Study Report SR473 [2022]

Roadmap for evaluating building performance for low-carbon houses

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Abstract

Buildings need to be warm, dry, healthy and zero carbon, but there is currently no consistent, integrated New Zealand-based online solution to evaluate whether a design will meet these performance requirements. The aim of the project was to scope how we can work towards a web-based, accessible, integrated solution that draws on existing tools (possibly with adaptation).

This BRANZ stakeholder engagement project investigated the possibility of developing a tool that evaluates a range of interrelated variables such as embodied and operational carbon, thermal performance, energy efficiency, moisture risk and indoor environment quality for new building design and construction.

This project brought together the primary building industry stakeholders to co-design a collective roadmap for evaluating building performance. The project comprised a two-fold approach – an online survey and a number of stakeholder engagement workshops.

The preferred option is to have a single tool that assesses multiple building performance metrics. The tool should be able to be used right through the design, compliance, and construction phases, be viable for multiple building typologies and integrate with existing industry tools. 'Must haves' for the tool related to measures assessed, integration with industry tools, accessibility, training, user experience, compliance, data, benchmarks and scope. However, there was also a recognition that we need to start reducing operational and embodied carbon emissions in buildings now even if our evaluation and calculation tools are not perfect.

Keywords

Building performance, evaluation, zero carbon, energy efficiency.

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Executive summary

With growing urgency to measure carbon emissions from building and construction and create warmer, drier, healthier homes, how can evaluation and calculation tools help?

This BRANZ stakeholder engagement project investigated the possibility of developing a tool that evaluates a range of interrelated variables such as embodied and operational carbon, thermal performance, energy efficiency, moisture risk and indoor environment quality for new building design and construction.

We canvassed the views of a range of industry stakeholders to identify the issues they face when evaluating building performance and the features they would value in a tool. Stakeholders included MBIE Building System Performance, architects, designers, building consent authorities and commissioners of buildings.

As part of its Building for Climate Change (BfCC) programme, MBIE plans to set a series of operational and embodied carbon emissions caps. We therefore placed a particular focus on calculating carbon emissions.

These are some key findings of the project:

- We need to start reducing operational and embodied carbon emissions in buildings now even if our evaluation and calculation tools are not perfect.
- We need to ensure other aspects of building performance are not compromised by a focus on carbon footprint compliance.
- A number of tools are currently available, but there is a preference for a single tool specifically related to the New Zealand building industry that would provide a wide range of building performance outputs based on consistent metrics.
- While a single tool was seen as aspirational, the important factor is consistency – consistent design analysis and outputs across a wide range of building performance criteria combined with consistent assessment in the compliance process.
- The tool should be able to be used right through the preliminary and developed design, compliance and construction phases, be viable for multiple building typologies and integrate with existing industry tools.
- It should be based on a consistent carbon dataset relevant to New Zealand that is regularly updated.
- Any new tool needs to be freely available and easy to use and have a robust introductory training scheme with ongoing support.
- Inputs need to be simple and quick to enter, with the potential to incorporate more detail as the design and construction processes progress.
- The ideal tool should be able to generate benchmarks based on a user's portfolio of completed buildings and a wider pool of other buildings. These can be used to set targets at the beginning of projects for warm, dry, healthy, low-carbon buildings. It will also allow MBIE to collect stock-level carbon footprinting data that can be used to set future thresholds as part of the BfCC programme.
- Manufacturers need to make reliable, current product data available, including carbon footprints.
- While the focus is on new builds, there will be a future requirement for evaluating alterations to existing stock and repurposed non-residential buildings.
- Voluntary action is not working across the industry. Regulation is essential in order to improve our buildings and meet our zero-carbon goals.

1. Project overview

1.1 Project aim

This project brought together the primary building industry stakeholders to co-design a collective roadmap for evaluating building performance.

Buildings need to be warm, dry, healthy and zero carbon, but there is currently no consistent, integrated New Zealand-based online solution to evaluate whether a design will meet these performance requirements.

A building is a total system – changing one variable affects another. Considering how to integrate a range of interrelated variables and inputs is fundamental. Several largely separate issues such as thermal performance, energy efficiency, embodied and operational carbon and moisture risk have the potential to be brought together in a coherent digital solution that aligns with design and consenting workflows.

Currently, measures/tools for building performance are separate and siloed, are often complex and difficult to work with and consequently have limited uptake. There are also many different tools with varying methodologies, levels of complexity, varied input requirements, datasets and results, which don't necessarily incorporate New Zealand-relevant data.

We need to move away from multiple tools with varying scopes, methodologies, complexities, purposes, underlying data and outputs, as these can lead to inconsistency, inaccuracies and confusion. The aim of the project was to scope how we can work towards a web-based, accessible, integrated solution that draws on existing tools (possibly with adaptation).

1.2 Project methodology

The project comprised a two-fold approach – an online survey and several stakeholder engagement workshops.

An online survey was sent out and completed by 84 industry professionals.

Stakeholder engagement workshops were then held with a number of sector groups.

MBIE Building System Performance – regulator

In-person workshop – 9 participants.

Architects/designers

Three online workshops:

- Greater Auckland/Hamilton region – 14 participants.
- Christchurch/lower South Island region – 16 participants.
- Greater Wellington and Nelson region – 22 participants.

South Island BCAs/TAs – compliance/consenting

Online workshop – 24 participants from 11 BCAs/TAs.

Commissioners of buildings

Online workshop – 11 participants.

2. Online survey

2.1 About the survey

An online survey was conducted in August 2021 to better understand the New Zealand building industry's opinions on the development of a consistent, integrated, New Zealand-based online solution to evaluate building design and performance.

The 10-minute survey (comprised of 15 closed questions and three open-ended questions) was primarily completed by building design professionals who were invited to complete the survey via email.

The survey was commenced by 216 individuals, although only 84 completed the full survey. Many of those who did not complete the survey were filtered out because they do not currently use digital tools to assist with the design, performance and/or compliance of residential buildings in their work. This requirement added to the strength of the results because respondents were familiar with the practices and challenges of using the software and the issues being investigated.

2.2 Summary of survey findings

Use of digital tools

- Almost three-quarters of all respondents currently use digital tools to assist with the design, performance and/or compliance of residential housing.
- The main focus of the digital tools used by respondents were thermal performance, ventilation, moisture risk and energy modelling.
- The tool most commonly used by respondents is Design Navigator, which was used by over half of respondents.
- When asked to self-rate their personal skills, competency and expertise in using digital tools, the most common answers from respondents were proficient (39%), and beginner (38%) as opposed to experienced (15%) and expert (7%).
- The most common way that respondents gained skills in the use of digital tools was from trial and error gained during self-training.
- The main challenge faced by respondents when using digital tools was identified to be a lack of formal training, reported by half of respondents. The factors that were key challenges for at least 25% of respondents also predominantly reflected limited knowledge or understanding of tools – lack of experts to provide advice (38%), information about the tool too hard to find (31%) and tool too complex (26%).

What's needed

- When asked to imagine a digital tool that could assist in overcoming the main barriers experienced, almost half of respondents imagined a single web-based tool that features multiple performance attributes.
- Assessment of energy efficiency, followed by ventilation and moisture risk were the elements most frequently considered as 'must have' in a digital tool.
- The most important outcome for digital tools according to respondents was assisting with building concept design followed by assisting with optimising building efficiency and measuring/obtaining compliance.
- Respondents wanted an independent organisation such as BRANZ, MBIE or a dedicated independent body to be responsible for developing, maintaining and providing support for the use of the tool (79%).

Usability

- Usability factors were the most common elements that respondents felt needed to be considered when developing a new tool.
- These comments emphasised that the tool must be easy to use, which means having an accessible, user-friendly interface that allows simple data input and produces clearly understandable results.
- Respondents also highlighted that the accuracy of data is vital, noting the tool must have capacity to accurately predict emissions and performance and that data needs to be standardised in consistent units and be from a common source.
- Other informative usability points made less frequently were the importance of effective training and having expert support available and that cost must not become prohibitive, particularly for smaller projects like single family houses that do not have the same budget to pay for software and expertise as larger developments.

Performance requirements

- Respondents noted that the tool would need to be flexible and suitable for a range of different contexts and situations such as small/large, residential/commercial or rural/urban projects.
- Comments emphasised that the tool must be robust and reliable overall in order to be useful and should include some specific factors such as sustainability considerations (around materials, carbon footprint and energy efficiency) or economic evaluations including product building availability and relative cost of energy-efficient materials.

Existing tools

- Several respondents recommended using or modifying existing tools noting there are a range of well-performing tools already in New Zealand and internationally (PHPP, Tally, EC3) and they felt that there is no need to "reinvent the wheel".

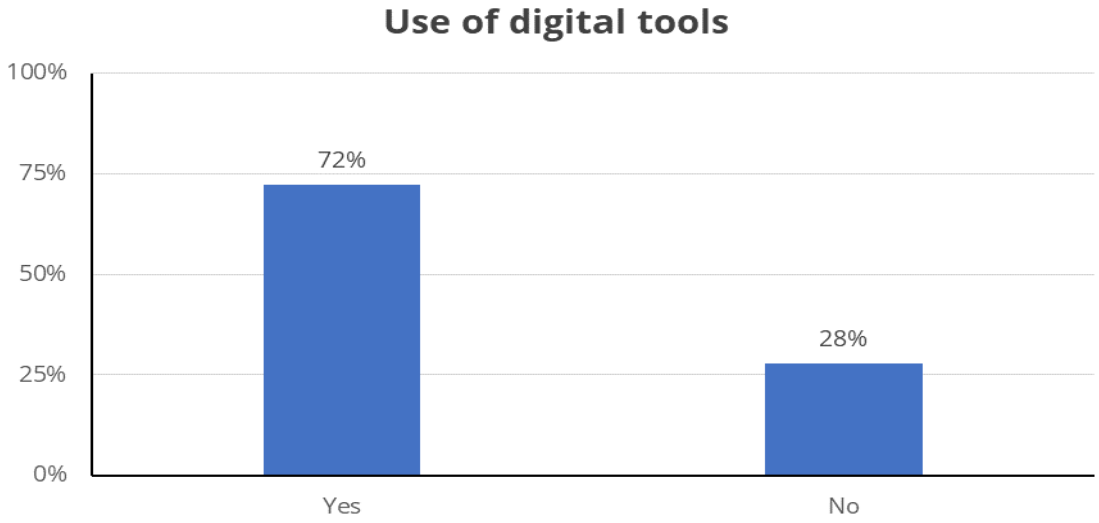
2.3 Detailed survey results

Simple statistical analysis was completed on all quantitative survey questions. More-sophisticated analysis was not completed due to the relatively small sample size. For example, frequency analysis was completed on data to present the percentage of respondents who selected each option when they were required to select one or multiple responses to a question. When respondents were required to rank options to identify priorities, the number of respondents who ranked each option from highest to lowest is presented.

Statistical results are presented in charts and interpreted in written analysis. Responses to free-text questions have been thematically analysed by reading and sorting (coding) comments to a consistent set of themes and topics prior to a synthesis of the points made being presented along with key insights being presented in written discussions. Charts are accompanied by interpretations detailing key findings or trends. Where applicable, additional text responses have been included. Responses to free-text questions have been grouped into themes and topics, which are discussed in order of most-to-least frequently mentioned.

Use of digital tools

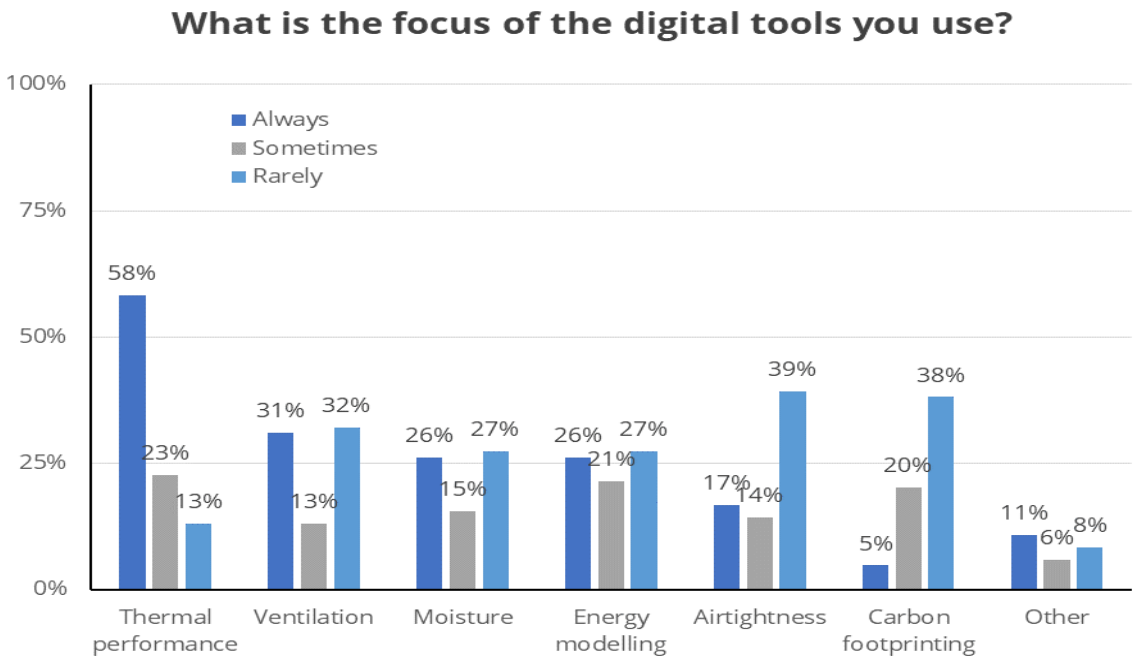
Respondents were asked: Do you currently use digital tools to assist with the design, performance and/or compliance of residential housing? (216 answers)



- Almost three-quarters of respondents (72%) currently use digital tools to assist with the design, performance and/or compliance of residential housing.
- Respondents who did use tools were from these professions: Designer (35), Architect (20), Technical Consultant (13), Project Manager (3), Building Consent Official (1), Other (11) consisting of Certified Passive House Designer, Construction Educator, Engineer (3), Development Manager, Building Services Consultant – HVAC, Structural Engineer, Architectural Technician/BIM Manager, Building Surveyor and Educator.
- Note that the 28% (60) of respondents who stated they didn't use digital tools were filtered out of the survey after they answered this question.

