
- Participants believed industry is either very competent or competent around the installation (58%) and maintenance (41%) of the building envelope.
- Conversely, participants saw 41% of industry as not at all competent when it came to understanding embodied carbon.
- In terms of industry zero-carbon and sustainable practices and experience of enacting these practices:
  - half of the sample had no experience in calculating GHG emissions (75%), transition plans (60%) and carbon footprinting of design (58%)
  - the only area of note where expert knowledge (15%) closely matched in-depth experience (15%) was in relation to reducing energy demand through passive design.
- Industry participants believed the greatest barriers to zero-carbon construction were:
  - inertia/disinterest from others (28%)
  - lack of information: "I don't know what to do" (26%)
  - time: "We are too busy with current workloads to do anything about climate change" (23%)
  - resources: "Our company doesn't have the resources to support our development in this area" (20%).
- When asked about the current education and training for industry on zero-carbon and sustainable construction, participants were largely neutral (40%) or were somewhat dissatisfied (34%) or extremely dissatisfied (15%) with what is available. Participants would like more information and training in the form of professional development workshops, seminars and trade talks.

The results from the survey indicate that the construction system is ready for change and is largely supportive of doing something to address climate change and to become a workforce with the knowledge and ability to transition to zero-carbon construction. While the survey identified that there is a desire for change, the results also highlighted that there is very little knowledge or experience across industry around zero-carbon skills and competencies. The education and training currently available to industry in this space is also limited so any upskilling will require a significant push from the education sector to provide resources in the channels that suit each of the various professions across the sector. As a next step, BRANZ seeks to partner with industry to test occupation-based zero-carbon skill and competence profiles and to co-create solutions with industry and government.

Importantly, the survey shows that there are other challenges the industry needs to consider outside of specific training for zero-carbon construction. The current make-up of the construction workforce and how it works together and the lack of underpinning knowledge outside of zero carbon are all concerns that need to be addressed to deliver a zero-carbon economy. Zero-carbon construction is a socio-technical issue that is going to require a significant behavioural shift. Alongside education, the sector will need to address the current socio-economic and cultural conditions of building and construction in New Zealand and find ways to incentivise quality construction practice so our zero-carbon goals can be achieved.

1. Introduction

The threat of climate change and the transition to a net-zero carbon economy is one of the greatest challenges facing the world. The United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement signed in 2016 sought to address GHG emissions mitigation, adaptation, and finance. The Paris Agreement (Article 2a) outlines that we need to hold the global average temperature increase to no more than 1.5°C above pre-industrial levels to avoid a climate catastrophe (MacGregor et al., 2018). The construction sector has an important role to play in addressing climate change. The Intergovernmental Panel on Climate Change recognised that "rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems" are required (IPCC, 2018, p. 15). This indicates that climate action should explore opportunities to optimise the construction sector to mitigate GHG emissions through zero-carbon construction.

Globally, buildings account for more than 40% of global energy consumption and approximately 30% of global GHG emissions annually (IPCC, 2007). However, in many parts of the world, the construction sector is prone to boom-bust cycles, which places great stress on the sector in terms of capability and capacity, especially in workforce development. Climate change mitigation and adaptation requires that the construction sector transforms its practices and products to ensure that we are constructing low/zero-carbon buildings across the building's life cycle (Giesekam et al., 2018).

Many countries require large-scale transformation of the construction sector to support and implement the transition to a net-zero carbon built environment. Stewart (2015, p. 9) observes that it is imperative that interventions to address climate change are not simply reactive to protect jobs but rather are proactive and intervene to shape the nature of the transition to a net-zero carbon economy. It is not enough that the transition to a net-zero carbon economy focuses on state-led, market-based mechanisms or a vision of ecological modernisation. We would argue that it requires a socio-technical transition that focuses on the radical transformation of social and technological arrangements through a coalition of social actors and stakeholders (Stewart, 2015).

Therefore, a central aspect of a socio-technical transition to a net-zero carbon economy requires the construction sector to focus on these questions:

- How will the building and construction industry respond to climate change and the transition?
- What are the values and practices that motivate people to act on climate change?
- Does the construction sector have the expertise at scale needed for zero-carbon construction?

The complexity of zero-carbon construction requires climate change literacy for all construction occupations as well as high qualification levels that cross the vocational/academic divide and broad occupational profiles to allow for dynamic teamwork and good communication across and within worksites (Lockyer, MacGregor & Knight 2023).

The passing of the Climate Change Response (Zero Carbon) Amendment Act 2019 provided a framework by which Aotearoa New Zealand can develop and implement clear and stable climate change policies. We have therefore sought to gain an understanding of the types of expertise, knowledge and competencies that are

required to enact these policies across and within the building and construction industry. The information provided by this completed research project will help identify the types of expertise needed most critically in the building and construction industry as well as help the industry to begin planning the best way to ensure that progressive change can take place across the entire sector to support the transition to zero-carbon construction.

Another pressing issue facing New Zealand's building and construction industry is the ability to effectively share and implement this knowledge across the whole sector. Low/zero-carbon building solutions, practices and materials are largely the purview of a small subset of the industry. This research aims to identify what expertise is necessary for the holistic development of zero-carbon training across the whole industry.

This research study was the first in Aotearoa New Zealand to examine the knowledge, skills, competencies and education and training requirements of the building and construction industry in relation to the transition to zero-carbon construction. This report outlines the results from a nationwide industry survey in which construction professionals were asked a range of multiple choice and short-answer questions regarding their current knowledge and experience of zero-carbon building, how much they know about the zero-carbon changes currently being implemented in the New Zealand Building Code and the ways in which they wish to be educated about zero-carbon building in the future.

1.1 Research aims

The research was guided by three central research questions:

- What expertise (knowledge, skills and competencies) are required for delivery of zero-carbon buildings across their life cycle?
- Does the building and construction industry have available the existing expertise, knowledge and competencies to deliver zero-carbon buildings? If not, what are the barriers to developing and deploying zero-carbon construction across the industry?
- How will the expertise need to be provided?

1.2 Structure of report

This report is structured as follows:

1. Introduction sets the scene for the research and outlines the research aims.

2. Methodology outlines the survey methodology and participant recruitment process, data analysis strategy and human research ethics information.

3. Results outlines the results of the survey, including participant demographics and occupational information, industry awareness of climate change and industry's knowledge and practical experience of skills in relation to zero carbon. Also outlined is how industry seeks to prepare for the transition to net-zero carbon such as its education and training preferences.

4. Conclusion and future research discusses the overall findings from the study and outlines some recommendations for future research.

2. Methodology

The Future of Work survey utilised both quantitative and qualitative techniques.

2.1 Future of Work survey

As part of the systematic review undertaken by Lockyer and others (2023), research that had utilised a survey methodology was identified and used to create a library of surveys that had been conducted with reference to skills and the transition to zero carbon within the construction sector. Based upon these past surveys and the researchers' knowledge of the sector, a survey comprising 34 questions was developed and conducted through Qualtrics.

The survey covered:

- participant demographics and occupational information
- awareness of climate change
- knowledge and practical experience of skills in relation to zero carbon
- preparing for the transition to net-zero carbon such as education and training preferences
- an invitation to enter a prize draw and participate in future research.

2.1.1 Participant recruitment

Research participants were recruited through several channels, including the BRANZ Twitter and LinkedIn pages. Special advertising was included in *Build* magazine, which has a national readership of over 70,000 people across the building and construction industry. Circulation of recruitment advertising was also arranged with several industry organisations through emails to members and in newsletters such as the Construction Sector Accord newsletter.

A key priority for sample selection was achieving a cross-section of industry rather than deliberately targeting specific professional occupations working in the construction sector. Hence, BRANZ's research partners ConCOVE and Waihanga Ara Rau also contacted various administrative bodies for each subtrade and asked them to distribute a link to the survey on our behalf. Each administrative body was provided with an information sheet and an explanation of the survey objectives before the link was sent out to their members.

Participants were recruited through two drives. The first call for participants took place in early November 2021 and the second in early February 2022. The Christmas break provided a good cooling-off period between the first and second call for participants. Recruitment for the survey ceased by March 2022. Participants who completed the survey and selected to be part of the prize draw were then put in a draw to win one of six $500 Prezzy cards. Winners were randomly selected by a party independent to the researchers.

2.2 Data analysis strategy

A descriptive statistics approach to data analysis was undertaken when reviewing the survey data. The priority for this report is to focus more on the quantitative data rather than the qualitative data, which will feature in another report.

