LOW CARBON LIVING CRC

Integrated Carbon Metrics (ICM), RP2007

Scoping Study Results

2015

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Contents

List of Tables

List of Figures

Acronyms

BIM	Building information model
CRCLCL	Cooperative Research Centre for Low Carbon Living
EC	Embodied carbon
EPD	Environmental product declaration
GHG	Greenhouse gas
ICM	Integrated Carbon Metrics
IELab	Industrial Ecology Virtual Laboratory
IO	Input-output
ISO	International Organization for Standardization
LCA	Life cycle assessment
OC	Operational carbon
PIM	Precint information model

Introduction

The Integrated Carbon Metrics Project (ICM), RP2007, is a collaborative research effort between UNSW Australia, The University of Melbourne, UniSA and industry partners AECOM, Aurecon, Bluescope and Sydney Water. The project aims to develop the metrics and decision support tools for building designers, manufacturers, planners and developers to support the successful implementation of low carbon initiatives.

The ICM project quantifies the carbon emissions for the various processes in our urban environment. This includes both the direct as well as the indirect or 'hidden' carbon emissions ranging from the production of building materials to the design and construction of whole precincts.

A comprehensive database of embodied carbon life cycle inventory data for building products and materials is the fundamental component of the project. The main objective of this part is to create a method that harmonises the life cycle data from different scales and sources by combining top-down and bottom-up approaches.

The database will be used in the 'ICM tool', which will be able to track carbon along the production and supply chains of materials and products, show the carbon outputs of industrial sectors at great detail as well as map carbon flows spatially across Australia.

The carbon emissions data will also be used in a 3D Precinct Information Modelling (PIM) tool. This will enable to calculate and visualise the carbon emissions of specific precinct development and retrofitting projects during their planning stage.

In order to test and validate the data and calculation methods, case study scenarios of urban precincts will be prepared for modelling with PIM tools. Scenarios depend on a number of factors including cohorts of buildings, urban morphologies, demolition rate, turnover of building stock, extent of retrofitting and time span of analysis. Options for low-carbon precincts will be evaluated.

In order to ensure that the ICM project meets industry and user needs a scoping study was conducted within Australia with construction industry professionals. The aim of the study included the following:

- Gain an understanding of the construction industry’s current approach to embodied carbon assessment;
- Identify perceived strengths and weaknesses of current embodied carbon assessment tools; and
- Identify potential areas for improvement to existing tools and recommendations for development for new embodied carbon tools

The results of the study were presented at an Industry Utilisation Workshop, which was held at the UNSW Australia on 22 May 2015. This workshop provided a platform where the tools and research related to the ICM project could be demonstrated to a wide range of industry professionals so as to gain feedback and generate discussion. The scoping study, together with the workshop, provided a means to determine where the ICM project’s future goals should be directed towards so as to ensure research and tools get developed that best suit industry requirements.

This report provides a summary of the scoping study’s findings and brief discussion of the workshop outcomes.

Background

Greenhouse gas (GHG) emissions from the building sector have more than doubled since 1970 to reach 9.18 Gt CO_2eq in 2010 representing 19% of all global 2010 GHG emissions (IPCC, 2014). In Australia, 20% of all GHG come from the operation of commercial and residential buildings alone (Climate Works, 2013). These GHG emissions have been demonstrated to negatively contribute to the effects of climate change (IPCC, 2014) with growing emphasis placed on the need to implement mitigation strategies. These mitigation strategies have been largely focused on reducing these direct (operational) emissions, however the indirect (embodied) emissions from materials and manufacturing, transport, maintenance and disposal have been estimated to make up another 11% of national emissions (Schinabeck and Wiedmann 2014). With growing international pressure to decrease national GHG, coupled with the fact that Australia is one of the highest GHG emitters in the world on a per capita basis (Garnaut, 2008; 2011), there is a need to address both the direct and indirect GHG emissions from buildings if Australia is to achieve their commitment of reducing GHG to 26-28% below 2005 levels by 2030.

Embodied Carbon

A building will emit carbon during a number of separate phases over its lifetime. These 'phases', as defined within BS EN 15978:2011, are broadly split up into the following four phases: product stage; construction process stage; use stage and end of life stage. Industry and government have been mainly focused on reducing the carbon emissions from the use phase, leaving the other phases largely ignored. However even before a building is occupied, between 30% to 70% of its lifetime carbon emissions have already been accounted for (ASBP, 2014). With the continuing decrease in operational carbon (OC), embodied carbon (EC) represents an increasingly significant component of the GHG emissions attributable to the built environment (Crawford et al., 2010; Dixit et al., 2012; de Wolf and Ochsendorf, 2014).