Focus of digital tools

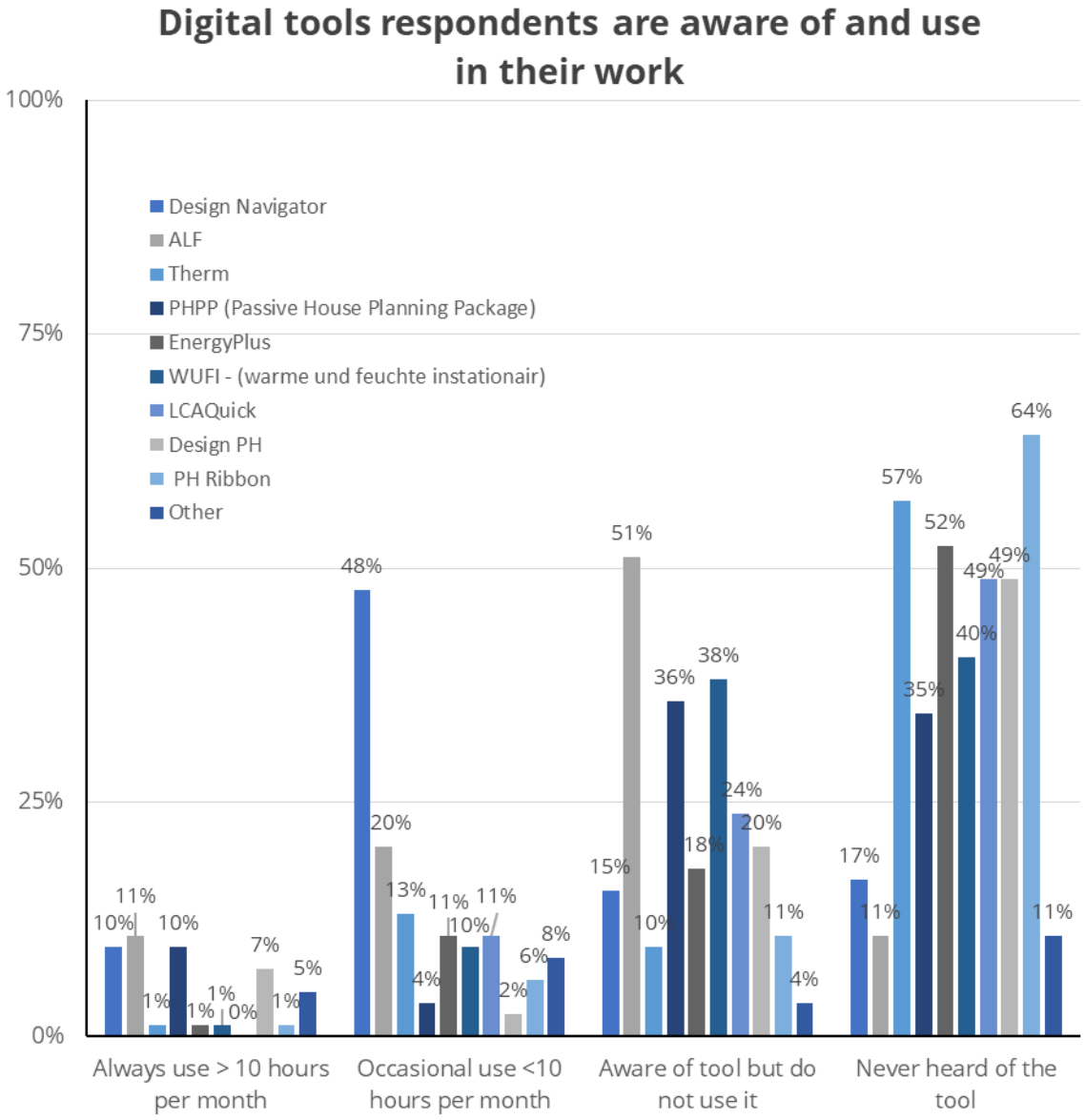
Respondents were asked: What is the focus of the digital tools you use? (84 answers) (Note the remainder of responses that make the total for each factor up to 100% were respondents who didn't answer the question. For example, 6% of respondents didn't answer regarding thermal performance. These are likely to be respondents who didn't focus on that factor at all. The factors that recorded the highest non-response rates also had the highest 'rarely' responses.)



- Thermal performance was most frequently classified as always the focus of digital tool use by respondents (58%), followed by ventilation (31%), moisture (26%) and energy modelling (26%).
- When 'always' and 'sometimes' responses were combined, thermal performance remained the most commonly focused on factor for digital tool use (81%), followed by energy modelling (47%), ventilation (44%) and moisture (41%).
- The elements that were most commonly reported as rarely the focus of the digital tools used by respondents were airtightness (39%, plus 30% NR) and carbon footprint (38%, plus 37% NR).
- Respondents who selected 'other' were asked to specify the focus of the digital tools they use. Responses included design (3), bracing (2), sun or thermal modelling (2), Homestar (2), waterproofing (1), structural elements (1), compliance (1), structural engineering (1), comfort modelling (1) and community (1).

Awareness of digital tools

Respondents were asked: Which of the following digital tools are you aware of and use in your work? (84 answers)



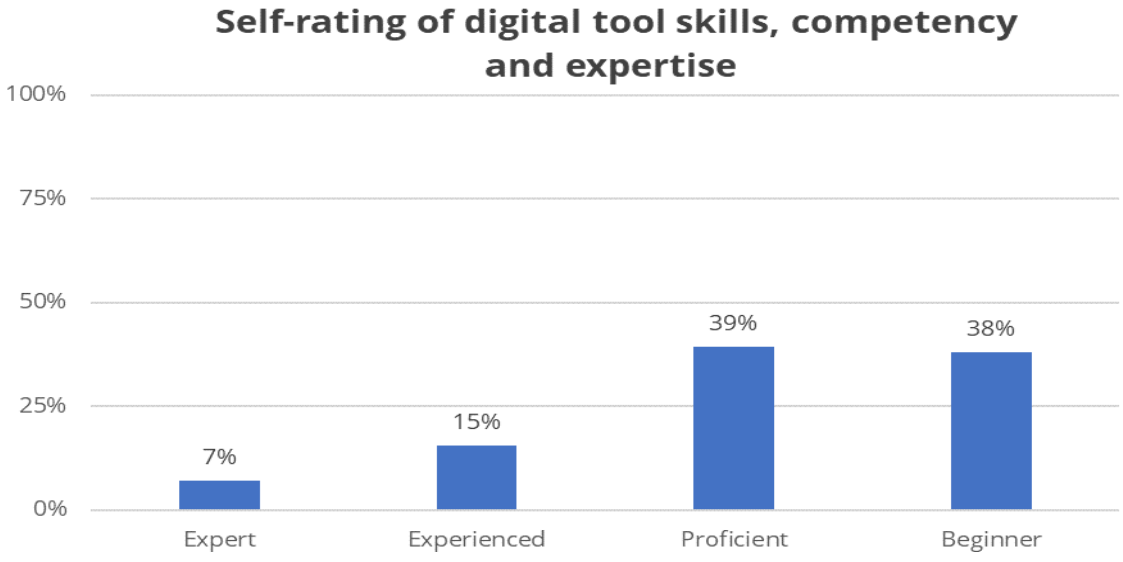
- The tool most commonly used by respondents is Design Navigator, which was used by 58% of respondents (10% always use and 48% occasionally use).
- ALF was the second most popular tool, used either occasionally or always by 31% of respondents (20% occasional use, 11% always use).
- ALF (11%) was most commonly used always, followed by PHPP (Passive House Planning Package) and Design Navigator both used always by 10% of respondents.
- All other tools were used occasionally or always by 13% of respondents or less.
- Other tools used occasionally or always by less than 3% of respondents were Design Builder (2%), HVAC CFD (2%), e-Tool LCD (1%), Embodied Carbon in Construction Calculator (EC3) (1%), Sefaira (1%), Building Carbon Calculator – Naylor Love (1%), IES-VE (Integrated Environmental Solutions) (1%), Flixo (1%), AccuRate NZ (1%), Sunrel (0.4%), Open Studio (0.4%), Tally (0%), Green Building Studio (0%), GaBi software (0%) and SimaPro (0%).
- ***Other responses:*** (15 comments) The free-text responses to this question were ArchiCAD (2), sun or thermal tools (2), Homestar (2), Eco Design Star (1), Sketchup (1), not applicable (1), BREEAM (1), Camel (1), Window (LBNL), BRANZ H1 calculator (1), Tas by EDSL (1) and "Natural design and build to environment considerations" (1).

Respondents were asked: Are there any tools not on the list you think we should include or be aware of? (please write) (17 answers)

- A moderate number of respondents shared other tools missing from the list. These included various building standards and measuring tools such as Homestar, Eco Design Star, LEED, NABERS and Green star.
- Other tools/programmes raised were ArchiCad (energy modelling, in-built environmental modelling, energy evaluation), Suncalc and LindQST. A respondent commented: "Firth industries have a carbon calculator for concrete EC3. Missing from the list is the ISCA tool which is used for a lot of infrastructure projects."
- Other comments made included "Gib bracing", "Trace" and a suggestion to look at the BRE website.
- One final comment noted tools need to be simpler, easier and accessible to all.

Rating of skills using digital tools

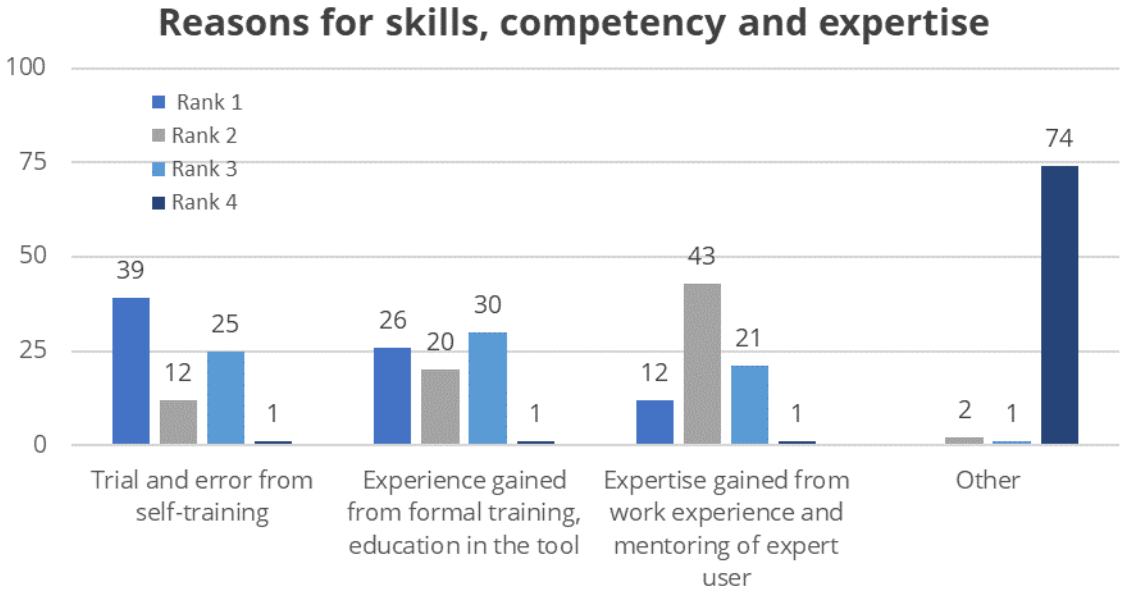
Respondents were asked: How would you rate your personal skills, competency and expertise in using these digital tools? (84 answers)



- A small number of respondents rated their skills, competency and expertise as expert (7%) or experienced (15%).
- The most common response to this question was proficient (39%), closely followed by beginner (38%).
- Overall, the results present a workforce with a low level of self-reports skills, competency and expertise. It is not possible to gauge from these results if this reflects the levels across the whole sector because of the low sample size, but results show a workforce that is reluctant to state they score highly in this area.

Ranking of reasons for skills and expertise

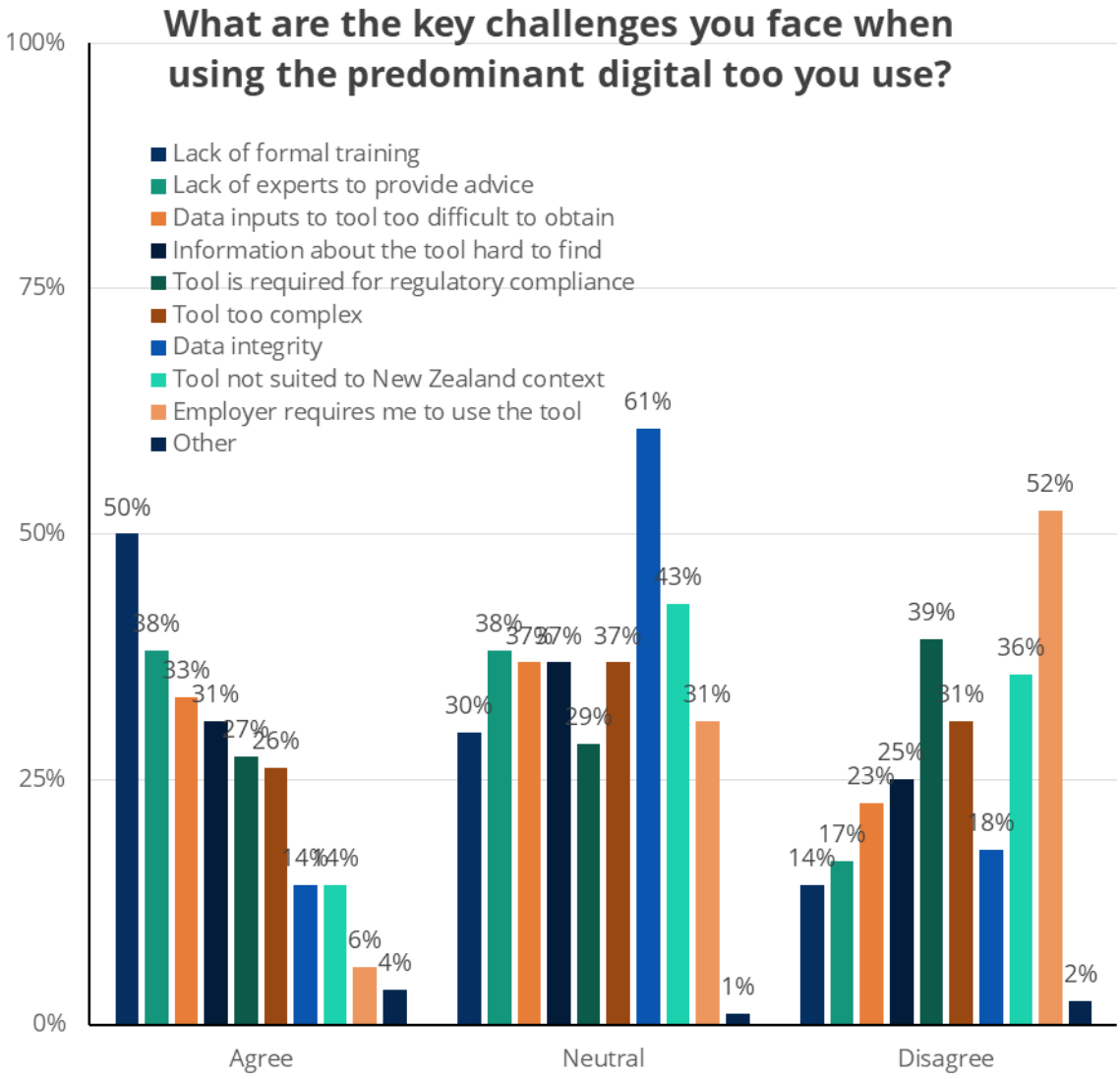
Respondents were asked: Rank the reasons for your skills, competency and expertise that reflects your experience (from 1 to 4). (77 answers)