2.3 Ethics

A BRANZ Human Research Ethics Application (ER-13203a) was undertaken for the research project. The application gained ethical approval on 15 November 2021 after an independent ethical review in line with the BRANZ Ethics in Our Work Involving Human Participants policy. The ethical conduct of research was maintained throughout the research process. All research participants consented to participate in this research.

3. Results

A total of 308 of valid survey responses were received (95% confidence level, 5.58% margin of error).

3.1 Demographic data

The survey started with a series of demographic questions to determine the characteristics of the participants.

When asked what profession they were in (Figure 1), 45% of participants identified as being in construction trades, 15% as designers and 9% as architects. The 15% categorised as 'other' were a combination of project managers, educators, sustainability managers and independent consultants. The remaining 16% comprised seven very minor categories, each accounting for 4% or less of the total sample. Of the 45% of participants who identified as being in the construction trades, 39% identified themselves as builders while another 39% identified as carpenters.

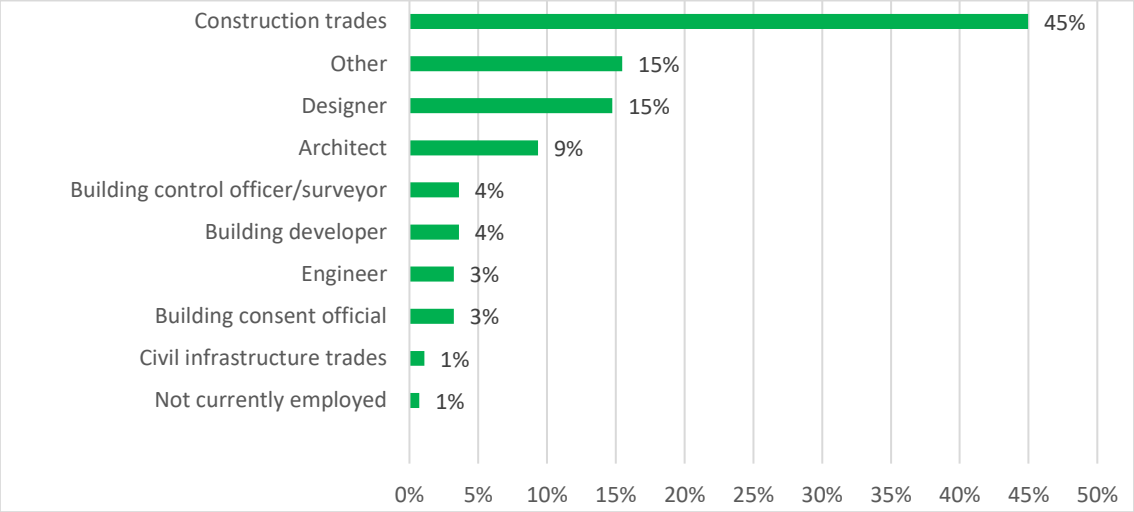

Figure 1. Professions of survey participants.

Age was more evenly split across the sample, with 26% of participants aged 26–35 years, 25% aged 36–45 years and 25% aged 46–55 years. The sample was largely male (82%) with less than one-fifth of the participants identifying as female. Most of the sample came from just three centres: Auckland (33%), Wellington (15%) and Canterbury (15%).

In terms of building and construction industry experience, the sample tended towards those more experienced in the sector (Figure 2). A significant proportion (30%) of the sample had been in the industry for 26+ years, while only 6% of the sample had 3 years or less of experience. The rest of the sample was more evenly split between a low of 4 years' experience through to 25 years' experience.

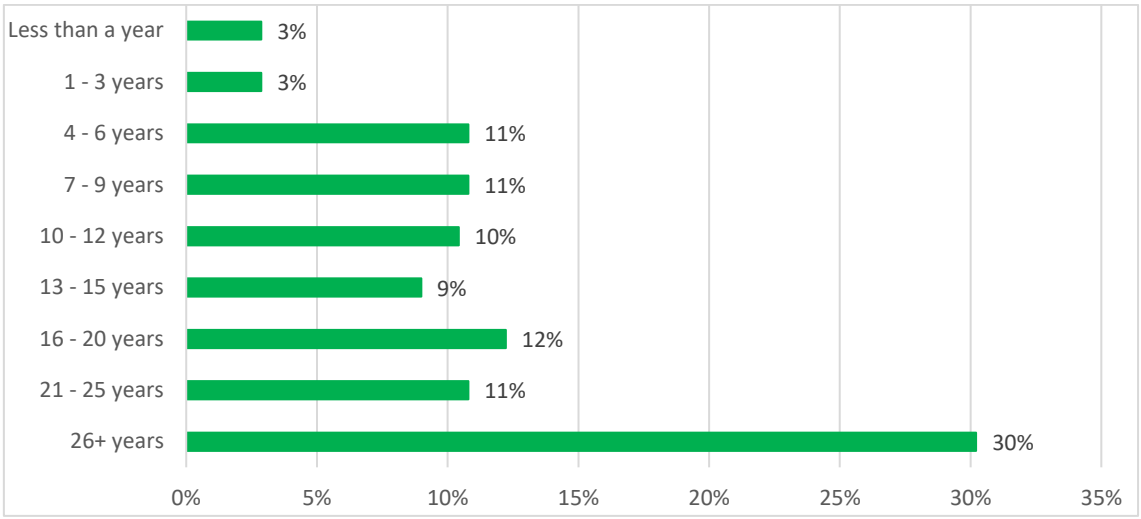

Figure 2. Survey participants' experience in the construction industry.

Most of the sample's experience was related to working in residential stand-alone housing (53%). Commercial buildings (13%) and 'other' (12%) were the next largest categories. Participants who chose 'other' usually worked on a combination of residential, commercial and infrastructure projects. When participants were asked about their most relevant industry qualification (Figure 3), the largest proportion mentioned their New Zealand apprenticeship (26%) as the most relevant followed by a New Zealand diploma (17%) or a bachelor's degree (15%). The high percentage of participants with New Zealand apprenticeships could be due to the large proportion of trades professionals who completed this survey.

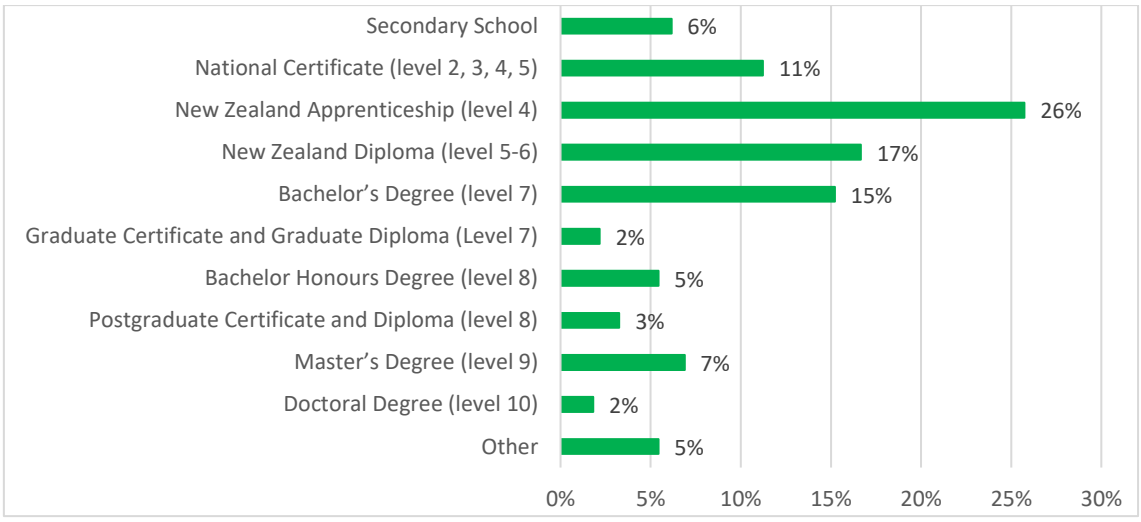

Figure 3. Survey participants' most relevant industry qualification.

3.2 Knowledge about GHG emissions

One of the key questions in the survey was created to test the building and construction industry's knowledge (climate change literacy) in relation to GHG emissions across a building's life cycle. Participants were asked to rank emissions during the life cycle of a building from the highest (1) to the lowest (6). The lower the mean score of the responses, the higher the category was ranked by the participants as a cause of GHG emissions over a building's life cycle. Embodied carbon had the lowest mean score, meaning the participants understand that embodied carbon creates

the most GHG emissions during a building's life cycle (Figure 4). The second-lowest score (i.e., the second-highest ranked emissions source) was the construction process. Waste decommissioning came in third with operational carbon just behind in fourth. Maintenance and operational water use were ranked at a distant fifth and sixth.