Methods of Embodied Carbon Assessment

Life Cycle Assessment (LCA) is widely acknowledged as providing an appropriate framework for assessing carbon emissions throughout the whole building life cycle (Menzies et al., 2007; Zuo et al., 2012). LCA is a method for evaluating the environmental impacts of products holistically, including direct and supply chain impacts (Lenzen et al., 2004). There are four fundamental steps for conducting an LCA namely: goal; inventory analysis; impact assessment and interpretation (Crawford et al., 2010). However each step requires a certain level of subjectivity. From defining the system boundary (to what extent each life cycle phase is included in the calculation) to interpretation of results (Treloar, 1998). This subjectivity can result in differing and often incomparable EC results for the same building element. Another aspect affecting the EC results is the inventory, which in influenced by a wide range of factors, from age of data; geographic location and degree of completeness (Crawford et al., 2010).

This LCA process is often seen as complex and time and resource heavy. There has been an increase in the amount of available tools and software to aid calculation, reaching from commercially available tools, such as SimaPro (Netherlands); GaBi (Germany); Boustead (UK) and eTool (Australia) to in-house developed data and tools, such as Arup's Project Embodied Carbon & Energy (PECD) dataset that consists of Arup projects with data extracted from Revit models. Each tool employs inventories that include the EC coefficients of building products and materials. The origin of these datasets ranges from ICE (UK); Ecoinvent (Switzerland) or AusLCI (Australia), to name but a few. Most of these datasets provide data from cradle to gate (resource extraction to factory gate). Several researchers have analysed and compared these available tools and concluded their advantages and disadvantages (Ariyarante and Moncaster, 2014 and de Wolf and Ochsendorf, 2014). The outcome of these comparisons often reflect some of the same characteristics that plague LCA as mentioned earlier, from inconsistent calculation methodologies and system boundaries resulting in a range of reported EC figures dependent on what tool is used. In addition to this, several upstream phases are left out of the calculation due to only relying on cradle to gate data (instead of cradle to cradle, i.e. resource extraction to re-use), resulting in a degree of incompleteness which has been shown to be 50% or more (Crawford, 2008).

Scoping Study

An Overview

In order to gain a general overview of the Australian construction industry's current approach to EC assessment, an online survey was created through the online portal 'Survey Monkey'. The survey provided a means to collect quantitative data, such as demographics (for example the type and size of organisation) along with specifics regarding the tools and databases used for EC assessment and the perceived strengths and weaknesses of current EC tools. This cross sectional survey (i.e. data collected over a defined time about a particular topic) consisted of multiple choice questions with several questions employing a Likert scale and approximately four open ended questions requiring written responses. The survey, which took approximately 10 to 15 minutes to complete, was distributed, via email, to over a hundred industry professionals within Australia ranging from architects, engineers, sustainability consultants, life cycle assessment practitioners and product manufacturers. A total of 45 responses were collected over a two-month period. MS Excel was used to perform descriptive analyses on the data, focusing on percentage response and frequency distributions.

In addition to the online survey, semi-structured one-on-one interviews were conducted with a total of 22 industry professionals identified through the online survey. The interviews were approximately 30 minute long and recorded via an audio device to be transcribed and coded afterwards. Interviews were conducted mainly at the participants' offices, located either in Melbourne or Sydney between 30/03/2015- 13/05/2015. Interviewees ranged from product manufacturers and organisations, LCA practitioners and consultants. The interviews provided a means to elaborate on some of the issues identified in the online questionnaire and gain more in-depth insight into the construction industry's approach to EC assessment and use of tools.

Survey Population and Sample

The population of the survey was construction industry professionals located within Australia. The sample identified were specifically professionals who work with building or building material related aspects. These professionals ranged from architects; engineers; LCA consultants; quantity surveyors and material manufacturers. The sample selection was identified via a web based search. The selection criterion was based on the fact that the professionals had to be based in Australia. Due to the fact that this was a scoping study with the intention of gaining a brief insight into the current practices of the Australian construction industry, the sample size did not need to be too large (even though a larger number would have ensured a greater confidence level). The intention of this study was to provide a base case that could be developed further for the next phase of the project. A total of a 100 questionnaires were distributed via email with 45 responses were collected over a two month period. The greatest percentage of responses came from LCA practitioners (27%), followed by sustainability consultants (20%), engineers (18%) and then contractors (11%). Most of the organisations represented, consisted of less than 10 people with 56% of the respondents mostly involved with residential projects and a further 24% stating they specialise in both residential and non-residential projects.