- Of the three options given, the most frequently ranked 1 was trial and error from self-training (39 times) – over half of the respondents who answered this question.
- Experience gained from formal training, education in the tool was second most frequently ranked 1 (26 times).
- Expertise gained from work experience and mentoring of expert users was least frequently ranked 1 out of the three options given (12 times).
- Again the sample size means these results can only be interpreted as indicative for the wider industry but they suggest there is significant opportunity for development in this area, in particular formal training.
- ***Other responses:*** (11 comments) Several respondents selected 'other' and wrote responses in a free-text box. These included real-life experience/trial and error (4), online webinars (1), use of natural considerations to environment elements (1) and CPD (1). Another respondent commented: "None at this point. As an AutoDesk Revit long time user and seat holder I have access to some simple energy modelling tools however, the digital building model, has a number of errors in the connectedness area that return a range of unexpected results, as a direct result of the integrity of the 3D model, therefore, the AutoDesk subscription benefits for the seat holder are very dubious. On this basis although untried as yet, I wonder what or if any of these issues are going to also be the outcome when using any or all of the packages you show here. Also, whereas in the past in the early days of Design Navigator, now Sefaira is very expensive for what it is and I would not attempt to become engaged with that product if I was not a heavy commercial user."

Key challenges

Respondents were asked: What are the key challenges you face when using the predominant digital tool you use? (84 answers) (Respondents who did not select a response for each key challenge are not reported on the chart (most commonly 7% of respondents), which is why percentages don't add to 100% for each.)

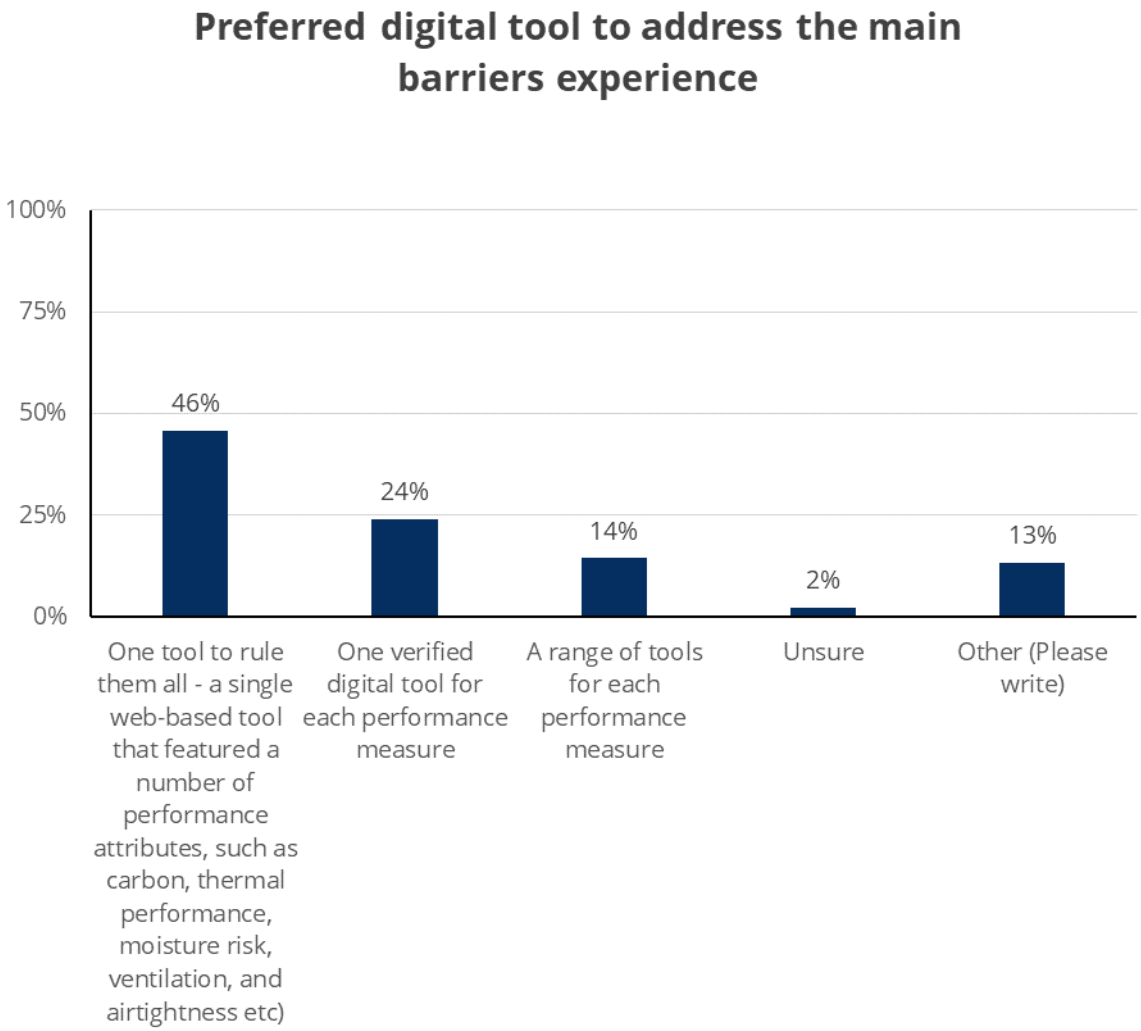


- The findings again suggest the industry is at an early stage of its adoption of digital tools. The issue that the highest number respondents agreed was a key challenge when using their predominant digital tool was lack of formal training (50%).
- The factors that were key challenges for at least 25% of respondents also predominantly reflected limited knowledge or understanding of tools: lack of experts to provide advice (38%), information about the tool too hard to find (31%) and tool to complex (26%).
- ***Other responses:*** (5 comments) Respondents who selected 'other' and wrote free-text responses to this question reported having issues with various elements of the tools they use. Two respondents cited time constraints and a busy workload as a challenge, with one noting that undertaking analysis is time consuming. One of these respondents also commented: "Information is not required usually by BCAs so modelling is not done and it keeps fees acceptable." Another respondent who uses AFL "because the inclusion of window gains results in a lower cost thermal

insulation solution for a client wanting to spend the minimum on achieving Homestar" noted that the software is clunky and inefficient to use. Other responses included a lack of awareness of a tool that does everything including carbon footprint and "low requirements from clients".

Imagining a tool that could address the main barriers

Respondents were asked: If you could imagine a digital tool that could assist you and address the main barriers you experience, what would this digital tool look like? (83 answers)

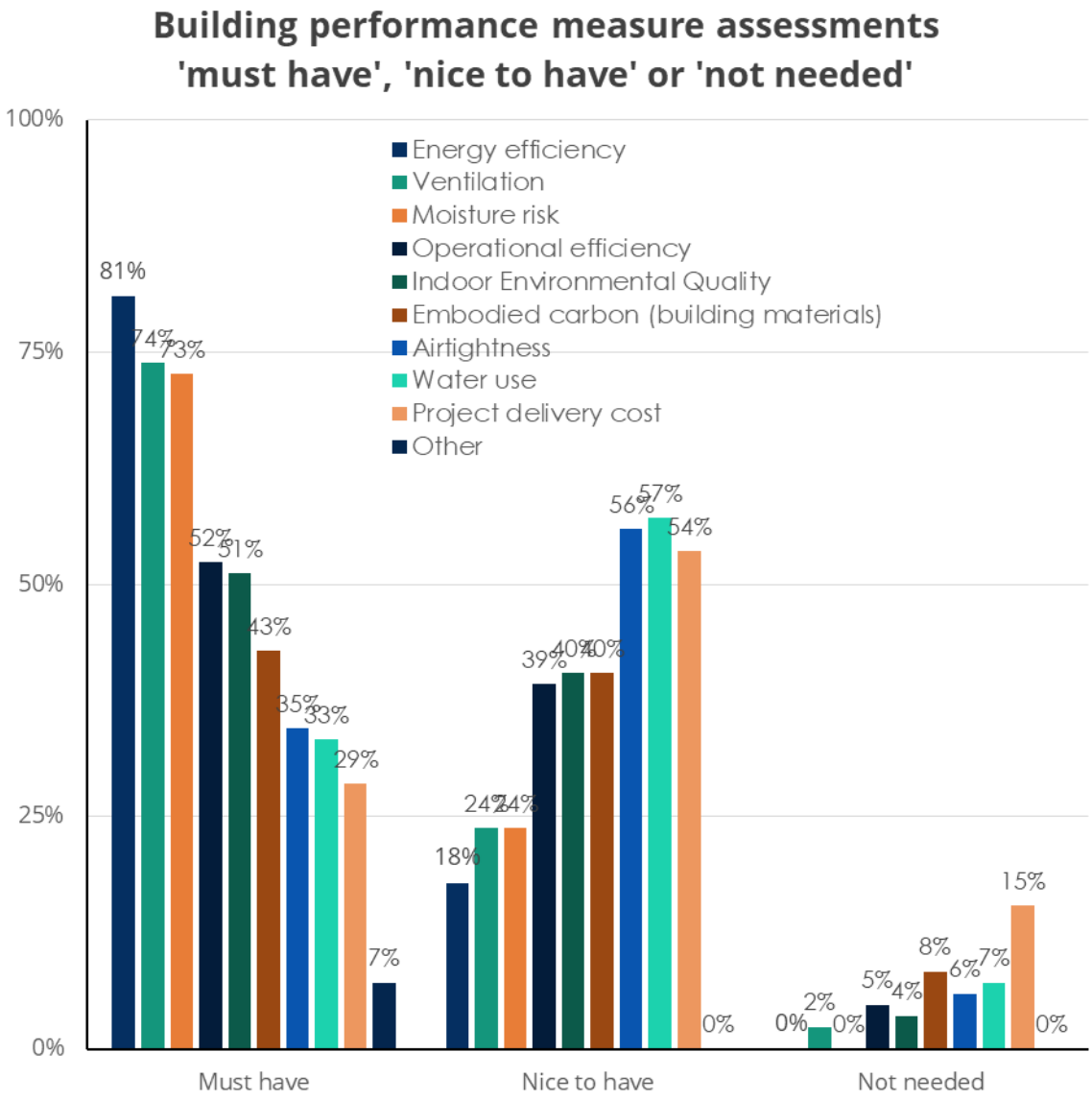


- Almost half of respondents (46%) imagined a single web-based tool that features a number of performance attributes.
- The second most popular option selected by just under a quarter of respondents was one verified digital tool for each performance measure.
- ***Other responses:*** (11 comments) Around a third of respondents who provided 'other' written responses to this question discussed PHPP (Passive House Planning Package). These comments noted that PPHP is a good tool that "does it all" and suggested it could be automatically linked to other programmes such as ArchiCAD. A few respondents also noted that improving links between various programs and tools may be better than having a single tool – especially if accuracy is compromised as a result of trying to create "one tool to rule them all". One respondent commented: "These metrics are typically assessed by separate people

– e.g., mechanical engineer assesses thermal performance, but is not usually engaged to look at the performance of airtightness. This means One tool to rule them all is unlikely to be of significant benefit. However, a suite of tools that [are] similar in appearance would be good." A couple of other comments about usability noted that the ideal tool would be "open source and easily changeable" and that "tools need more options available". Two other respondents commented: "Barriers are not in the tool but declaration of performance data required of suppliers/manufacturers." "Work to improve Homestar and Homefit would be much more valuable than introducing yet another tool, consumer awareness is critical for residential tool to be useful."