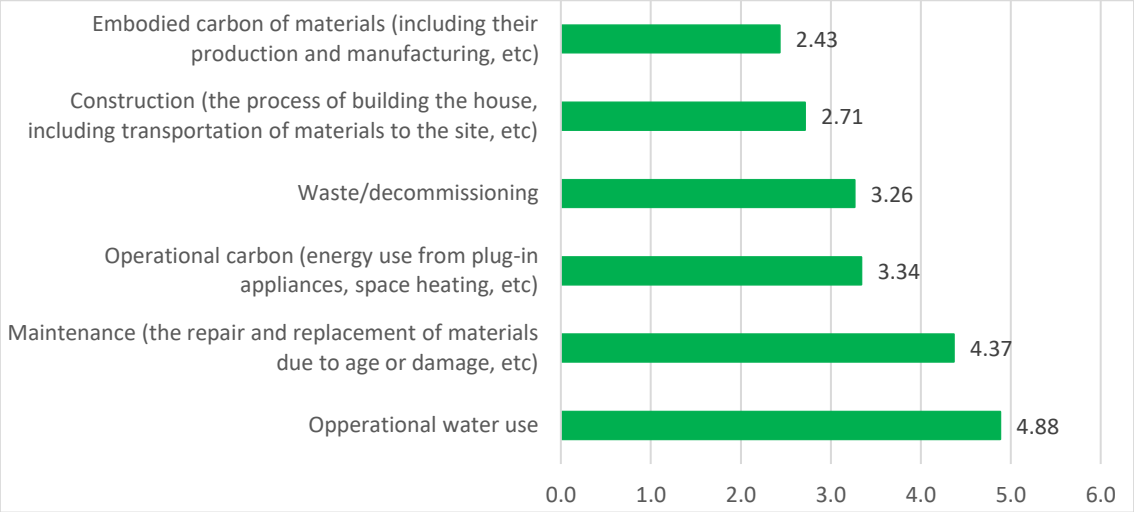

Figure 4. Ranking (1 being highest, 6 being lowest) of perceived causes of GHG emissions in relation to a building's life cycle

When looking at the measurements of GHG emissions across a building's life cycle, however, operational carbon (ranked fourth by the participants) is normally the number one cause of GHG emissions in most building typologies. Goodyear et al. (2021) highlight the biggest contributors to life cycle carbon emissions of the dwelling: when CO_2 sequestration is excluded, operational energy use comprises 59% of life cycle carbon emissions over a 90-year period, and when CO_2 sequestration is included, operational energy use rises to 71%. It was also significant that the participants recognised the importance of embodied carbon as a key contributor to GHG emissions. As Dowdell et al. (2021) outline, embodied carbon from the manufacturing of materials makes a significant contribution to a building's carbon footprint, and the timeframe over which GHG emissions occurs is also important. For example, if the contribution of materials over a 90-year service life is considered, materials make up 27% of a house's total GHG emissions. However, if their contribution in the first 30 years is considered (to 2050, by which time we should have shifted to a net-zero carbon economy), materials make up 45% of a building's total GHG emissions.

3.3 Proposed building regulation changes

Close to half (54%) of the sample had heard of building regulator MBIE's proposed updates to the New Zealand Building Code at the time of the survey (November 2021 to March 2022). Set out in its *Building for climate change* programme, the proposed requirements will update Acceptable Solutions and Verification Methods for clause H1 *Energy efficiency*. Fewer than half the participants (45%) had also heard of MBIE's Whole-of-Life Embodied Carbon Emissions Reduction Framework, and only a third had heard of the Transforming Operational Efficiency Framework (Figure 5).

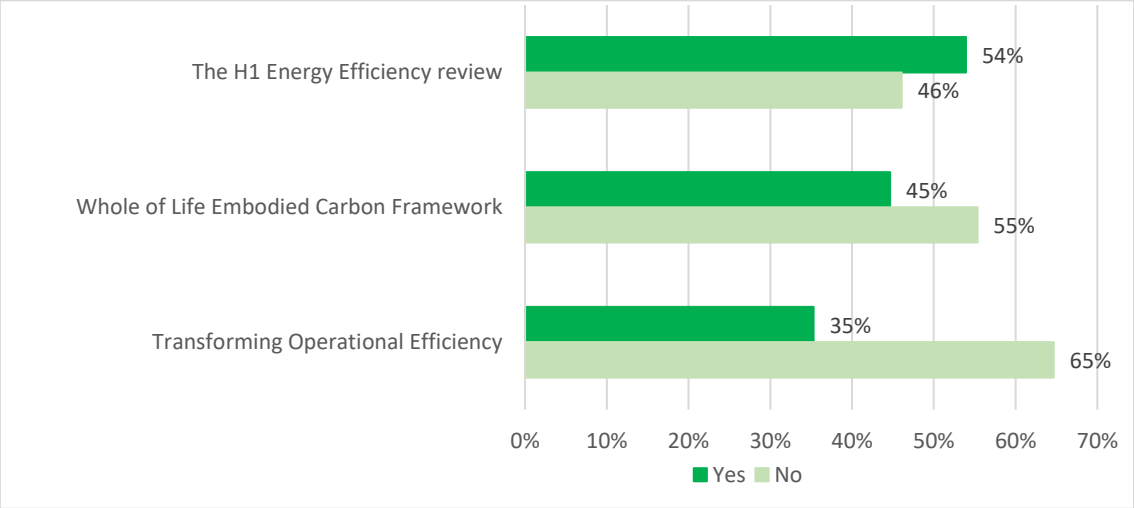

Figure 5. Awareness of the proposed building regulation changes and frameworks.

When analysed by profession, participants working in construction trades had the lowest awareness of MBIE's proposed changes across the sample with less than 35% of these participants having heard of any of MBIE's proposed changes (Figure 6).

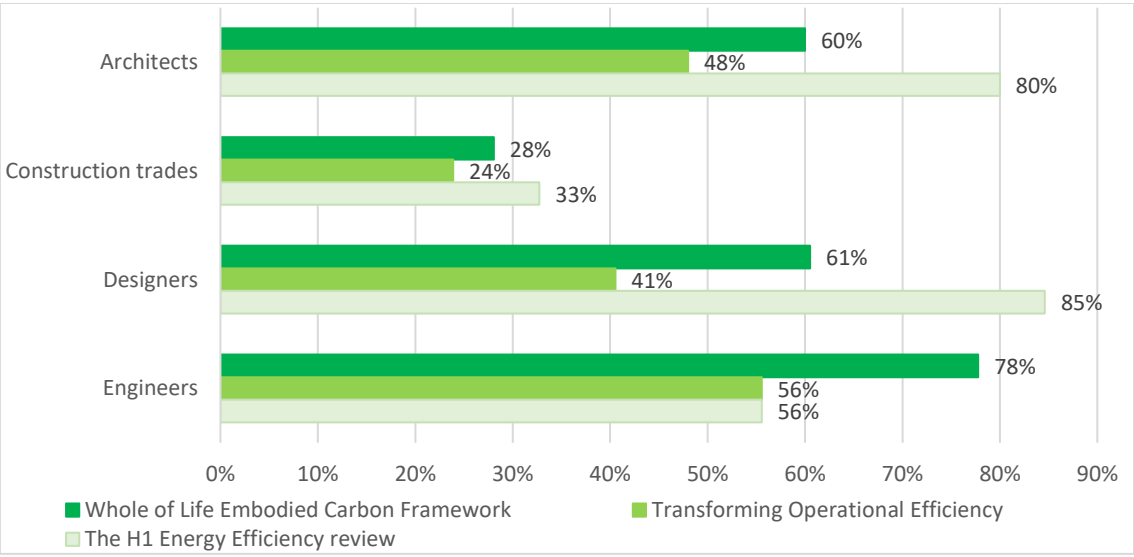

Figure 6. Awareness of proposed changes and frameworks by profession.

However, while a significant portion of the sample hadn't heard of the proposed building regulation changes and frameworks, once they were made aware of these initiatives, 86% of the overall sample were supportive of MBIE's proposals (Figure 7). Furthermore, none of the most-represented professions in the sample had an approval rating lower than 75%, which suggests widespread industry support for MBIE's proposed changes. While the participants hadn't heard of all the changes proposed, they are generally supportive of the ones they know about or, more likely, supportive of MBIE needing to make changes in this space.