Survey Analyses

The main method employed was descriptive analyses, through Microsoft Excel, so as to count the number of responses and gain insight into what the majority of the research sample is doing towards EC analyses. The percentage of each response in each category was calculated to identify the most common response. Exploratory factor analysis was carried out on the open-ended questions, such as 'recommendations to new EC tools' (and questions such as the listing of strengths and weaknesses of current EC tools) to extract common codes and divide the items into the most common categories.

Results

Demographics

A total of 45 responses were received for the online questionnaire, with the greatest percentage of responses coming from LCA practitioners (27%); followed by sustainability consultants (20%), engineers (18%) and then contractors (11%). For the interview, 22 responses were gathered with the greatest percentage from product manufacturers, multi discipline consultancies and LCA practitioners.

Most of the organisations represented, consisted of less than 10 people with 56% of the respondents mostly involved with residential projects and a further 24% stating they specialise in both residential and non-residential projects. Most of the projects are performed at a building scale, followed by material scale and then precinct level. When asked about the importance of reducing the carbon footprint of their projects, 67% stated it is very important.

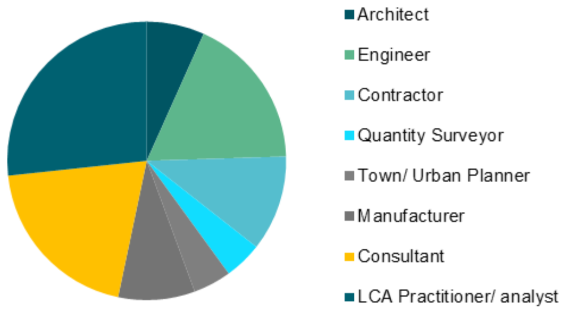

Figure 1: Online questionnaire responses indicating the type of organisation

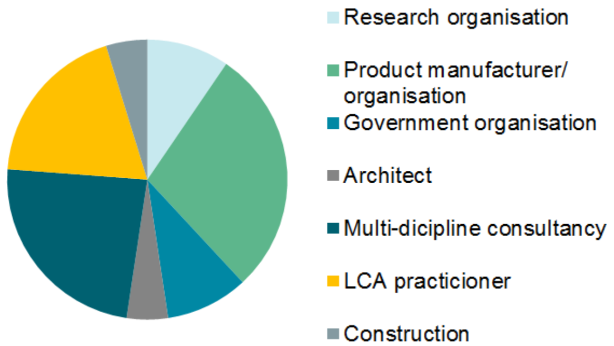

Figure 2: Interview responses indicating the type of organisation

Key Themes

Throughout the scoping study process several key themes became apparent when talking about embodied carbon. The three major themes identified, as illustrated below in Figure 3, were whole life cycle carbon, data and communication.

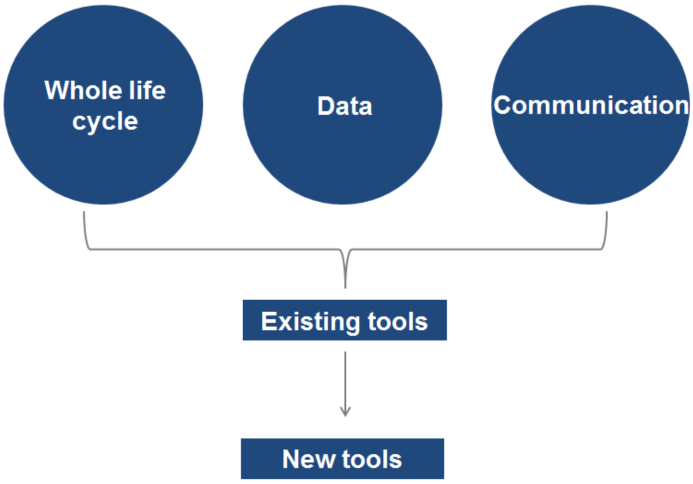

Figure 3: Key themes identified in the interview process

Whole Life Cycle

One of the major themes that were consistently brought up via the interview and questionnaire process was the issue of whole life cycle assessment when looking at carbon.

Based on the interviews, most participants understood the value of whole life cycle assessment. From product manufacturers wanting to demonstrate the value of their product over a whole life time, stating that looking at just one life cycle stage can be counterproductive and provide skewed results. Several other participants emphasised that operational and embodied carbon impact needs to be looked at simultaneously. However, when aiming to address a holistic carbon analysis, the issue of data became a key concern.