'Must have' performance measures

Respondents were asked: What building performance measures do you consider 'must have', 'nice to have' or 'not needed'? (84 answers)

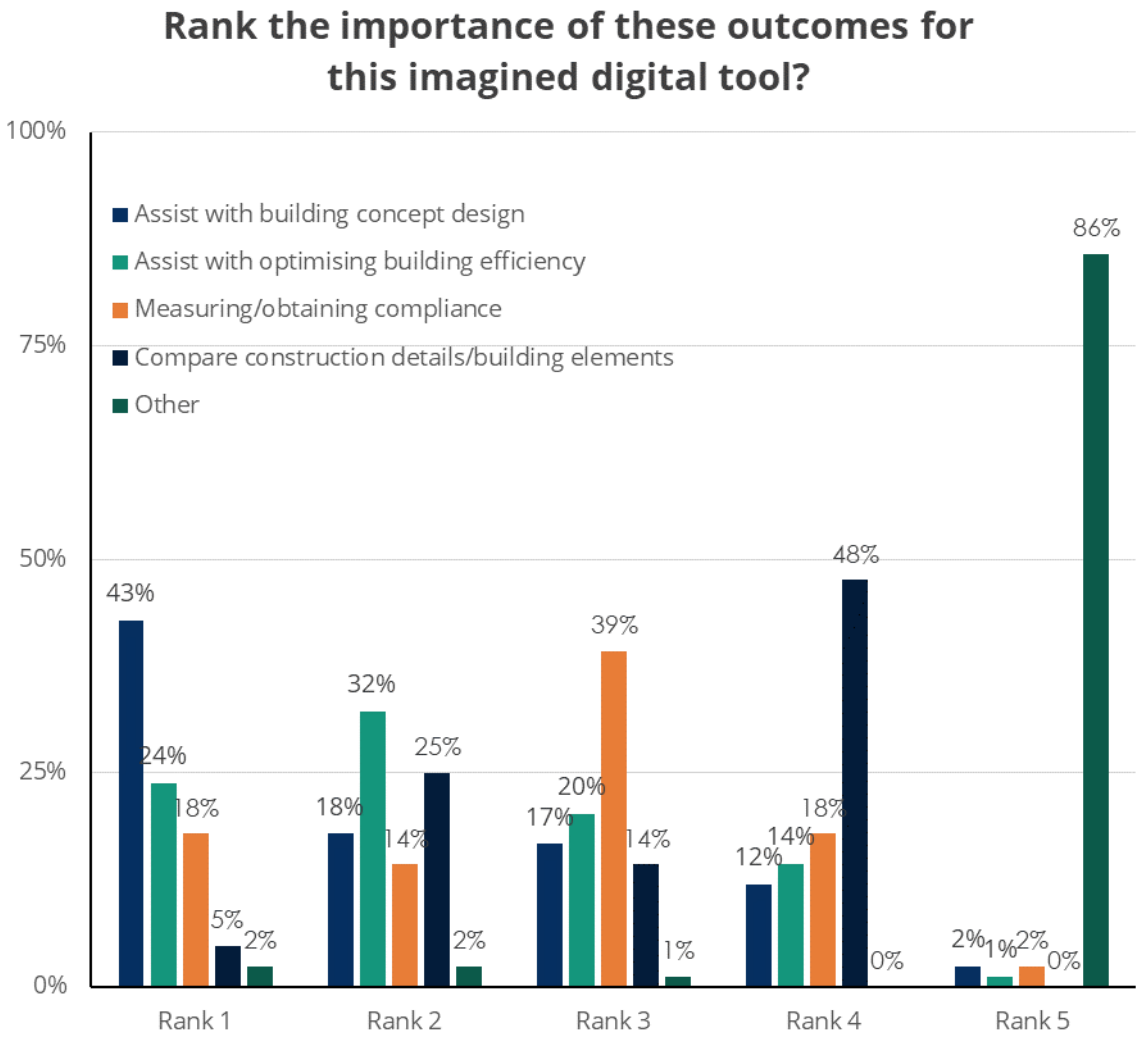


- Energy efficiency was the performance measure most frequently considered a 'must have' (81%).
- Around three-quarters of respondents also viewed ventilation (74%) and moisture risk (74%) as 'must have' performance measures.

- Over half of respondents considered operational efficiency and indoor environmental quality as 'must haves'.
- Project delivery cost was the performance measure most frequently considered as not needed (16%).
- ***Other responses:*** (9 comments) Several respondents selected 'other' performance measures as 'must have' items. These were specified in a free-text box. These responses were thermal performance, including bridging, R-value, thermal mass and efficient use of sunlight (4), carbon emissions, including end-of-life carbon emissions data, and a way to evaluate the implied cost of avoiding CO_2 release (2), moisture content of timber framing (1), sustainability enhancements like rainwater harvesting and waste management (1), comfort (1) and community and avoiding urban sprawl (1).

Outcomes for imagined digital tool

Respondents were asked: Rank the importance of these outcomes for this imagined digital tool? (from 1 to 5) (77 answers)

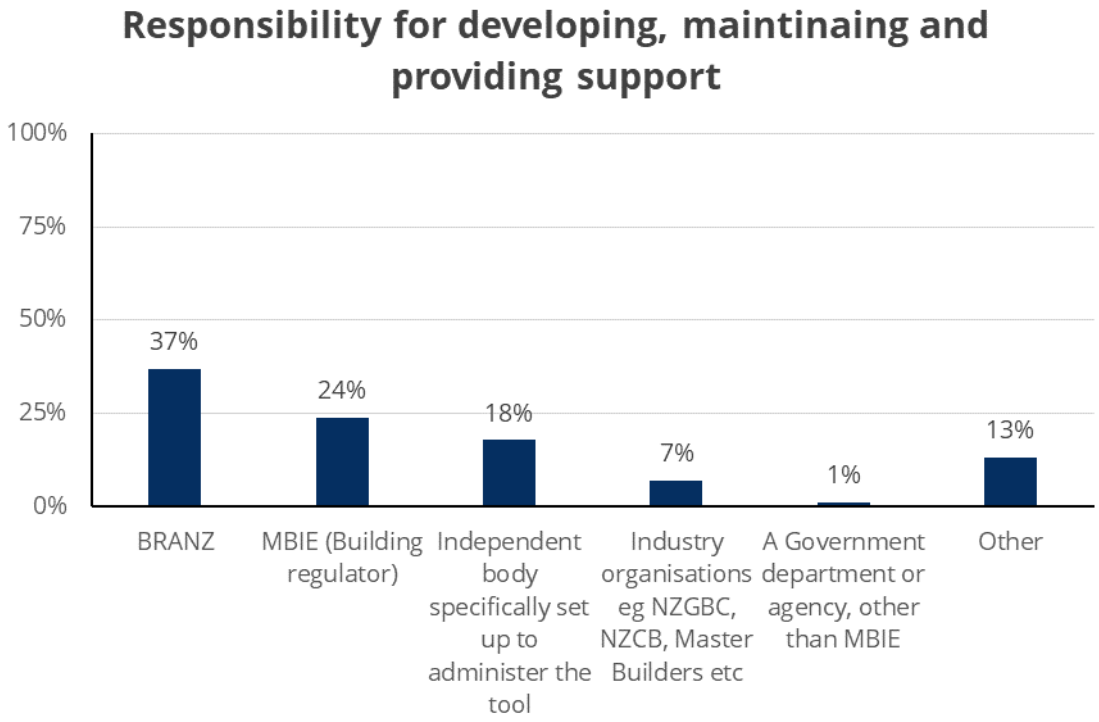


- The outcome most commonly ranked 1 (high) was assist with building concept design (43%).
- The outcome most commonly ranked 5 (low) was compare construction details/building elements (48%).

- ***Other responses:*** (9 comments) Responses in the 'other' free-text box included issues with the ranking function (2), reducing whole-of-life carbon emissions (1), embodied carbon operational relationships (1), comparing costs of options and economic modelling (1), publishable measures – limited number (1), marketing advantage (1), a score for both individual areas and overall (1), and utilising natural environmental elements (1).

Who should be responsible

Respondents were asked: When thinking about the imagined digital tool, who should be responsible for developing, maintaining and providing support for the use of the tool? (84 answers)



- The majority of respondents (79%) wanted an independent organisation such as BRANZ (37%), MBIE (24%) or an independent body created for the purpose of this tool (18%) to be responsible for developing, maintaining and providing support for the use of the tool. It is difficult to know if the sample frame (the cohort of respondents) influenced this result.
- ***Other responses:*** (11 comments) Several other suggestions were made by respondents in the free-text box, with some of these accompanied by an explanation. These included Passive House Institute (2), an independent body (2) (with one respondent specifying that organisations like NZGBC would not be appropriate as they advocate for a specific building style) and that the responsible entity should be selected based on their competency (2). One of these comments elaborated: "Need someone who is interested in keeping it simple. Most programmes are set up by people who have no bloody idea of the industry. The designer of the system must be able to relate to how the industry needs the outcome otherwise it is too bloody hard and no one uses it." Other suggestions with only one comment each included MBIE (felt to be most appropriate if the tool is to be used for compliance), the private sector (due to perceived heightened efficiency and cost-effectiveness), specific industries collaborating with government providing the framework (as industries can be more flexible and quicker and that,

as multiple tools will likely be needed, there must be multiple developers), all of the above (without broad involvement this will merely be "yet another tool to add to this list") and the Design Association of New Zealand.

Important things to consider

Respondents were asked: What do you think is important to consider in the development of a digital building performance evaluation tool for New Zealand? You may want to consider the following concerns or feel free to discuss other topics:

- The key attributes the digital tool would need in your area of design or construction.
- The underlying data needed to support the tool.
- The format the data should be in.
- Attributes that the digital tool would need to be 'trustworthy' for industry.
- Factors necessary for online tool usability – computer based vs mobile compatible.
- The ability to submit new data or update data.
- Training, support or advice for using the tool.

A free-text response box was provided for respondents to write their answers.

Usability factors (65 comments)

Ease of use and interface (24)

- The majority of these comments emphasised that the tool must be easy to use. Respondents indicated this would entail having an accessible, user-friendly interface that allows simple data input and that produces clearly understandable results. One respondent offered a specific suggestion, stating: "The tool must be easy to use. Input of data must be simple to do. The tool should allow photos to be embedded easily. Photos should sit with relevant comments/information."
- A few respondents highlighted that this ease of use should not be contingent on extensive technical knowledge or extra time and training, while another noted top-level ontology should be used. "The system has to be simple. If a 50 year old builder or designer cannot understand the outcome you have it wrong […] It has to be a system that all can use and produces results that all can understand."
- Other suggestions included that the tool must be quick and efficient and allow users to compare different products and construction systems. A few comments specified how the tool should be integrated into workflows to optimise the design process: "It could be a stepped process where the input of 3D data based on orientation, exposure and construction, using defined construction systems, should give a general thermal performance and a cost efficiency rating whenever prompted to during the design process." "The ability to quickly analyse what-if scenarios early on is fundamental." "Documented workflows."
- One respondent argued that making it too simple would negate its usefulness, stating: "Please do not mandate the use of the tools – usually tools get built to be usable by laypeople meaning that they are bad for professionals – ALF and the healthy homes tool are examples of tools that are bad for iterative processes."

Data input and quality (14)

- The importance of ensuring that quality data can be input easily was discussed in several comments. Five of these highlighted the accuracy of the data itself as vital, noting the tool must be able to accurately predict emissions and performance and that data needs to be standardised in consistent units and from a common source.

Two comments focused on the need for accurate data regarding local materials and suggested how manufacturers could provide this: "What we need is better information about the performance of locally supplied materials and building elements, e.g. getting reliable thermal conductivity data with three decimals is difficult, getting U-values for glazing and frames with sufficient accuracy is difficult." "Format for the data – consistency of units and availability of data. A standard for this would assist manufacturers to provide data."

- Respondents also stipulated that provision must be made for custom or unusual materials: "Option for input for different combinations of materials – i.e. yes it is great to have a drop down list of common materials & structures, but also need to be able to input custom materials and combinations."
- A few comments noted that the tool needed to be integrated with other tools (such as BIM modelling and ArchiCAD) to ensure that data and models in multiple formats could be input with ease. "The evaluation tool should be able to be incorporated into the design tool, Archicad or Autocad, and /or other." "It is definitely crucial to be able to input data in more than 1 type of format to account for the various and many exported data flows from the primary AEC product suppliers – AutoDesk Revit, AutoDesk AutoCAD, Graphisoft ArchCAD, AutoDesk Civil, VectorWorks and so forth that are most commonly used by most of the professional and semi-professional designers, and related stakeholders in the wider design and construction industry in NZ."
- Additionally, a couple of respondents simply reiterated one of the suggested topics given in the question: "The ability to submit new data or update data."

Training and support (14)

- Several respondents underscored the importance of effective training and having expert support available. While the majority of these comments were not detailed, when they elaborated on platforms for this training, a couple of people suggested that online webinars and tutorials should be available (at low cost) or that peer support or user groups where people can ask questions would be necessary. One respondent discussed the problems with lack of data and support in current tools: "I work in a small architect's practice and DesignPH/PHPP are the best available energy tools applicable (can be used around the world) and PHRibbon which is a plug-in for PHPP, a British tool which was very easy to adjust to NZ. Training is the key issue for DesignPH/PHPP in NZ as the Passive House qualification does not include tool training, and for PHRibbon the key issue is lack of data and user group or similar to ask a peer a question or progress your own learning with the tool."
- Another pointed out that some people may not be receptive to new tools: "Training new ideas takes time for older designers to accept."

Affordable and viable for small business (6)

- Ensuring the tool is affordable (low cost or free) and not too time-consuming to use was raised by a small number of respondents. They emphasised that this is particularly vital for small businesses and projects where costs are tighter and profits are generally lower, arguing that expensive tools can become just another way to "drive us out of the market". A couple of comments noted concerns around tools that require a range of specialists or specialist knowledge that is only accessible for larger companies. "Most houses and low-rise townhouses will be designed by small firms who are low cost and low profit. They cannot afford expensive systems. Bigger projects, say low-rise multi adjoining units or apartment buildings, can usually afford the employment of specialist consultants to ensure

thermal, etc standards are reached. But most housing at the moment is still single family standalone housing and the cost must not become prohibitive if all of this work is not to be done only by large multi-consultant building companies." "If all industry had to use a combination of tools that are specialist in their application I do not feel that would be workable for the majority of smaller building projects in terms of trained users and cost to develop and test a design."

Open source and adaptable (5)

- Comments emphasised the importance of being able to continue updating and developing the tool in response to feedback. Respondents suggested the tool needed to be open source and open API and adaptable, with people actively working on recommendations as to how to improve it. One proposed that designing the tool should be an open project with a paid project lead. Another respondent stated: "The tool needs to be constantly under development, i.e. if you have a fixed budget for a project you have already failed, it needs an annual budget. It needs a feedback loop, an ongoing measure of predicted vs actual results being used to constantly improve it."

Computer based (2)

- Two comments noted the tool should be computer based, with one elaborating that the complexity of the tool would require computer rather than mobile: "The challenges and targets are becoming increasingly complex and integrated and a digital tool will be the only way to really assess and enable optimisation of the parameters."