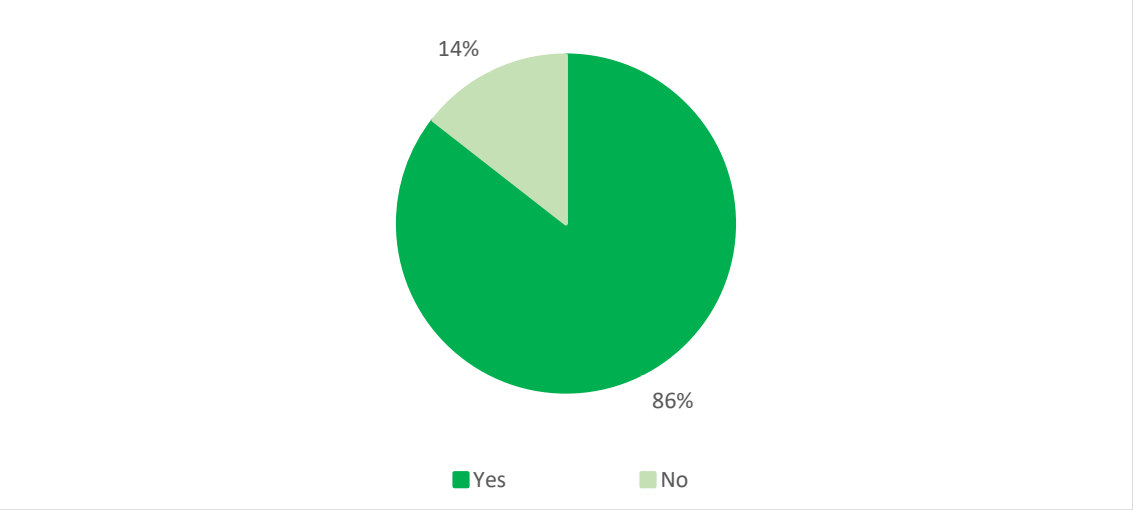

Figure 7. Support for the proposed building regulation changes and frameworks.

Common reasons given by participants who were not supportive of MBIE's proposed changes were a lack of knowledge or a belief that these changes were less than practical. The information gaps cited by these participants were usually in reference to the lack of New Zealand-based case studies on zero-carbon construction. However, a fair number of participants just didn't know enough to make an informed decision.

Another strong narrative among those unsupportive of MBIE's proposed changes was that the changes weren't practical enough. 'Practicality', however, was viewed from two opposite perspectives. Some participants thought climate change was overblown in the construction system and that all the changes were doing was adding more costs to and overregulating an industry already buckling under the pressure. Conversely, other participants thought the system wasn't going far enough and that MBIE's current and proposed changes wouldn't ultimately achieve its goals of zero-carbon construction.

3.4 Importance of new skills and knowledge for the construction system

New skills and knowledge related to zero-carbon and sustainable construction were rated as incredibly important by the participants. As shown in Figure 8, when asked which areas were most important for skills and knowledge development, the participants rated the following as important or very important:

- Knowledge of how your work connects with the work of other trades (96%).
- Knowledge of general building, architectural and engineering principles (93%).
- Overall understanding of sustainable construction strategies (90%).
- Understanding the environmental impact of GHG emissions (83%).
- Broad awareness of climate change (83%).

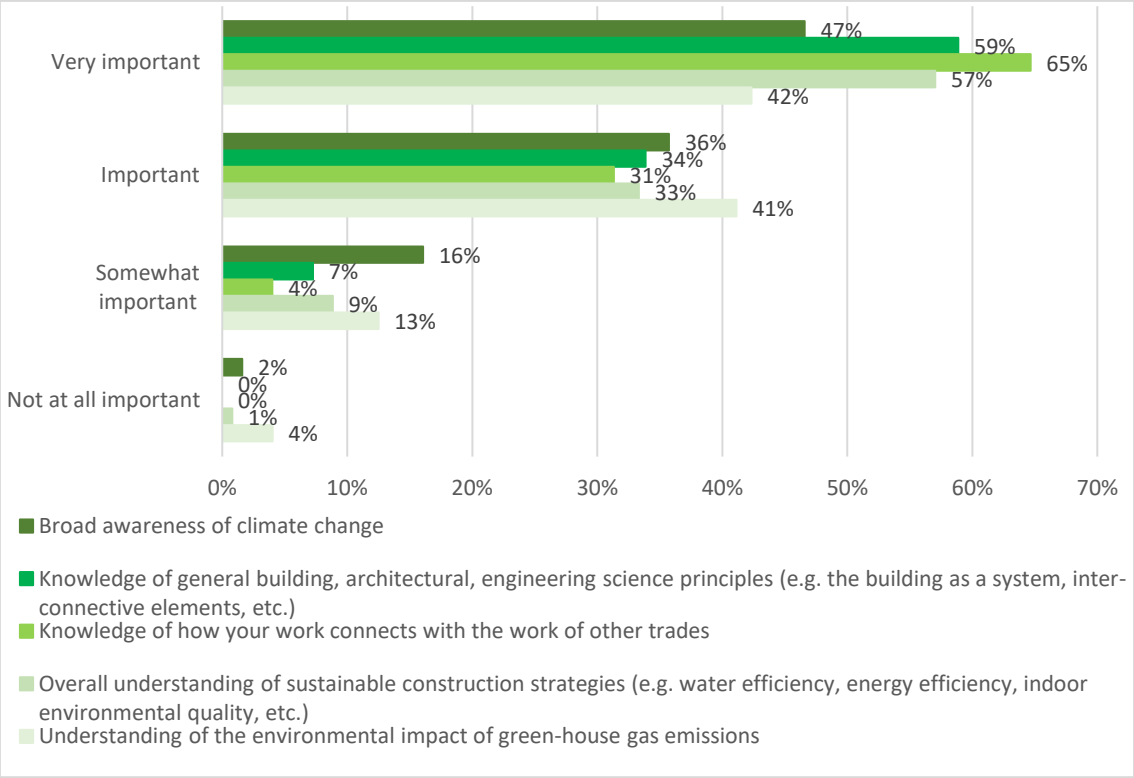

Figure 8. Importance of new skills and knowledge for the construction system.

While all areas related to zero-carbon and sustainable construction were rated as highly important, the area that was rated as most important was knowledge of how an individual trade connects and coordinates with the work of other trades rather than specific knowledge about zero-carbon or sustainable construction.

A major theme coming out of the comment sections of the survey was concern around the current fragmentation of the workforce. When discussing the technical issues seen on the worksite, one respondent mentioned a focus on a fragmented workforce that encouraged a siloed approach to knowledge.

This approach, said the respondent, often leaves workers uncoordinated and uncollaborative, focusing on their specific tasks rather than the quality of the whole build:

> "Knowledge seems to start and end with each person's particular specialty. A broader understanding of the impacts of each piece of the puzzle is needed."

An uncoordinated and uncollaborative siloed approach to construction is at odds with the best-practice approach to zero-carbon/sustainable construction that focuses on a 'high road' approach (see Table 1).

Several survey participants commented that, when the role of a construction professional is limited to their profession, it leads to issues where the quality of the whole build is often overlooked as workers focus on products and systems and rarely on their interaction with others in the build team.

For example, one professional remarked:

> "They are focused only on the element/s of the building that are relevant to them, not necessarily taking into account how a small change on their part could have a major ramification elsewhere in the building. For example, mechanical ventilation – location of units, vents etc. – could affect lighting, internal layout, and overall performance of each space."

The requirement for more knowledge about other trades was one of the highest rated by the participants. This requirement is understandable when you look at the context (best practice and current industry experience) in which these more in-depth comments were made.

Table 1: Characteristics of a best-practice zero-carbon construction firm.

Organisational characteristics	Outcomes
Dominant market strategy	Quality
Management style	Quality, decentralisation and involvement
Corporate culture	Participatory
Product delivery	In-house centralised
Subcontractor strategy	Limited number of long-term relationships and full involvement of construction team
Organisational design	Order-based
Organisation of construction processes	Task integration and involvement from design to finishing
Level of standardisation	Standardisation and off-site prefabrication of subassemblies; customised operations at construction site
Teamwork characteristics	Broad tasks and intensive collaboration on the construction site
Allocation of workers	Stable construction teams for the whole duration of the building process
Planning	Fine-tuned and updated on site by project leader in close interaction with workers and subcontractors
Problem-solving, decision-making latitude	Risk of disturbances are managed at team level on the basis of decision latitude and contextualisation opportunities
Required skills	Required knowledge and training in lower-carbon construction principles and materials and key steps in the construction process
Job quality, learning opportunities and stress risks	Teamwork decentralised; problem solving enabling knowledge sharing and learning and reduced stress risks

Source: Adapted from Ramioul et al. (2016).