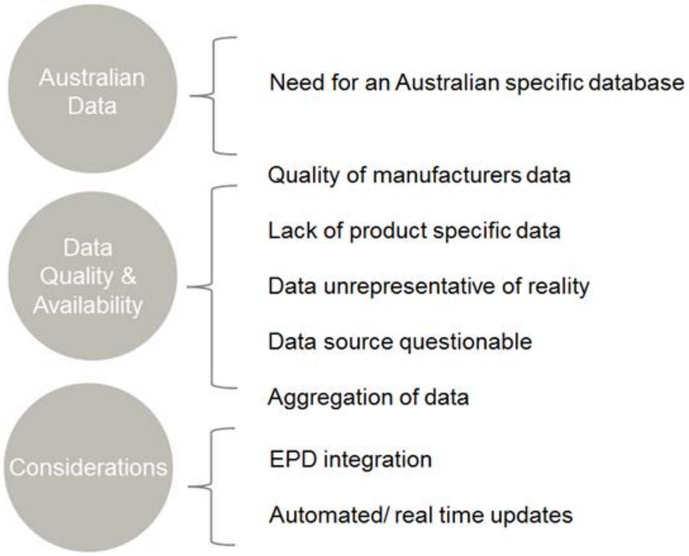

Figure 4: Main data concerns

Data

The major concern when it came to data was the fact that there is a clear need to address the lack of Australian specific data on embodied impacts, as demonstrated in Figure 4.

The next most prominent issue when addressing data for embodied carbon and energy analysis was the quality and availability, especially the lack of product specific data.

Possible considerations were the fact that over 14% of interviewees stated that there was a need to integrate EPD information with data source. Another consideration was the role of real-time updates. This is however a complex issue, but can aid the problem of data becoming out of date quickly.

Communication

However, regardless of good databases, tools and holistic life cycle method, if we don't understand how to communicate this, the whole process becomes pointless. This was common train of thought, regardless of what industry was consulted.

It became apparent that six common themes, as illustrated in Figure 5 below, were associated with communication, ranked here in order of importance based on frequency mentioned.