Performance requirements (41 comments)

Suitable for different contexts (11)

- Several respondents pointed out the need for the tool to be flexible enough to be applicable across a range of different contexts and situations. This flexibility encompassed being suitable for both small and large projects, different requirements, residential and commercial builds, rural and urban properties, multi-unit developments as well as stand-alone houses and application across varying construction methods. "I think it's important to retain simple tools for small projects and basic builds so as to avoid blowing out the costs of such projects. The calculation method could be tweaked to allow for more stringent requirements even if its scope of use were restricted." "Providing calculation methods for multi-unit developments (not just stand alone houses) and how this building typology can help with achieving greater/mutually beneficial results."
- A few comments also noted that it needed to be location specific, including material availability, encouraging local products and aligning with localised environment measures.
- Finally, one emphasised that the tool would need the flexibility to cater to different audiences, noting: "Consumers and real estate agents need to be able to compare choices simply, professionals need to be able to dig deeper."

Robust, comprehensive and up to date (9)

- Several respondents discussed the tool's overall reliability and robustness, including keeping the tool up to date. The need for it to be comprehensive and cover all key areas of performance was raised in a few comments, with one elaborating: "I have

seen so many tools that can be cheated. The mechanical engineer may think they have a good model but they don't see the architect thermal bridging etc. The tool needs to be robust, based on international standards, and cover all the bases. We so often miss airtightness etc."

- A few other comments merely repeated two of the topics suggested in the question: "Attributes that the digital tool would need to be 'trustworthy' for industry." "The key attributes the digital tool would need in your area of design or construction."

Factors to include (9)

- Several comments were made describing measures and factors that should be included. Respondents who focused on sustainability noted the tool should encourage local products and recyclable materials, include recognised attributes to reduced carbon footprint and energy efficiencies and consider CO_2 in relation to whole of life and end of life. A couple of respondents emphasised that the tool must incorporate economic evaluation, including product building availability and relative cost of energy-efficient materials. One elaborated: "The biggest issue with housing today is affordability. The tool must include economic evaluation. It should encourage alignment of structures to gain the maximum possible from the sun. It should allow rational decisions about increasing insulation, or swapping out materials to save CO_2 (i.e. implied cost of avoiding CO_2)."
- Other factors included being clear about the scope and limitations of the tool, going beyond current standards to future-proof against climate change in all regions in New Zealand and, lastly, the importance of independence and ensuring the tool does not unfairly favour particular sectors of the industry: "Not allowing a monopoly to develop, or that a single body, unduly influenced by private companies, should push certain materials or systems."

Universally understood and accepted outputs (8)

- The need for the tool to be accepted across the board if it is to be effective was raised. This was specified as being accepted by all government bodies, councils and regulatory authorities as well as having wide public awareness. For this broad use, a couple of respondents pointed out, the output needs to be understandable for all stakeholders. Respondents also noted the tool must be aligned with all compliance requirements and standards and that it should be based on international standards. "I think the output should have a single measure (like stars) and a summary of the key measures, like the nutritional info on the side of the box. Consumers and real estate agents need to be able to compare choices simply, professionals need to be able to dig deeper." "There is at present controversy over the Healthy Homes Standard, which should have been avoided by proper alignment of the Standard with other assessment methods and established norms. The tool you suggest has potential to resolve such an issue."

Mandatory use and compliance (4)

- Of the comments addressing mandatory use, two were in support while two raised concerns. Those who supported mandatory use suggested that this was necessary to ensure new dwellings align with carbon-neutral New Zealand, while another argued that publishing results of the tool or submitting them for building consent should be mandatory. One respondent warned against mandatory use, doubting that a tool could be suitable for both a layperson and a professional, while another stated: "Ensure various routes to compliance, not prescribed methods only"

Existing tools (10 comments)

- Several respondents discussed using or modifying existing tools, noting that there are a range of well-performing tools already in New Zealand and internationally (PHPP, Tally, EC3) and there is no need to reinvent the wheel. One respondent suggested that it was a "no-brainer" that Passive House should deliver the tool. "The Passive House standard is already an energy efficiency standard that has been adopted around the world. Why reinvent the wheel? There is so much independent research that shows it delivers what it says and takes into account the minimum number of variables to achieve performance that is undeniable. I have been using this tool for 11 years and completed more than 130 projects in NZ." "Building performance modelling is a complex area with so many related variables. On the other hand there are already real world verified ways that have demonstrated that a design tool does not need to be overly complex to deliver an outcome. The modification of existing tools, like the PHPP, to suit would be a great way to start." "See what is used around the world, New Zealand doesn't have to reinvent the wheel here. Look what NZGBC are doing with Homestar Version 5, laying a 'skin' over PHPP etc."
- A couple of comments mentioned flaws with existing tools, noting that LCAQuick and other BRANZ tools are "not quick" and that the ALF and the Healthy Homes tool are bad for iterative processes.

All of the above (9)

Several responses simply noted that all of the above were important.

Any other questions or comments

Respondents were asked: Do you have any question or comments that have not already been addressed? (please write)

A free-text response box was provided for respondents to write their answers.

Scope and requirements (4 comments)

- Respondents raised a variety of elements they felt should be considered, including encompassing Ministry of Education DQLS requirements for acoustics and lighting along with thermal, ventilation and internal air quality and a suggestion for minimum insulation requirements (roof R5, walls R3.2, floor R3). Others discussed carbon modelling and a need for standardised outputs, targets and benchmarking. "Scope and boundaries are fundamental for carbon modelling in particular, given the work by LETI, RIBA and RICS in the UK any scope defined for use in NZ needs to compare to these being the best available." "Already have the tools we need, ie DesignPH/PHPP and PHRibbon (and many others you've listed), it's not the lack of tools, we lack a standard set of output details, like an EPC (UK) for carbon and for that matter energy efficiency, plus targets or benchmarks against which we can compare outputs along the lines of RIBA 2030 Challenge and LETI."

Usability (3 comments)

- Two respondents reiterated the importance of the tool being user-friendly to encourage widespread adoption. One commented: "Whatever the outcome it has to be simple to use and understand. Must have it that you can load data one and it will do the whole project, but changeable for say one wall where it may have different cladding or construction is quite different from the rest."

- Another comment emphasised that flexibility was key, suggesting multiple tools that worked together on a cloud-based platform.

Importance of developing the tool (3 comments)

- Three respondents indicated that such a tool would be useful and they were pleased BRANZ was taking it up. One respondent noted they were happy to help as it was "important to get it right". Another respondent offered a more detailed comment: "A simple analysis tool would be welcome. The higher the standards for ordinary buildings the greater the overall improvement you will get nationally and for climate change. Hence I would support Higher Building Consent standards and if such a tool was developed by MBIE would need to be kept up to date. BRANZ would be my next choice for this tool development as they will be able to do it quicker and be more responsive."

Other (6 comments)

- Comments in 'other' included one statement that eHaus was present in all of these regions except the West Coast, one comment that simply said "no" and one that highlighted other areas where processes could be streamlined: "Too much focus is placed on build industry added complication and additional cost, the need for and use of consultants, regulation interpretation, when there are simple applications that would more easily accessible. Just because we change to more focus on carbon footprint reduction and energy efficiencies does not need to include greater cost. There are many simple areas we should address first for example, why do four separate entities get paid for a new house connection to electricity?"
- A few respondents suggested more open-ended comment opportunities throughout the survey.

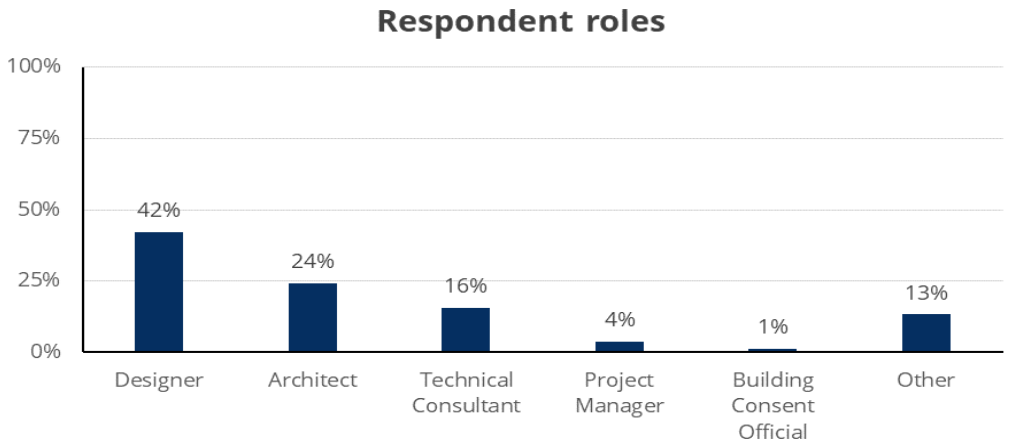
2.4 Respondent characteristics

Role

Respondents were asked: What is your role? (respondents could select one option) (83 answers)

- 42% selected Designer (35 respondents).
- 24% selected Architect (20 respondents).
- 16% selected Technical Consultant (13 respondents).
- 4% selected Project Manager' (3 respondents).
- 1% selected Building Consent Official (1 respondent).
- 13% selected 'other' (11 respondents).

'Other' responses given in the free-text box included Structural Engineer (1), Structural Engineer also responsible for carbon calculations and B2 durability (1), Engineer (1), Architectural Technician/BIM Manager (1), Construction Educator (1), Educator (1), multiple roles (1), Certified Passive House Designer (1), Development Manager (1), Building Services Consultant (1) and Building Surveyor (1).

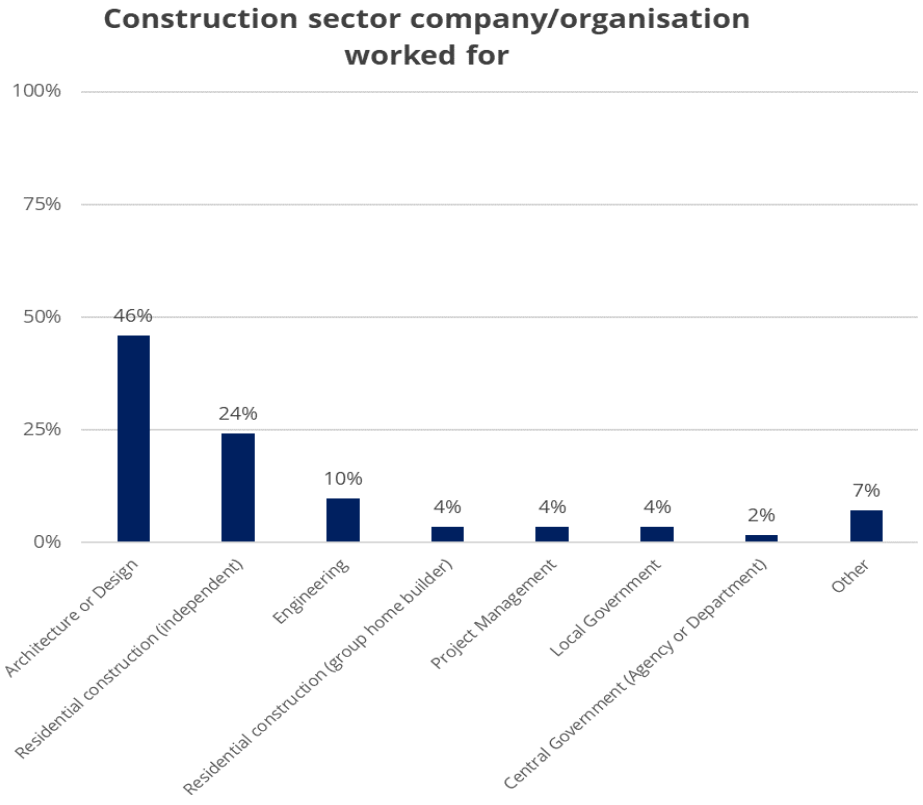


- The most common role amongst respondents was Designer (42%).
- Around a quarter of respondents selected Architect (24%).
- Technical Consultant was the third most common role among respondents (16%).

Organisation type

Respondents were asked: What type of construction sector company/organisation do you work for? (84 answers)

- 46% selected architecture or design (51 respondents).
- 24% selected residential construction (independent) (27 respondents).
- 10% selected engineering (11 respondents).
- 4% selected residential construction (group home builder) (4 respondents).
- 4% selected project management (4 respondents).
- 4% selected local government (4 respondents).
- 2% selected central government (agency or department) (2 respondents).
- 7% selected 'other' (8 respondents).

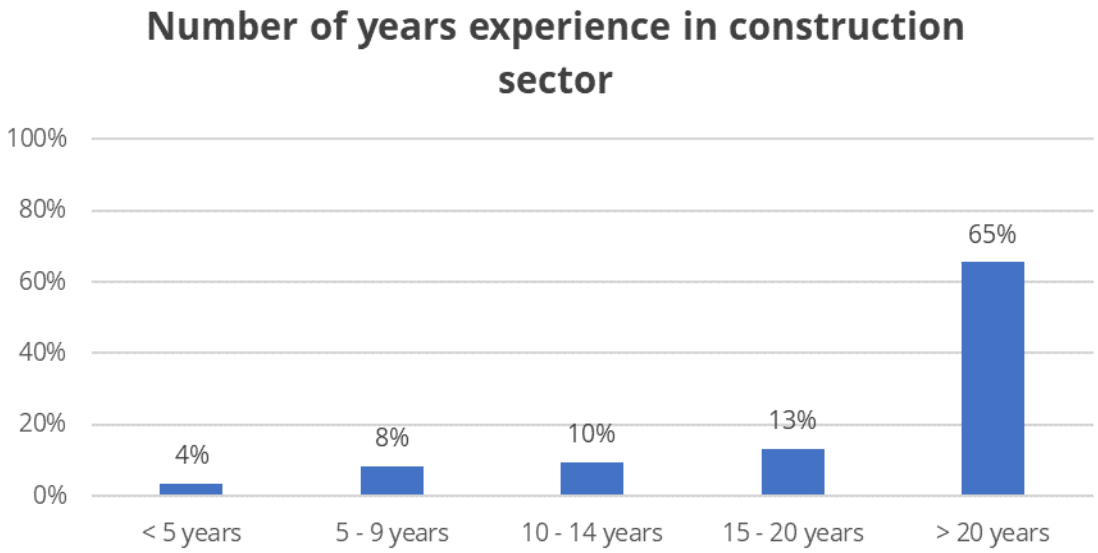


- Architecture or design was the most commonly selected sector (46%).
- Around a quarter of respondents selected independent residential construction (24%).
- Engineering was the third most frequently selected sector (10%).