The participants recognised that future progress by the industry in zero-carbon construction will be limited if the current gap in knowledge about the roles of different trades and how they coordinate is not addressed. Errors and performance issues most often occur at the intersection of different building systems (Love & Edwards, 2004; Page & Gordon, 2017, p. 10). If individual construction professionals cannot consider how a specific element of a building relates and connects to others, the system will struggle to produce a more-sustainable, zero-carbon buildings because of the strict requirements needed to reach the expected level of performance.

3.5 Competency of the industry

The survey asked the participants to evaluate competency in the industry over a range of technical skills (Figure 9). Overall, most participants perceive industry practitioners as somewhat competent across the technical skills represented in the survey. Not unexpectedly, participants were more confident in the industry's competency in areas outside of carbon – for example, participants scored practitioners as competent or very competent in the installation (59%) and management of the building envelope (41%).

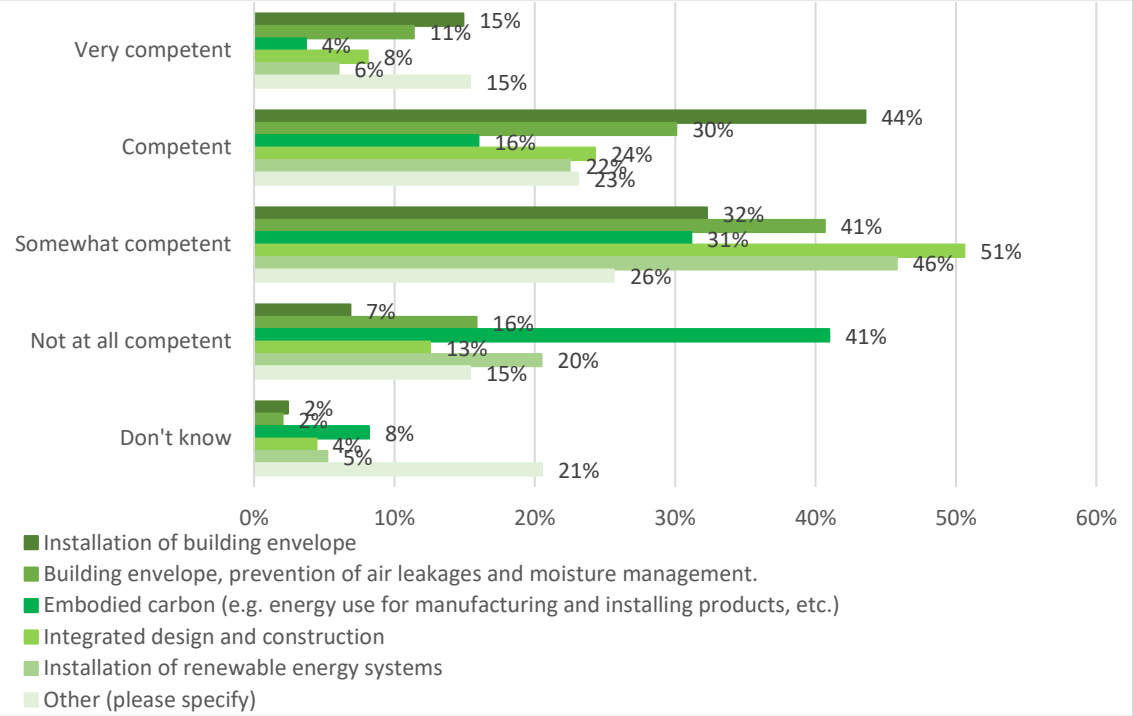

Figure 9. Competency of the industry.

This finding might suggest high confidence within the industry that there is the skill and knowledge among building professionals to undertake these tasks. However, worryingly, 39% of participants also scored their peers as only somewhat competent or not at all competent in the installation of the building envelope, and 57% scored their industry peers as only somewhat competent or not at all competent in building envelope management.

Of particular concern when considering the system's progress to net-zero carbon construction is the large proportion of participants (41%) who rated industry practitioners as not at all competent when it came to technical skills related to embodied carbon, understanding the energy use of manufacturing materials and the installation of building products.

A major theme among the comments was concern around competency in general building practice. Participants commented about a basic lack of "care", lack of understanding of the "bigger picture", lack of "robust quality assurances measures" and an inability to "follow basic specifications". Although these types of comments sit outside of zero-carbon specific concerns when discussing and assessing current competencies within the industry, they do suggest that competency in zero-carbon construction is contingent on more than just zero-carbon construction training.

When participants were asked to elaborate on why they are not satisfied with current technical skills within the industry, they often referred to the current state of the industry as being non-conducive to zero-carbon and sustainable construction. Participants were most concerned about the overall culture of the industry, saying there is a "lack of understanding of bigger picture, or a lack of time to complete tasks to level of quality required". In general, participants were worried that external factors will continue to erode quality. As one respondent outlined, "Our industry falls short of thinking quality first. [It would] rather complete the job quickly – get paid and go."

Having an internal culture that recognises the importance of quality buildings is important to the implementation of zero-carbon construction. As the participants have suggested, zero-carbon competencies will need to also address common issues that have dogged the industry for a long time if the industry is to successfully transition to zero-carbon construction.

3.6 Project management skills

When asked about their colleagues' competency in communication, problem solving, teamwork/coordination with other trades and time management – all essential project management skills – participants were more positive. Most thought their colleagues were either competent or very competent (Figure 10). However, close to a third thought their colleagues were either somewhat or not at all competent in these areas.

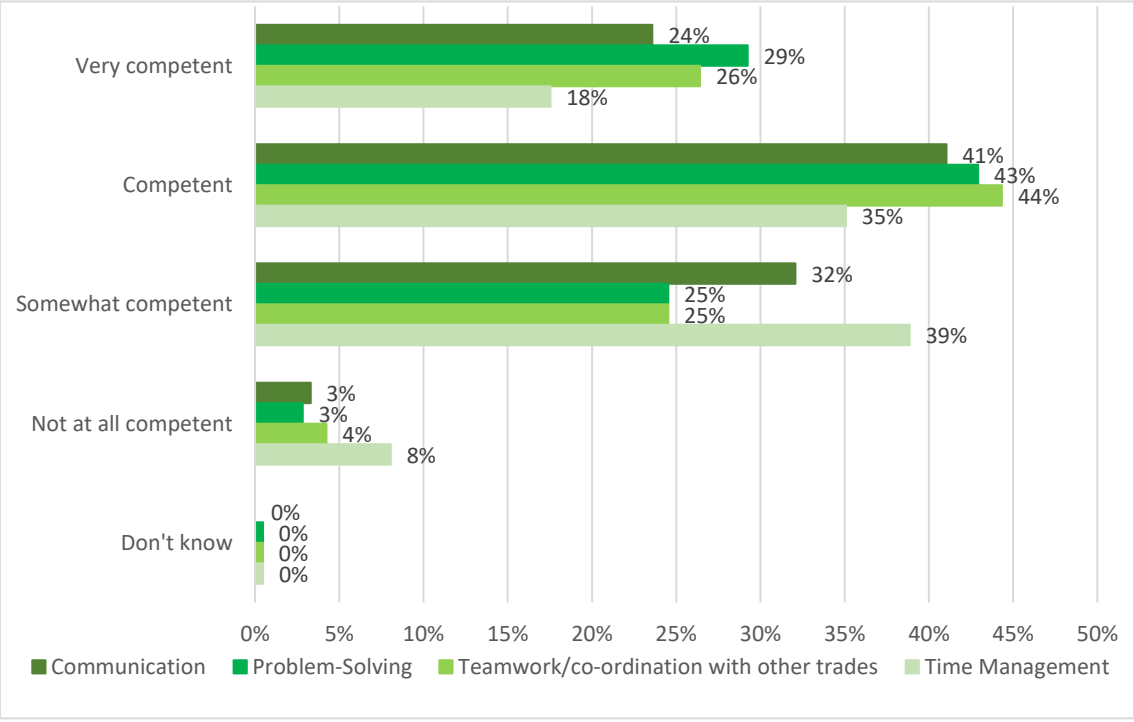

Figure 10. Project management skills.

Problem solving was the most highly rated skill, while time management was the skill rated most poorly by the participants. The participants also rated communication quite highly, with 65% of participants saying their colleagues were very competent or competent in this area. We suggest that communication is ranked highly by participants because they feel they have strong intra-trade/profession communications – they feel communication within their own team/regular co-workers is good. However,

several long-answer comments spoke to how poor communication usually is on site, particularly inter-trade communication – communicating with other professionals outside of your own speciality.

Participants also highlighted that builders sometimes make assumptions and do not check closely enough with their designer/architect. As this is an important concern for best-practice zero-carbon construction, this will be investigated in future iterations of this research.

3.7 Knowledge of zero-carbon and sustainable construction

The participants were asked to self-rate their levels of knowledge of various technical aspects required for zero-carbon construction (Figure 11). Overall, participants didn't see themselves as experts in any area. When asked about calculating greenhouse gas emissions, most participants (68%) had no knowledge on that subject. The majority saw themselves as having a little knowledge in areas like low/zero-carbon principles (80%), reducing energy through passive design (71%), the impact of the built environment on climate change (65%) and carbon footprinting of design (64%).

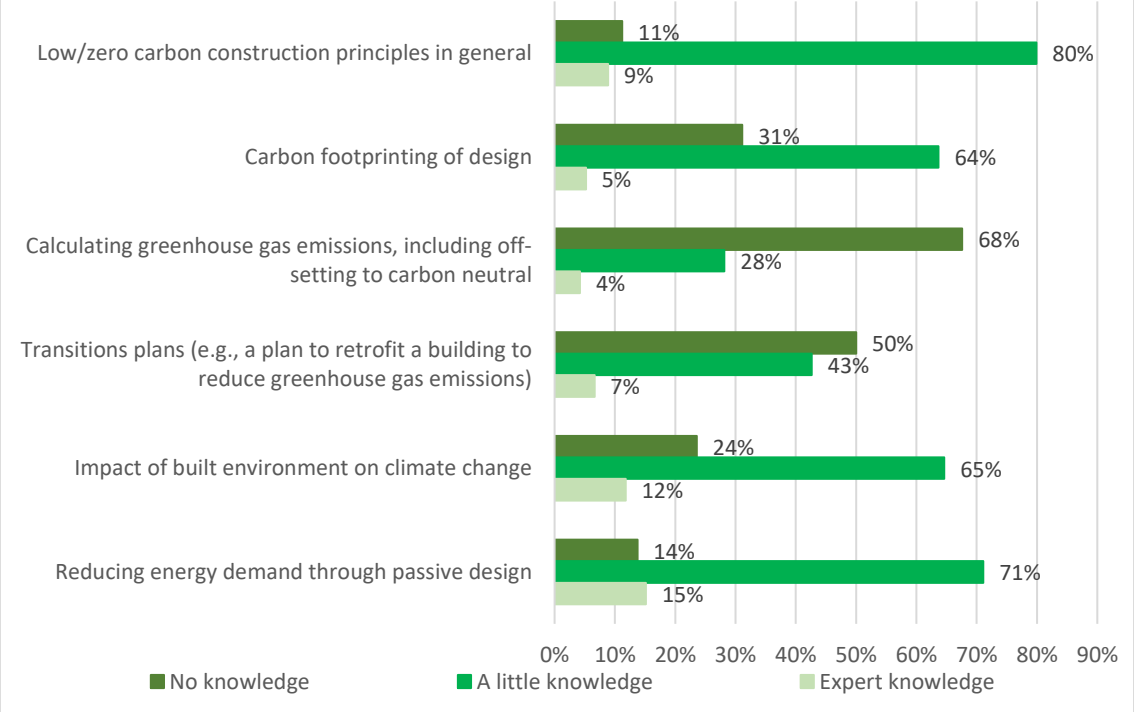

Figure 11. Knowledge of zero-carbon and sustainable construction.

3.8 Experience with zero-carbon and sustainable construction

There is a significant gap between having knowledge of zero-carbon and sustainable practices and actual experience enacting these practices. A majority of the participants had **no experience** in calculating GHG emissions (75%), transition plans (60%) and carbon footprinting of design (58%). The only area of note where expert knowledge (15%) closely matched in-depth experience (14%) was in relation to reducing energy demand through passive design.

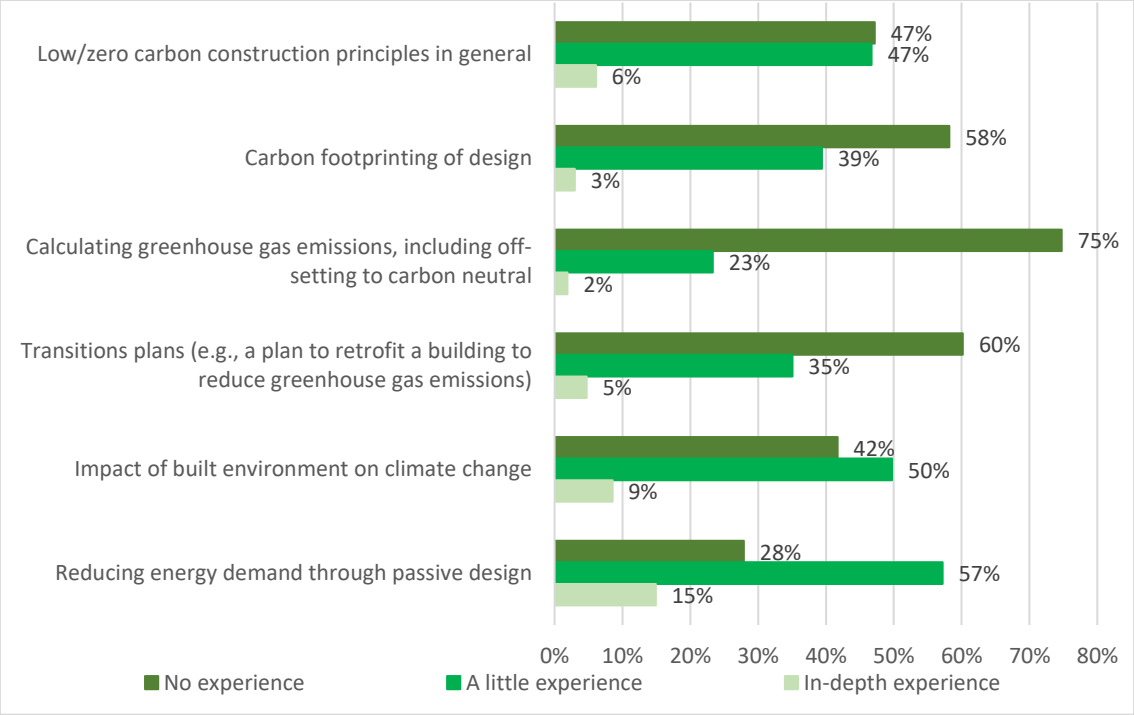

Figure 12. Experience with zero-carbon and sustainable construction.

3.9 Barriers to zero-carbon and sustainable construction

The survey asked participants what they thought was the main barrier to addressing climate change in construction within Aotearoa New Zealand (Figure 13). The participants were evenly split between four categories: inertia/disinterest from others was ranked highest at 28%, followed by lack of information ("I don't know what to do", 26%), lack of time ("We are too busy with current workloads to do anything about climate change", 23%) and lack of resources ("Our company doesn't have the resources to support our development in this area", 20%).

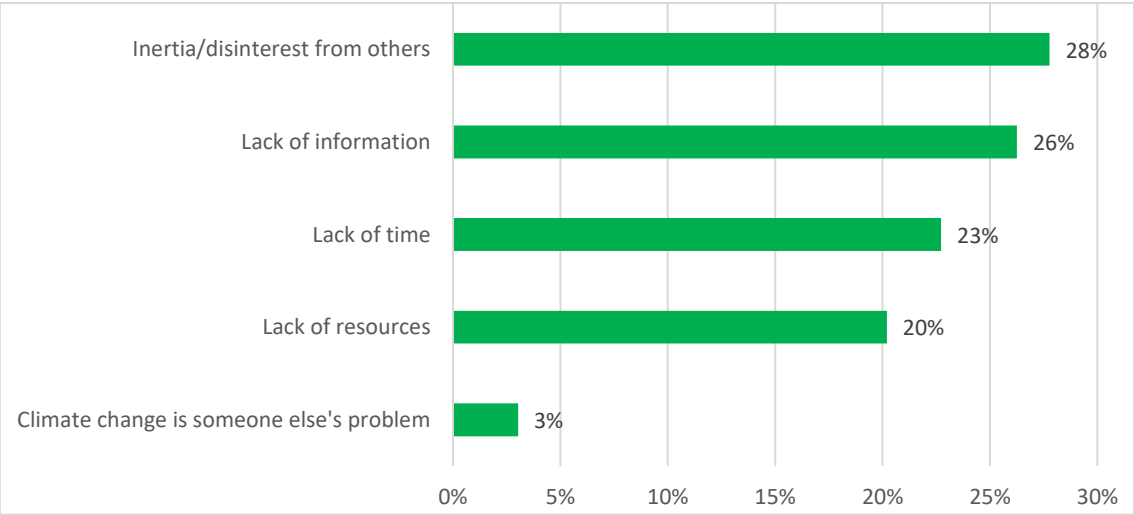

Figure 13. Barriers to zero-carbon and sustainable construction.