Experience

Respondents were asked: How many years' experience do you have within the construction sector? (84 answers)

- 65% had over 20 years' experience in the construction sector (55 respondents).
- 13% had 15–20 years' experience in the construction sector (11 respondents).
- 10% had 10–14 years' experience in the construction sector (8 respondents).
- 8% had 5–9 years' experience in the construction sector (7 respondents).
- 4% had less than 5 years' experience in the construction sector (3 respondents).

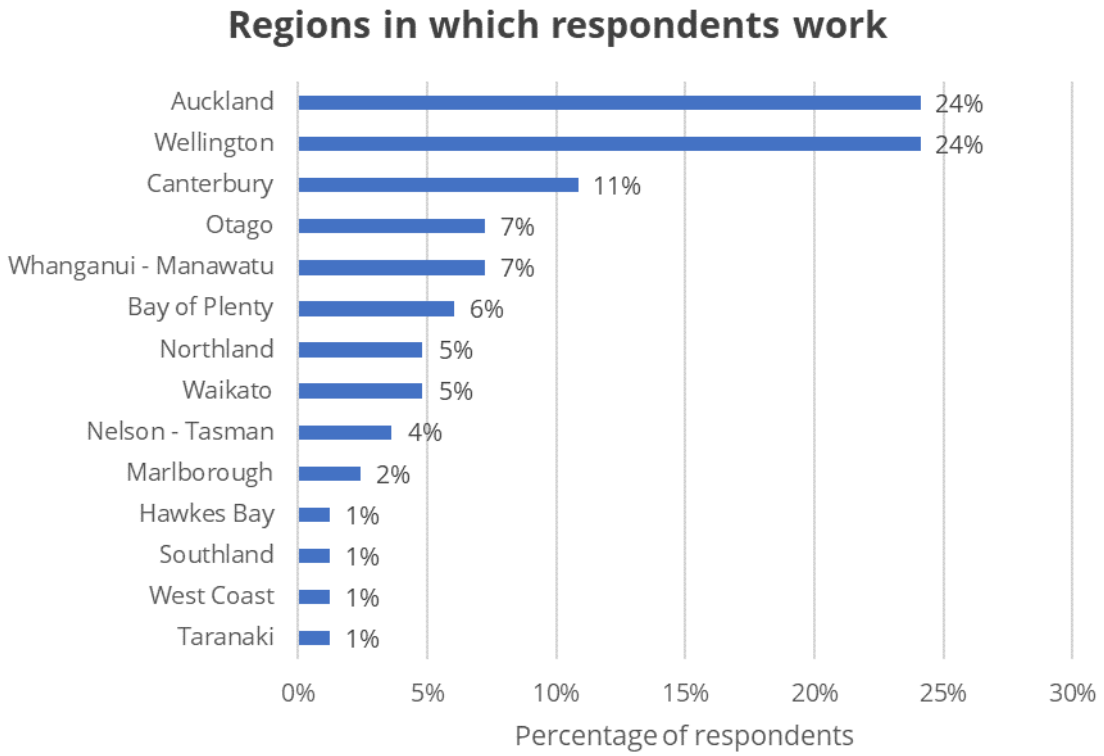


- The majority of respondents had over 20 years' experience in the construction sector (65%).
- A further 23% of respondents had at least 10 years' experience in the construction sector.

Region

Respondents were asked: In what region do you work? (83 answers)

- 24% work in Wellington or Auckland (20 respondents).
- 11% work in Canterbury (9 respondents).
- 7% work in Otago or Whanganui-Manawatu (6 respondents).
- 6% work in Bay of Plenty (5 respondents).
- 5% work in Northland or Waikato (4 respondents).
- 4% work in Nelson-Tasman (3 respondents).
- 2% work in Marlborough (2 respondents).
- 1% work in Hawke's Bay, Southland, West Coast or Taranaki (1 respondent).



- The regions that most respondents work in are Auckland and Wellington (24% respectively.
- Canterbury was the next most commonly selected region, with 11% of respondents working there.
- All other regions had fewer than 10% of respondents working there.

3. Stakeholder workshops

Following the online survey, the next stage of the project involved holding a series of stakeholder workshops to gain a deeper understanding of the results of the survey by testing the findings and exploring particular areas more deeply.

3.1 MBIE Building System Performance workshop

An in-person workshop was held with nine MBIE Building System Performance staff. These questions were discussed, and the responses follow below:

- Indication of MBIE's thinking about what's coming down the line over the next few years so we can engage in discussions and know what to prepare for.
- How do we want to be evaluating building performance in the future?
- Over what timeframe might this be staged and what might this look like?
- What is in scope – thermal performance, energy efficiency, embodied carbon, operational carbon, moisture risk, IEQ (ventilation rates, heating/cooling), other?
- What underlying data will be needed to underpin such a system and in what format?
- What do we see as the key attributes necessary in building performance evaluation to provide rigour, robustness and consistency and consenting/compliance verifiability?
- What criteria and metrics will we be using – per m^2, per m^3, per occupant? How do we avoid perverse outcomes?
- Do we want one tool/system or are several tools/systems acceptable?
- If several tools/systems, how do we ensure they are interoperable and fit with existing design workflows?
- How would the needs of government agencies be serviced by such a system?
- Are these tools public or just for industry?

General comments

- MBIE confirmed that it is also looking at a systems approach.
- The focus of the roadmap project is on new builds but there is also a need to measure the performance of alterations to existing building stock and repurposing of buildings
- This is a challenge – we need to transform the sector with respect to meeting carbon emissions caps but it will be painful for many. Is there room for incentivisation in order to change behaviour?
- We need to facilitate people's learning and take things step by step.
- We also need to recognise that we are designing and building houses for people, so houses have to meet their needs.
- There is also an issue of supply – MBIE can't mandate something that can't be built.
- It would be helpful to look at the learnings from overseas.
- MBIE's role is to provide pathways to compliance, but information and pathways also need to be provided for how designs can be improved and go beyond Code minimum.
- A question was raised about industry good versus BRANZ commercial gain. It was confirmed that the rationale for the roadmap project is industry good, not commercial advantage.

Methodologies and emissions caps

MBIE is conscious that the sector is looking for answers and for a methodology to measure carbon emissions (embodied and operational) and for the caps on emissions. There will be a series of emissions caps that vary over a period of time.

MBIE is working on methodologies for measuring embodied and operational carbon so there is one source of information for consenting purposes that is consistent across all BCAs. These methodologies can then be turned into tools and be supported by targeted interventions.

The methodologies need to be developed before the emissions caps can be set. The methodologies should be developed by the end of 2021. The emissions caps will then be set but the timeframe is yet to be decided.

A paper is to be submitted to Cabinet in 2022 about BfCC proposals as a whole. This will include emissions caps and timing. Carbon footprints for consent will be required in order to build up the data to robustly set embodied carbon emissions caps.

Tools

The BfCC framework states there will be a small buildings carbon calculation tool for buildings less than 300 m². MBIE will not necessarily be providing this tool but could reference the use of one or a number of tools produced by others to use as an Acceptable Solution.

Larger buildings will have their own performance-based tools so the methodologies that MBIE is developing are important. People could possibly develop their own tools as long as they use the same methodology.

The approach is that the small buildings tool might be an Acceptable Solution and the methodology might be a Verification Method. Testing of the tools to achieve expected carbon footprint results would provide the Verification Method for the tools that claim to use the methodology.

Tools for consent need to be freely available and easy to understand for a wide range of people.

There needs to be integrity around the way tools are used in order to avoid perverse outcomes.

The question was raised of whether there should be an accreditation system for tools.

Building is a system – how do these things work together to create a warm, dry, healthy low-carbon house? Improvements to reduce carbon have impacts on other areas. Some performance evaluations are based on rules of thumb and simple tables. Other related compliance pathways need updating and need to be more sophisticated.

New Zealand is a small market. We can't expect complex standards to be developed into simple tools by industry. Tools exist overseas so the solution is potentially not to reinvent these tools but to adapt them for New Zealand.

The assumption is that these tools are used at design stage, but in reality, changes are made part-way through construction. We need a consistent tool based on a common database. This database needs to be readily available at all stages – design, consent, construction and compliance – and relevant for and usable by all professions.

Users

Many people in the industry do not have the skills to use the current evaluation tools, and they are used mainly by experts and consultants. We need an equitable transition to low carbon. Is it possible for LBPs to use these tools? Some tools simplify things (such as the BRANZ *House insulation guide*) while others make them more complicated.

We need an audit of what is currently available. It was noted that BRANZ is undertaking a research project that addresses this.

Some existing tools need user experience work. If they are endorsed by MBIE, they need to be easy to use so people within the expected scope of use can use the tool consistently and with the same results. A small buildings tool needs to be simple, easy to use and conservative.

Metrics

Embodied and operational carbon will be measured per m^2, but there is some debate as to what this includes – net or gross interior? What about multi-storey where elements are shared?

Data

The priority for tools is verified data that is relevant to New Zealand and is regularly added to and updated.

BRANZ has a significant role to play here. It has a dataset that underpins several BRANZ resources and others already in use in New Zealand or shortly to be available, including CO_2NSTRUCT, LCAQuick, PHINZ High Performance Construction Details Handbook and NZGBC Embodied Carbon Calculator tool. MBIE would like to know more about this dataset including the issues and gaps in the data.

BRANZ confirmed a pilot project is under way to better understand the costs and resourcing required to put all relevant BRANZ data into the cloud in order to make it accessible.

The question was raised that, if MBIE has a verifiable national dataset, does this sit with BRANZ as the 'custodian'? What are the cost and IP implications? And if data is freely available, what are the implications of people using it in commercial tools?

It was acknowledged that there is a tension between data needing to be up to date but the user not wanting the data to change part-way through a project. Data would need to be updated on at least an annual basis.

BRANZ noted that the Building Act is about sustainability and not just carbon emissions. We should therefore include data about other sustainability indicators in order to future proof it, even if it is not made public at this stage.

MBIE agreed that, although it is desirable for other sustainability indicators to be included in BRANZ data gathering and datasets, it does not want these to hold up the delivery of the carbon emissions work.

Building product information

Building product information will change things too as this is likely to include carbon information. What information will organisations such as EBOSS and MasterSpec hold? What will be the minimum product information? Who will be liable for data accuracy?

Plan and timeline

Parts of industry are interested in taking immediate action. MBIE agreed that it needs to publish a plan with dates as soon as possible to give clarity to the endpoint and to timeframes so industry can prepare and innovate.

Building Code updates

Changes are likely to be made via the Building Code update process. MBIE is envisaging lots of changes to Building Code clauses at regulatory level and Acceptable Solution/Verification Method level, both to support changes in the sector towards low-carbon construction but also to implement the regulatory changes proposed in the frameworks (i.e. emissions reporting and emissions caps).

The next Building Code update decision document will be released in early October. This will include, inter alia, decisions on the first round of updates to clause H1. The BfCC needs regulatory approvals and methodologies so this restricts the first updates to H1. This means that H1 updating will be an ongoing process.

3.2 Architects/designers workshops

Online workshops were held with 52 architects and designers over three locations. Workshop attendees were briefed on the Roadmap project and then put into breakout groups to discuss and respond to two key questions:

1. What if, in order to get a building consent, a design must have a carbon footprint and that carbon footprint must be below a certain limit. What issues do you see arising for a designer?
2. What features would you look for in a digital tool for evaluating building performance? What would make life easier for you?

General discussion occurred following feedback from the groups on each of the questions. The responses from each workshop follow below.

3.2.1 Greater Auckland/Hamilton architects/designers workshop

Question 1 key outcomes

- Need to "make a start" – warts and all, let's just get going. Carbon footprint tool might be a blunt instrument initially.
- Design on paper may not account for actual installation – i.e. precut frames incorporating more framing than expected
- Design rating vs built rating – how it's actually assembled can affect carbon footprint.
- How do we accurately measure materials and waste associated with materials and construction?
- How is product substitution during construction accounted for?
- Carbon associated with internationally supplied products – where is this accounted for (shipping/freight)?
- Costs associated with carbon assessment certification – potentially a specialist area.

- Requires a level of expertise for certification/assessment.
- Self-certification – lead designer to take responsibility?
- What about carbon figures for items outside the building envelope?
- Size of dwelling – there should be no disincentive for larger or smaller homes.
- Need to ensure social engineering issues are avoided – i.e., carbon based on number of occupants etc.
- Concern that we'll measure what's easy to measure rather than what counts. For example, getting good scores on some existing rating tools means nothing for the actual materials used.
- Weakness of tools is that a focus on carbon counting might result in trivial changes just to get under a certain score/number.
- Tools need to take account of how many people live in a dwelling.
- Designer still has to be able to work to client needs/requirements.
- Tools need to allow carbon to be measured/modelled early in the design process.
- Crude measures early can show relativity. Leave detailed measures until later.
- Need a custodian of carbon data for the industry – MBIE or BRANZ.

Question 2 key outcomes

- Ability for various tools/programmes to talk to each other.
- Consistency of info and data.
- Enough tools currently out there to do what we want but we need to pick the right ones to ensure consistency across industry.
- Need database of EPDs that are freely available.
- Local tool with local database that is freely available and used by all in the industry, with a central gatekeeper for the info, regularly updated.
- Ideal to have one tool that does it all very simply!
- Could have producer statement that does all in one hit?
- Tool to have integrated interface that allows the outputs for a project to all be in one place.
- Various parts of carbon, H1, IEQ, biodiversity – summary upfront would be helpful to proceed through process.
- Risk of one tool is that's it's very reliant on input into that tool. Can cross-check if have multiple tools. However, if there is only one tool and if it is wrong, we are all as wrong!
- Some tools 'talk' to each other already.
- Crucial to have a database of performance of different buildings.
- Schedule of quantities or BIM model? This will be difficult for some smaller companies, not achievable for many.
- Would an architect be willing to issue a PS1? Not a legal document in Building Code.

General discussion key outcomes

- Need to clarify exactly what should be included in a carbon footprint.
- Require information on priorities in reducing carbon emissions re operational/embodied (what are the things that will really make a difference).
- Need consumer education on operational carbon – operational emissions very user dependent so no benefit in designing a low-carbon house where carbon reductions are irrelevant due to how the house is lived in.
- Require central database of effective carbon-reduction solutions.