Since the survey asked participants to choose the most relevant answer, the split between these four areas suggests that each should be considered a significant barrier to addressing climate change in construction and the importance of tackling climate change systemically.

3.10 Informational needs on zero-carbon and sustainable construction

Like the question that explored barriers to zero-carbon and sustainable construction, the desire for information is evenly split across a wide number of categories related to climate change and construction (Figure 14).

Considering the participants' self-identified lack of knowledge, it is no surprise that informational needs are evenly spread across many categories. The only category that had fewer responses than the others was 'Greening the financial system and climate risk' (7%).

A lack of knowledge and experience was the largest theme that came out of the survey comments. The challenge for the building and construction industry will be the diversity of knowledge required to transition to zero-carbon construction. Furthermore, as previously noted, some of the requirements go beyond zero-carbon training. For example, there were frequent comments about a lack of "general theory" in relation to building science. The participants also raised concerns about poor communication and collaboration between trades, saying the current lack of coordination needs to be addressed, teams need to become less siloed and different trades need to think more about the quality of the whole building rather than individual parts of the system.

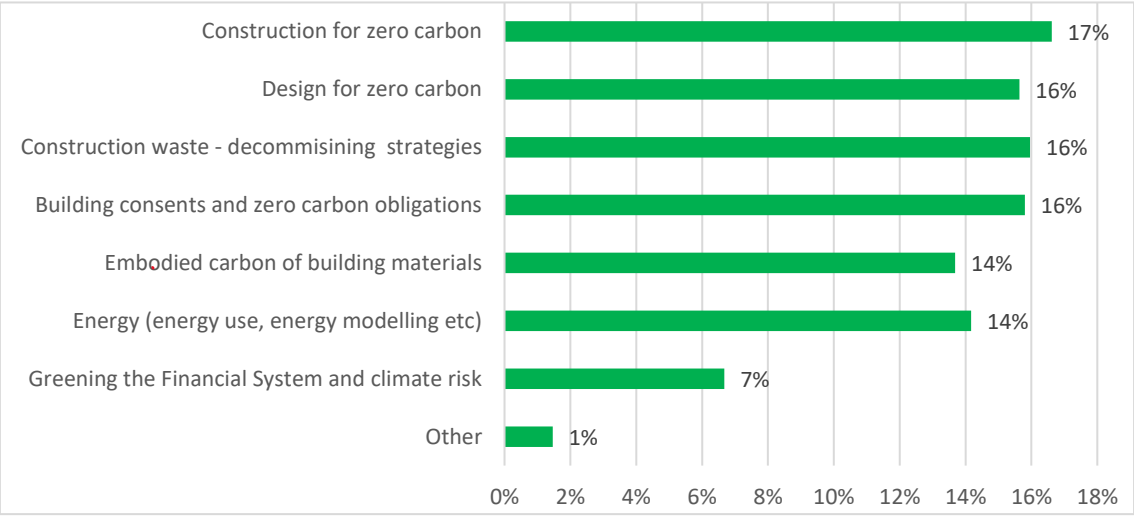

Figure 14. Informational needs on zero-carbon and sustainable construction.

3.11 Education and training in zero-carbon and sustainable construction in New Zealand

The participants were more mixed when it comes to the current education and training being offered in relation to zero-carbon and sustainable construction (Figure 15), with 40% of participants neither satisfied nor dissatisfied with the industry's current

education and training on zero-carbon and sustainable construction, 34% dissatisfied and 15% extremely dissatisfied.

Only 10% of our sample was either satisfied or extremely satisfied with the current education and training on offer in these areas.

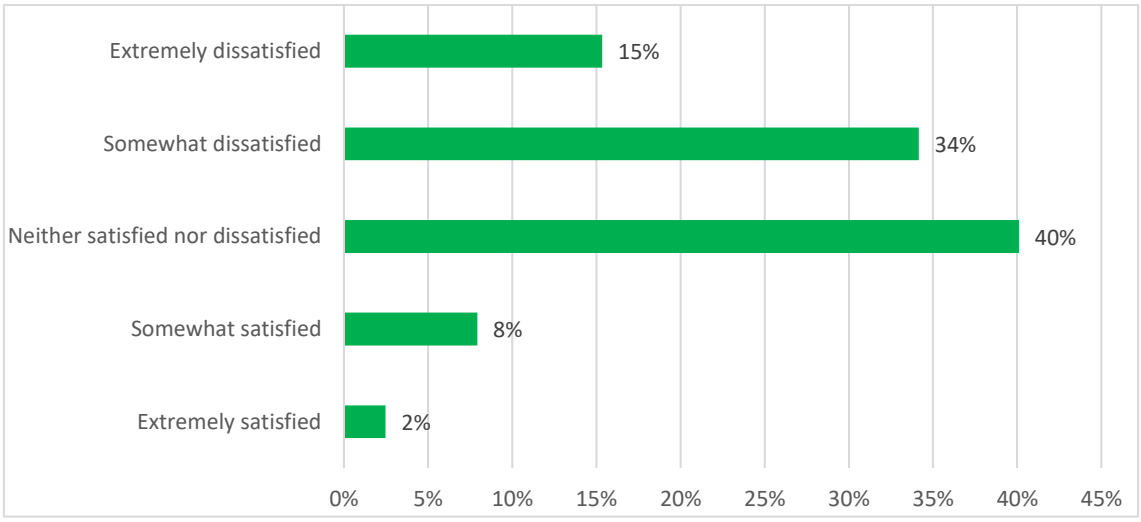

Figure 15. Satisfaction with current education and training in zero-carbon and sustainable construction in New Zealand.

3.11.1 Preferred methods to upskill industry

Professional development workshops, seminars and trade talks were overwhelmingly the participants' preferred method for learning more about zero-carbon and sustainable construction (Figure 16). Part-time certificate programmes (13%) and apprentice programmes (11%) were also mentioned but to a much lesser degree.

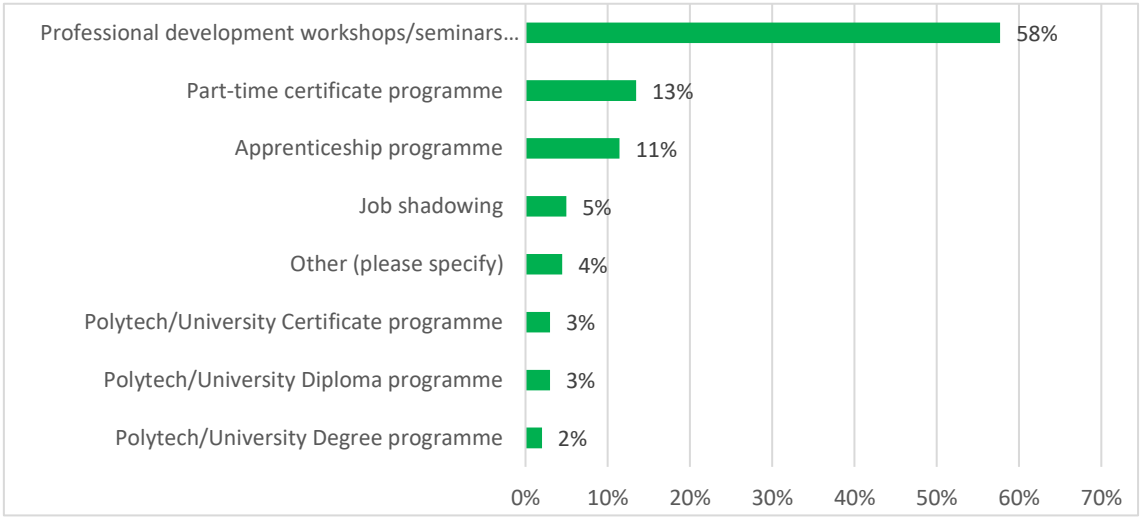

Figure 16. Participants' preferred methods to upskill industry.

In a follow-up question to see what modes of delivery would be effective for addressing gaps in knowledge and skills around zero-carbon and sustainable construction, the participants identified online (26%), in-person (25%) and on-site education (16%) as the best approaches.

3.12 Other concerns identified by industry

The final question asked participants to outline any issues that had not already been addressed in the survey. Most of the participants had no further comment to make, but the comments from those who did cluster around two key areas – construction and demolition waste and transition engagement and leadership.

3.12.1 Construction and demolition waste

The participants knew they had to reduce waste and wanted more guidance on how to do this effectively.

3.12.2 Transition engagement and leadership

The comments around engagement were varied. For example, participants were worried about the support they need from government and whether the science system would be fit for purpose. Other comments were about the need for information to lift engagement within industry about the transition to zero carbon. Participants also expressed their concern that current engagement is curt and not reaching the subtrades and that a lack of understanding about what zero-carbon construction means for consumers is not helping the transition.

Another concern not addressed in the survey and that was important to participants was leadership within industry on zero carbon. Participants felt that there was uncertainty about who should be leading zero-carbon transformations within the system at large and also within workforce-specific teams. Is it the designer who is the arbiter of zero carbon? The regulator? The builder? This is a question to address in future research.

4. Conclusions

This research project has sought to gaining an understanding of the building and construction industry's knowledge and experience in relation to zero-carbon construction. The research was guided by three central research questions:

- What expertise (knowledge, skills and competencies) are required for delivery of zero-carbon buildings across their life cycle?
- Does the building and construction industry have available the existing expertise, knowledge and competencies to deliver zero-carbon buildings? If not, what are the barriers to developing and deploying zero-carbon construction across the industry?
- How will the expertise need to be provided?

This research study is the first in Aotearoa New Zealand to examine the knowledge, skills, competencies and training requirements of the building and construction industry in relation to the transition to zero-carbon construction.

These are the key results from the survey:

- The largest proportion of the sample (45%) was made up of those who identified as being in a construction trade. These participants primarily worked on residential stand-alone buildings, and there was an even split between builders and carpenters. The next most-represented professions were architects and designers, who made up 24% of the sample.
- The participants rightly identified the significant impact embodied carbon has on GHG emissions across a building's life cycle. However, they also scored operational carbon (energy use from plug-in appliances, space heating, etc.) lower than expected. Operational carbon (ranked fourth by the participants) is normally the greatest source of GHG emissions in most building typologies.
- Over half of the survey participants were not aware of some or all of the changes proposed by MBIE's *Building for climate change* programme. Despite this, 86% were supportive of MBIE making changes to address climate change.
- The key areas that were identified as important or very important new skills and knowledge for industry were:
  - broad awareness of climate change (83%)
  - knowledge of general building, architectural and engineering principles (93%)
  - knowledge of how your work connects with the work of other trades (96%)
  - overall understanding of sustainable construction strategies (90%)
  - understanding the environmental impact of GHG emissions (83%).
- The areas where survey participants had no knowledge at all were:
  - calculating GHG emissions (68%)
  - transition planning such as retrofitting an existing building to be zero carbon (50%).
- Participants believed industry is either very competent or competent around the installation (58%) and maintenance (41%) of the building envelope.
- Conversely, participants saw 41% of industry as not at all competent when it came to understanding embodied carbon.
- In terms of industry zero-carbon and sustainable practices and experience of enacting these practices:
  - half of the participants had no experience in carbon footprinting of design (58%), calculating GHG emissions (75%) and transition plans (60%)

    - the only area of note where expert knowledge (15%) closely matched in-depth experience (15%) was in relation to reducing energy demand through passive design.
- The participants saw the greatest barriers to zero-carbon construction to be:
    - inertia/disinterest (28%)
    - lack of information: "I don't know what to do" (26%)
    - time: "We are too busy with current workloads to do anything about climate change" (23%)
    - resources: "Our company doesn't have the resources to support our development in this area" (20%).
- When asked about the current education and training for industry on zero-carbon and sustainable construction, the participants were largely neutral (40%) or were somewhat dissatisfied (34%) or extremely dissatisfied (15%) with what is available. Participants would like more information and training in the form of professional development workshops, seminars and trade talks.

The findings from this industry survey show that the building and construction industry is ready for change, is largely supportive of doing something to address climate change and wants to become a workforce with the knowledge and ability to transition to zero-carbon construction. This last point is well demonstrated in the survey, as the participants commented on the frequent lack of specific knowledge in the industry about more technical aspects of zero-carbon construction.

The participants were aware of the importance of embodied and operational carbon emissions within a building's life cycle. Furthermore, while the participants in this industry sample knew very little about the proposed regulatory changes from MBIE's *Building for climate change* programme, they were supportive of changes needing to be made to address climate change.

Significantly, the survey results identified that, while there is a desire for change, there is very little knowledge or experience across industry around zero-carbon skills and competencies. The current training available to industry in this space is also limited so any upskilling will require a significant push from the education system to provide resources in the channels that suit each of the various professions across the system. As a next step, BRANZ seeks to partner with industry to test occupation-based zero-carbon skill and competence profiles and to co-create solutions with industry and government.

Perhaps more importantly, the survey shows that there are other challenges the industry needs to consider outside of specific training for zero-carbon construction. The current make-up of the construction workforce, how it works together and the lack of underpinning knowledge outside of zero carbon are all concerns that need to be addressed to deliver on zero-carbon construction.

This research helps to highlight that zero-carbon construction is a socio-technical issue that is going to require a significant behavioural shift. Alongside education, it will need to address the current socio-economic and cultural conditions of building and construction in Aotearoa New Zealand and find ways to incentivise quality construction practice so our zero-carbon goals can be achieved.

References

Dowdell, D., MacGregor, C., Jaques, R., Berg, B. & Butler, J. (2021). The greenhouse gas emissions of stand-alone residential houses in New Zealand: challenges and oppurtunities. In L. Grant, H. Viggers, & P. Howden-Chapman (Eds.), *Improving Buildings, Cutting Carbon* (pp. 39–48). Steele Roberts.

Giesekam, J., Tingley, D. & Cotton, I. (2018). Aligning carbon targets for construction with (inter) national climate change mitigation commitments. *Energy and Buildings, 165*, 106–117. https://doi.org/10.1016/j.enbuild.2018.01.023

Goodyear, R., Bentley, A., White, V., Bretherton, C., MacGregor, C., Jaques, R., Dowdell, D., Butler, J., Fabian, A. & Dickson, C. (2021). Understanding the state of our housing: Housing in Aotearoa: 2020 | Te māramatanga ki te tūnga o ō tātou whare noho: Ngā whare noho i Aotearoa 2020. *New Zealand Population Review*, *47*, 33–69. https://population.org.nz/wp-content/uploads/2021/08/Goodyear_etal_State_of_Housing_2020.pdf

IPCC. (2007). *Climate change 2007: Synthesis report. Contribution of Working Groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change*. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar4/syr/

IPCC. (2018). Summary for policymakers. In V. Masson-Delmotte et al. (Eds.), *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Cambridge University Press. https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SPM_version_report_LR.pdf

Lockyer, O. MacGregor, C. & Knight, A. (2023). *The Future of Work: Construction system knowledge, skills and competences for the transition to zero carbon: A systematic narrative review* [Unpublished paper]. BRANZ Ltd.

Love, P. E. & Edwards, D. J. (2004). Determinants of rework in building construction projects. *Engineering, Construction and Architectural Management, 11*(4), 259-274. https://www.researchgate.net/publication/235274279_Determinants_of_rework_in_building_construction_projects

MacGregor, C., Dowdell, D., Jaques, R., Bint, L. & Berg, B. (2018). *The built environment and climate change: A review of research, challenges and the future* BRANZ Study Report SR403]. BRANZ Ltd. https://www.branz.co.nz/pubs/research-reports/sr403/

Page, I. & Gordon, G. (2017). *What is quality in buildings?* BRANZ Study Report SR380. BRANZ Ltd. https://d39d3mj7qio96p.cloudfront.net/media/documents/SR380_What_is_quality_in_buildings.pdf

Ramioul, M., Benders, J. & Van Peteghem, J. (2016). Green construction and team design. Low road and high road teams to build energy-friendly houses. *World*

Review of Entrepreneurship, Management and Sustainable Development, 12(1), 33–49. https://www.researchgate.net/publication/288875389_Green_construction_and_team_design_Low_road_and_high_road_teams_to_build_energy-friendly_houses

Stewart, F. (2015, November). *ACW Baseline Sub-Report: Policies and practices to promote work enhancing pathways in the transition to a low carbon economy* [Paper presentation]. Presented at the Adapting Canadian Work and Workplaces (ACW) International Workshop, Toronto, Canada. https://yorkspace.library.yorku.ca/xmlui/bitstream/handle/10315/39441/03_ACW_Baseline_Report_2015_EuropeanStewart.pdf?sequence=1&isAllowed=y