3.2.2 Christchurch/lower South Island architects/designers workshop

Question 1 key outcomes

- Credibility – need a tool that is accurate and based on good science.
- Easy to use, inexpensive tool with an "acceptable" level of error to allow for ease of use.
- What does the metric look like? Per person? Per m² of building? Per m² of land? Per building? Different for different building types?
- Is the calculation only within the site, or can I do things off site too?
- Are BC fees cheaper per carbon footprint? (Incentive?)
- Tool needs to be holistic to avoid unintended consequences of a wholesale focus on carbon.
- Tool needs to be flexible enough to use as a preliminary design tool.
- Tool needs to easily make comparisons between options in design and construction. What if?
- Must calculate operational and embodied carbon.
- Outcome based, not input based.
- No schedule methods.
- Designers of more-complex buildings have greater knowledge so could use more-complex tools.
- Need a range of tools. Don't need to reinvent the wheel. Plenty of options already, so could leverage existing tools.
- Whole-of-life approach for carbon footprinting required.
- Accuracy of data critical – common across the industry.
- Cost to designers – need to hire additional specialists or do it in house.
- The Building Code would require Acceptable Solutions and Verification Methods.
- The Acceptable Solution would ideally have a certified tool so a report can be produced so the BCA can just view it.
- Although the tool needs to be simple and easy to use, it is important that it is not dumbed down and includes all parts of the building.
- The Building Code will need a threshold to aim for. It needs to be aspirational yet achievable. Perhaps a step change over time. Eventually to net zero, both embodied and operational. Throughout all the step changes, there could be incentives for further achieving past the requirement. Incentives to achieve "better" carbon results could be considered.
- Perhaps a different requirement based on how easily net zero is achieved – i.e. dwellings are easy but an open-air stadium is much more difficult so needs to have an achievable limit.
- Notification to public, manufacturers and importers/suppliers that this is coming so they can gear up for this, so when it is a requirement, it is easier to achieve as the materials/carbon data will be readily available.
- Notification to all suppliers that they will need to provide an EPD.
- Agree what needs to be included in the carbon footprint.
- Incentivise adaptive reuse of existing building and reuse of existing older/recycled materials.
- Building smaller and denser needs to be incentivised.

Question 2 key outcomes

- Should take less than half a day to calculate a carbon footprint.

- What tools are being used now (such as Design Navigator)? Could that tool be built up to include carbon?
- Building performance is complex, so we need a suite of tools.
- Use a mini Passive House calculator. Can go from thermal environment to fine detail.
- What about using Homestar 5?
- Get experts to provide calculations.
- Difficult to have a tool that works for small-scale buildings as well as larger buildings.
- Can drill down into specific data like how much sequestered carbon.
- At a design level, be able to see embodied and operational carbon alongside each other and how design changes affect each of those differently.
- Flexible enough to be able to do it quickly for easy estimates at design stage.
- Easy to swap out initial broader estimates based on final specification for certification.
- Can import a BIM model for easy quantities and be able to easily integrate it for correct specification selection
- Things to include – comfort (range and surface temperature), interstitial condensation for both health of occupants and durability of timber, embodied and operational carbon, water use per person per day, air quality/ventilation.
- Easily integrates manufacturers' and suppliers' EPDs so all EPD information is consistent.
- Ideally an add-on for ArchiCAD and Revit
- Should come with standard templates and also the ability to make your own template.
- Where on the scale between simple and accurate is the tool targeted?
- Needs to be multi-layered – simple for compliance purposes but can dive into deeper detail if needed.
- Assumptions built into the tool such as maintenance can make a difference to the result.
- Tool must be flexible and updatable.
- Could be based on EPDs.
- Have plug-ins for more-detailed areas.
- Should come with common construction details/types templates and also be able to set up our own templates in the tool.

General discussion key outcomes

- Tool needs to be simple and easy to use.
- Schedule method or Acceptable Solution? Should be a VM, not a schedule method.
- Are we jumping the gun to develop a tool before the framework is developed?
- Adapting and reusing buildings should be highly incentivised.
- Focus should be on now and the short term rather than what will happen in 50 or 100 years' time.
- What do we mean by net zero? This is about reducing carbon as much as possible, then perhaps offsetting.
- Current emissions are crucial.
- Would RMA be the place to bring in regulations about whether we should be building at all?
- If we just focus on building itself, we are missing wider opportunities – there are much broader questions than just buildings. Parameters of framework should include broader factors such as site.

- How holistic does the tool need to be. Take into account wider picture. Important we don't create another problem because we are focusing just on carbon.
- EPDs are currently static PDFs but these will be changing to electronic data files so can be imported into datasets.
- Designers don't have time to research data. Just need to have standard data that designers can use, NZ defaults.
- Need to be careful about product substitution.
- Tool needs to be a compliance and a design tool – one tool that can generate a simple compliance report.
- Potential for experts to be involved and for producer statements.
- At a government level, need to be able to see the volumes of carbon generated across the country.
- BRANZ provides the data.

3.2.3 Greater Wellington/Nelson architects/designers workshop

Question 1 key outcomes

- Consistency issues – different tools currently give different results.
- Tool needs to be easy to use but accurate.
- Linked to a library of components so people can build up a building. Walls, roofs and floor systems can be selected.
- What type of building does carbon footprint refer to?
- Tool needs to be iterative as technologies and processes are developed and new methods can be incorporated. Need to be feedback loops for opportunities for improvement.
- Separate tools? Pros and cons.
- We've got to move away from simplistic tools that we currently have such as the H1 schedule method.
- Start simple so long as we keep developing it.
- Easy to incorporate industry-specific info such as EPDs.
- Alignment with international tools and standards.
- Education and training are critical.
- Great to have a reward approach for exceeding minimums. Incentivising.
- Need good accurate NZ data for a number of different building typologies.
- One tool needs to be user friendly and consistent.
- Needs to become the new normal, like the E2 risk matrix.
- Should be no way someone can distort the outcomes or process.
- Substitution is an issue – who will certify?
- Tool needs assessment per m² and whole floor area. Needs to define floor area. Needs to define embodied carbon for each material.
- How to avoid perverse outcomes where a smaller building that is poorly designed might do well in terms of carbon.
- Embodied and operational carbon are both important. What we build now will continue to consume energy in the future
- Use all carbon modules? Across whole life cycle of materials?
- Getting designs consented is already challenging. This will add yet another layer
- Can we incentivise good practice?
- Tool would need to be moderated with other countries but have NZ data.
- Align with design workflows. Start quite sketchy in early stages and then get more detailed.
- How do we know BCOs will know what they are looking at? Need training.
- Need consistency across all councils.

Question 2 key outcomes

- 'One button' approach tool.
- Needs beautiful intuitive interface. Easy to use.
- Occupants have a big influence on operational carbon so how do we educate them to reduce impact?
- How do we consider thermal mass?
- Tool needs to show how we are reducing emissions – it should be educational and not just a simple calculator.
- Waste is important. How is this taken into consideration in a tool?
- Understanding where our modelled results fit against actual build.
- Need feedback loop for continuous improvement.
- Balance of variables is important – daylight/shading vs thermal implications.
- Opportunity for tool to be educational and assist people to learn and see how to improve their designs.
- Needs to work with additions and alterations.
- Waste needs to be considered, including packaging.
- Performance in winter and summer – heating and cooling.
- Across variable climates.
- Need to be able to incorporate client feedback.
- Need to take a holistic view.
- Tool should support but not dictate the design.
- Issue of one-off vs high-volume construction.

General discussion key outcomes

- Doesn't need to be perfect in the beginning – just need to get on with it. Refine over time.
- Need to stop equating space heating with operational carbon. Also includes water heating and plug loads.
- Require more carbon footprint information for alternative building materials – earth building, straw bale etc.
- Need to educate consumers to get them demanding low-carbon buildings.
- House occupancy can't be used for footprint calcs as we can't control (and shouldn't control) how a building is occupied.
- Require central database giving detailed comparable embodied carbon information for all common building materials.
- need to consider realistic carbon budgets for houses - if the budget is difficult to achieve industry will revolt
- What grid do we assume? The greener the grid, the less important operational carbon becomes compared to embodied carbon.
- Tool should be trialled. How long would this take? Things need to happen NOW.
- Need a change in attitude.

3.3 BCAs/TAs workshop

An online workshop was held with 24 participants from 11 BCAs/TAs. Workshop attendees were briefed on the Roadmap project and then put into breakout groups to discuss and respond to two key questions:

1. What if, in order to get a building consent, a design must have a carbon footprint and that carbon footprint must be below a certain limit. What issues do you see arising for you/your BCA?
2. How could an evaluation tool or tools make your life easier?

The following themes/comments emerged from the breakout groups.

The role of BCAs, designers and approved bodies/experts

- BCAs should not be assessing carbon footprints. This is a niche for specialised and/or approved bodies.
- BCAs lack the skills and knowledge to assess operational and embodied carbon. This should be the designer's responsibility.
- Emphasis needs to be on the applicant providing the data to the BCA through something like a producer statement.
- Users of tools could be accredited.
- Carbon calculations should be done right at the outset of the design process. Tools need to be available at this stage, prior to application for consents. This could open up a niche for accredited organisations and/or accredited tools so designers can provide certificates to BCA.
- BCAs should just be checking certain inputs and not the calculation itself so the process is as quick and easy as possible. Like a fire report, needs to show scope, how used and verification. Designers need to provide the evidence and explain the approach taken rather than just submitting a design with no explanation
- All houses will need a schedule of quantities to allow carbon to be calculated accurately – this will be a big change/extra cost and a challenge for smaller design firms in particular.

Carbon footprinting needed at all stages

- There is a difference between what is consented and what is built. Substitution and variations are commonplace. Carbon footprinting therefore needs to be able to be done at all stages of the design and construction process.
- If there are variations during the build, there could be a margin to make a decision. If variation does not fall within margin, the designer would have to sort it out.
- Designer and applicant need to be involved in carbon footprinting as early as possible, not at end of design.

Upskilling and productivity

- The problem is that staff in BCAs are so busy already, how can we upskill them and improve capacity?
- What qualifications and skills will staff need in order to assess carbon footprints?
- Should this be a separate team within BCAs – and how would this be funded?
- Whatever MBIE decides, it needs to be easy so BCAs are not the ones holding up the process.
- BCAS and industry need training before the carbon requirements are rolled out.

Tools

- Any carbon calculation tool needs to be simple and easy to use
- Builders and others who are not computer savvy need to be able do these calculations.
- Any tool needs to integrate into existing software/systems.
- There are existing tools overseas – could these be adapted for use in NZ?
- Would be useful to have a deemed-to-comply tool as an Acceptable Solution for smaller buildings and a Verification Method for tools for larger buildings.
- Would carbon emissions have a new Building Code clause that incorporated an Acceptable Solution for embodied and operational carbon and a Verification Method

for small residential buildings (relatively simple tool) and another for larger residential buildings and commercial (more complex tool).
- Carbon data should only be updated on a programmed basis (such as once a year) so that there is one set of data for a set period.
- Will all materials in a house be included in embodied carbon calculations or just the 'big' carbon materials?

Building product information

- There is a relationship between MBIE's BfCC programme and building product information.
- Building products should have their own ratings and information.
- Carbon should be part of a product information database. This would also help when substitutions are made so carbon footprint of new product can be verified.

Data collection on carbon

- BCAs need systems for collecting stats to know how much carbon has been consented within their region.

Other comments

- Element of immediacy in calculating carbon. At what stage in the life cycle is carbon emitted? How is this accounted for in a carbon footprint? For example, the fumes from a truck compared to the carbon stored in timber.
- This might limit the number of bespoke houses.
- Include alternative building materials/methods (straw bale, earth buildings).
- Is the RMA being considered as part of the BfCC programme?
- Is it realistic to believe small product manufacturers will be able to provide accurate embodied carbon figures for their products – e.g. kitchen cabinetry?
- MBIE needs to take time to get the process right.

3.4 Commissioners of buildings workshop

An online workshop was held with 11 commissioners of buildings. Workshop attendees were briefed on the Roadmap project and then asked to respond to two key questions:

1. What if, in order to get a building consent, a design must have a carbon footprint and that carbon footprint must be below a certain limit. What issues do you see arising when commissioning a building?
2. What features are important in a digital tool for evaluating building performance? What would make life easier for you and your organisation?

The following themes/comments emerged from the workshop participants.

Consenting process

- BCAs would need to invest in training staff to ensure they have the confidence and skills. They also need to look at their processes.
- Currently, there are different compliance reports from different manufacturers. Would be easier for someone to provide Alternative Solution that encompasses all aspects for this particular project. For example, if there was a standard template that can be used for the summary report. People could include what tools they have used in the summary report. Makes it easy for BCA to access.

Typologies

- Designers are working on different building typologies – stand-alone houses, MDH, apartments, commercial, schools. Tool needs to accommodate different typologies.

Refurbishments and renovations/retrofits

- Evaluation/calculation tools need to include refurbishments, renovations and retrofits.

Durability

- Issues for developers – durability considerations and end-of-life reuse could impact on design upfront. May change the way industry is currently dealing with this.

Cost

- There would be extra fees that start impacting on project costs and might start impacting on volume too. Success will come down to how successful the tool is.
- Could use an architect for a small residential building but maybe use a consultant or specialist for bigger developments.

Perverse outcomes

- When we look at how we measure embodied and operational carbon, we need to consider perverse outcomes. Higher framing ratio makes thermal envelope much weaker for example. Peripheral issues – if we use just timber but it is treated, it could make it more toxic.
- If only look at A1 to A3 but not A5, this unfairly disadvantages low-carbon materials made in NZ – could be quite significant and shouldn't be ignored.

Regulation vs voluntary action

- Voluntary action hasn't worked. If there is a mandate for builders and developers, it will push the market to design better products.
- It is impossible to encourage better buildings when there is no regulatory requirement. All we have is incentives. Unless there is a requirement, people will meet the minimum requirements. Unless we change the Code, we will not see the shift. There will always be early adopters, but we won't see broader change. A compliance or a regulatory component is the most expedient way to get movement and get the market to design better.
- With EPCs – proven that if there is no mandatory measure, these things are not picked up no matter how well they are designed.

Impact on SMEs

- The tool could have a bigger impact on SMEs. This will be a big change for small firms with some significant costs to access the expertise and get their head around knowledge. Will need to be easy to use for the whole industry.
- For smaller organisations – some don't have BIM – how will they submit carbon information based on their existing low levels of technology? Or how will they upgrade their technology?

Substitutions and variations

- Practical issues we already face around product specifications and variances. How do BCAs calculate carbon when there are substitutions and/or the construction varies from the design.

- Tool needs to cover all stages including product substitution.

Accessibility

- Needs to be an online tool

Transparent, New Zealand-based, consistent dataset

- We need a transparent, consistent, verified dataset.
- Challenge of a dataset is validity and what comes from suppliers. Updating and keeping it current.
- NZ central database for materials – use of centralised consistent materials data, freely accessible to all industry, will save the industry time and money.
- NZ central database for LCA results – facilitate benchmarking and guide future standards. Ideally also include real in-use data. Related to NABERS?

Product database

- This would help BCAs. There is inconsistency across BCAs and wide interpretation around how the NZBC is applied.

Interface

- Be able to directly interface CAD/BIM software (Revit or ArchiCad) to capture the necessary building geometry and data.

Modularity

- Bring together existing software package under one application (LCAQuick + thermal package + …) to maintain consistency with users of the individual packages. Apps could then also be substituted out or in.

ISO standards

- Meet ISO standards for LCA so results are comparable to bespoke international software such as eTool.

Versatility

- Extend building types to include other similar typologies such as schools. Include other Ministries to co-develop – all have the same end goal of net-zero carbon.

Standard templates

- Standard template for output suitable for building consent applications and to streamline verification.

Life cycle assessment (LCA) scope

- Include water as the resulting emissions can be significant yet are often ignored. Includes demolition waste given potentially large volumes and therefore emissions.

Retrofits

- Tool has to work for new builds but these are only 5%. Need a tool that supports retrofit and upgrade of existing stock. Include design for deconstruction. Quantity and quality of recyclable materials in the construction.

4. Conclusions

We need a systems approach to ensure outcomes for building performance are integrated, consistent and verifiable and used not just to prove compliance but for designing beyond Code minimums. There was a strong belief from stakeholders that the industry had to do something to not only reduce operational and embodied carbon emissions in buildings but also to improve overall performance and that this should be undertaken urgently.

Stakeholders had a clear understanding of the potential future compliance requirements to design and build low-carbon buildings and were supportive of the requirement. However, they were concerned that other aspects of building performance should not be compromised by a focus on carbon footprint compliance.

Industry stakeholders showed a preference for having access to a tool that would analyse a design and provide any required compliance information on a range of performance criteria. While there was a strong focus on a tool that provided both embodied and operational carbon outputs to facilitate the design and construction of low-carbon buildings, stakeholders expressed a keen interest in developing tools/systems that also ensured that these buildings had higher performance and were also warm, dry and healthy.

While a number of tools are currently available, feedback shows there is a preference for development and use of a single tool that is specifically related to the New Zealand building industry and would provide a wide range of building performance outputs based on consistent metrics. However, it was also considered that it would be useful to audit the tools that are currently available.

The tool should be able to be used right through the preliminary and developed design, compliance and construction phases, be viable for multiple building typologies and integrate with existing industry tools.

It should also be based on a consistent dataset relevant to New Zealand that is regularly updated. It was identified that there is a significant role for BRANZ to play with respect to developing a national database given its current position with respect to available tools and data and the pilot project under way looking at the issues and costs associated with transferring and maintaining data in the cloud. There will also be a challenge for manufacturers to make reliable, current product data available.

For the tool to be used for compliance and lifting building performance and to encourage uptake across the industry, it needs to ideally be freely available and easy to use. Costs and time of acquisition and training to become proficient need to be considered. Ideally, calculating a carbon footprint of a specific building design should be a one-click process that can occur at any stage of the building's life cycle.

It is important that any tool is able to be regularly updated to integrate changes such as Building Code amendments (such as H1) and BfCC initiatives and requirements and be suitable for application across the industry.

MBIE indicated that it is considering a tool for buildings less than 300 m² and others for larger buildings. It is possible that a tool could be an Acceptable Solution with the methodology a Verification Method and that there could be an accreditation system for tools.

A lack of formal training was identified as an issue with current tools, with most professionals becoming proficient through self-learning. Ideally, the tool would have a robust introductory training scheme and ongoing support.

Inputs need to be simple and quick to enter, with potential to incorporate more detail as the design and construction processes progress. This is particularly important for small firms that don't typically produce a full schedule of quantities and for ensuring that LCAs are being done early in the design process. Designers also need to be able to iteratively compare design options as the design develops and to be able to assess product substitution during construction.

The ideal tool should also be able to generate benchmarks based on the user's portfolio of completed buildings and a wider pool of other buildings. These can be used to set targets at the beginning of projects for warm, dry, healthy, low-carbon buildings. It will also allow MBIE to collect stock-level carbon footprinting data that can be used to set future thresholds as part of its BfCC programme.

While a single tool was seen as aspirational, the desire for consistent design analysis and outputs across a wide range of building performance criteria combined with consistent assessment in the compliance process was seen as something worth due consideration for development.

Below summarises the criteria that the stakeholder groups identified.

4.1 Ideal tool

The preferred option is to have a single tool that assesses multiple building performance metrics. The tool should be able to be used right through the design, compliance and construction phases, be viable for multiple building typologies and integrate with existing industry tools.

Measures assessed

Ideally, the tool would assess multiple building performance metrics, with the most important being carbon, energy, comfort/thermal, and ventilation (for example, CFD). Other metrics that would ideally be integrated are moisture, other environmental impacts, structure and fire (for example, RESIST). Ideally, all these metrics could be assessed quickly, iteratively and accurately. Water use was also a consideration with respect to both actual volume and water heating energy use.

Integration with industry tools

Ideally, the tool would also integrate existing industry tools so that they can be better integrated into the design/project management process. Priority tools for this are Revit and ArchiCAD, but other tools mentioned were AutoCAD and Vectorworks. The tool should also function on its own for firms that do not or cannot use the tools listed. While integration was seen as important, it is also important that the tool could "stand alone" as well – for example, when used by a building official to assess compliance, it would not be used in conjunction with CAD.

Accessibility

For the tool to be used for compliance and to encourage uptake, it needs to ideally be freely available and easy to use. Costs and time of acquisition and training to become proficient need to be considered. Ideally, calculating a carbon footprint should be a one-click process that can occur at any stage of the building's life cycle.

Training

In the workshops, a lack of formal training was identified as an issue, with most professionals becoming proficient in their tools through self-learning. Ideally, the tool would have a robust introductory training scheme and provide ongoing support.

User experience

Inputs need to be simple and quick to enter, with potential to enter more detail as the design and construction processes go on. This is important for small firms that don't typically produce a full schedule of quantities and for ensuring that LCAs are being done early in the design process. Designers also need to be able to iteratively compare design options as the design develops. It is absolutely critical that the tool is useful at the concept design stage, allowing a designer the opportunity to enter different data to immediately see the impact of the various design choices.

A large number of buildings (particularly residential) are designed and documented without a schedule of quantities – the tool must take this into account.

It is also important that the user interface is easy to navigate and understand. It will be used by a wide range of people in the industry – from those extremely skilled in a wide range of programs to those who have relatively low levels of computer literacy.

Compliance

Ideally, the tool could be used for compliance in line with the changes to the Building Code that MBIE's BfCC programme plans to make. The tool should be able to produce a metric (such as $kgCO_2eq/m^2$ GFA) and/or a report detailing how the design meets the Building Code.

All assessments should use a common dataset to make demonstrating compliance easier.

Data

For compliance, ease of use and consistency, the tool should use a national dataset that is representative of the New Zealand built environment. The dataset should include New Zealand materials, be relevant throughout the design process and allow users to replace broad estimates with finer detail later on.

It should be transparent so that users can see what assumptions are being made for the carbon footprint. It may also include carbon footprints and/or quantities for construction templates (such as wall, floor, and roof constructions). It needs to include assumptions for carbon footprinting and energy modelling. It should ideally link to a commonly used building product information system such as CBI.

Grid electricity impacts should reflect New Zealand grid impacts.

The tool should be informed by a series of defaults when EPD data is not available but allow users to overwrite these to better reflect the materials that they are actually specifying.

Updating should happen at specific intervals so that everyone knows when to start using the new data. One potential problem is the possibility for submitting a consent for compliance that used one dataset and then having it assessed from an updated dataset and the issues that could arise from this.

Benchmarks

The ideal tool should be able to generate benchmarks based on a user's portfolio of completed buildings and a wider pool of other buildings. These can be used to set targets at the beginning of their projects. It will also allow MBIE to collect stock-level carbon footprinting data that can be used to set future thresholds as part of its BfCC programme. An accessible database of examples was considered desirable.

Scope

At minimum, the tool should account for the scope needed for compliance under MBIE's BfCC programme. The tool should at least calculate the impacts for life cycle stages/modules A1–A5, B2, B4, B6, B7 and C1–C4. The tool should also include data for and allow users to calculate the structure, enclosure and finishes of a building.

4.2 'Must haves'

See Figure 1 below for a summary of the must haves.

Measures assessed

- Carbon footprinting
- Energy efficiency
- Comfort/thermal (IEQ – heating/cooling/ventilation)
- Water use
- Moisture

Integration with industry tools

- Revit
- ArchiCAD

Accessibility

- Low cost

Training

- Formal introductory training available

User experience

- Iteratively assess designs and compare carbon footprint to previous iterations
- Users can make broad assumptions at the start around material quantities and add detail as design progresses
- Easy and intuitive to use for all relevant industry users

Compliance

- Must be able to report carbon footprint in $kgCO_2eq/m^2$ GFA and report detailing data used so it can be assessed for compliance

Data

- Use data from a national database representing New Zealand materials, energy and water
- Also include a set of defaults for modelling New Zealand materials that do not have EPD data available

- Link to a building product classification system that is frequently used in New Zealand such as CBI
- Data updated regularly

Benchmarks

- Allow users to create benchmarks from wider pool of building carbon footprints

Scope

- Calculate modules A1–A5, B2, B4, B6, B7 and C1–C4
- Calculate impact for buildings structure, enclosure and interior finishings

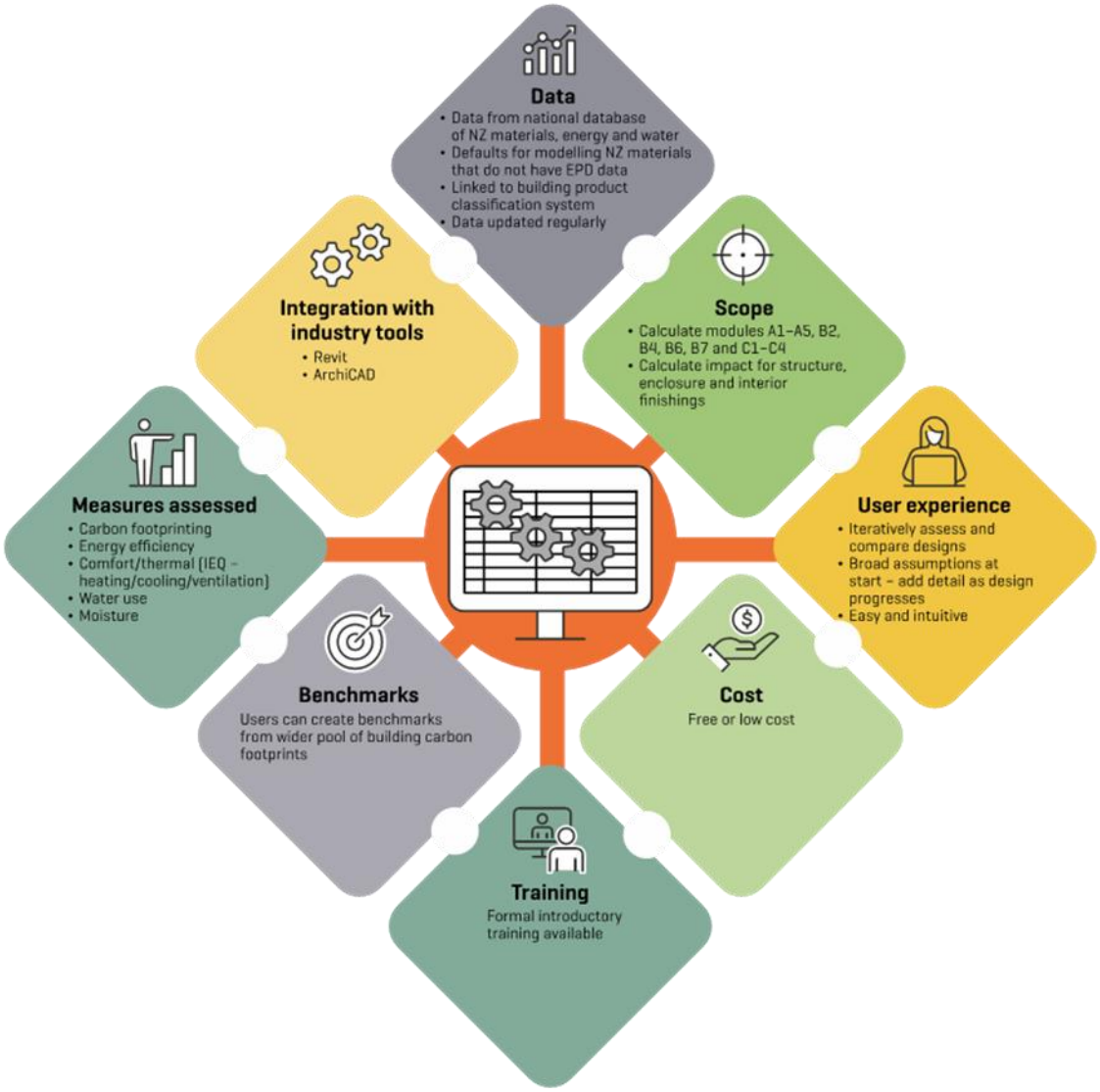


Figure 1. Must haves for a tool that evaluates building performance.

4.3 'Nice to haves'

Measures assessed

- Ventilation
- Fire
- Structure

Integration with industry tools

- AutoCAD
- Vectorworks

Accessibility

- Freely available
- Can start assessing carbon footprints instantly

Training

- Online resources (webinars, YouTube videos)
- Ongoing support for projects

Data

- Database of common construction types (wall, floor, roof) that users can specify then adjust
- Make data/defaults being used visible to the user