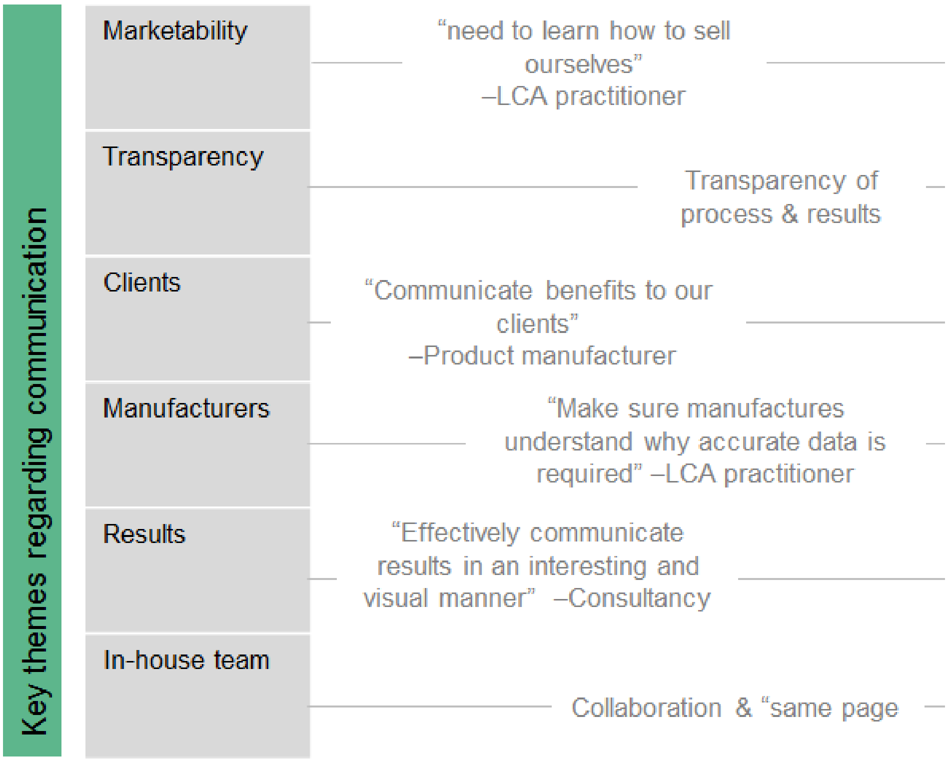

Figure 5: Key themes regarding communication

Services Provided by Organisation

This section of the survey was designed to gain insight into the services provided by each organisation and specifically the prevalence of EC assessment. Operational carbon (OC) assessment is provided by 85% of the respondents, with only a small percentage outsourced (8%), as illustrated in Figure 6. Approximately 68% provide EC assessment services, but with a greater percentage outsourced (16%). One respondent stated that “when requested on projects we complete these services; however the industry focus is on operational energy”. Another respondent provided further insight by stating “This is project specific. Preliminary in-house assessments are regularly undertaken, however this is outsourced for Green Star Projects”. Approximately 80% of the respondents stated that they do provide energy/green ratings (such as Green Star) with almost 20% of those services outsourced.

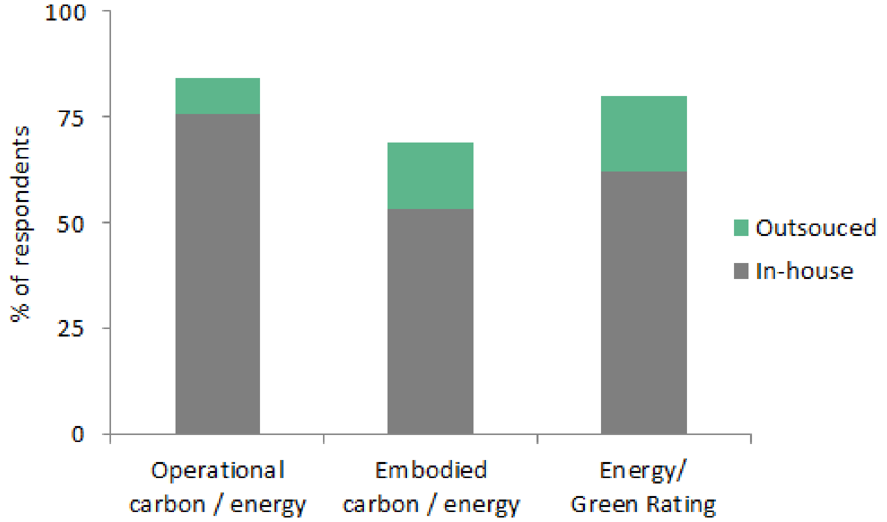

Figure 6: Services provided by organisation

For those organisations that don’t provide EC assessment as a service, the main reason provided was lack of project budget (59%) followed by client disinterest (41%), lack of set standards (35%) and no clear cost/profit incentive (29%). Please refer to Figure 7 below. However, when asked whether these organisations would consider providing EC assessment as part of their services in the future, 65% said they would.

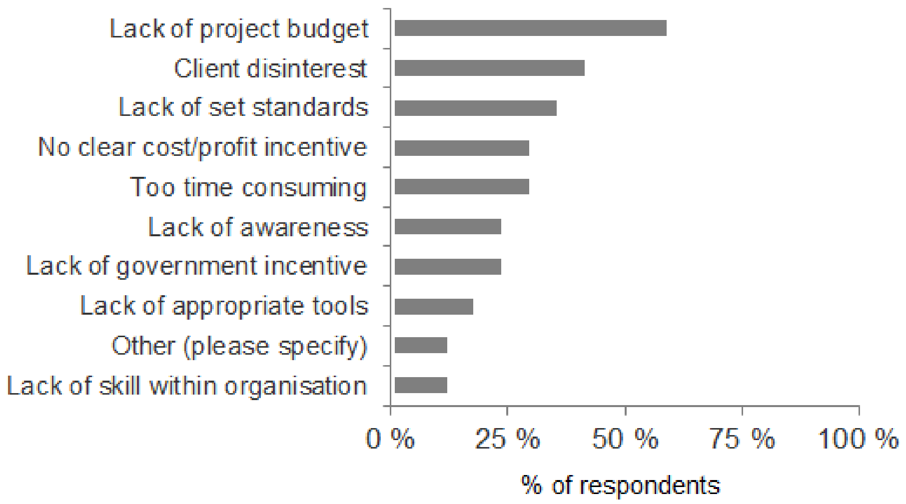

Figure 7: Reason provided for not providing embodied carbon assessment within organistion

Embodied Carbon Assessment: Existing Tools and Databases

This section of the survey specifically focussed on the organisations that provide EC assessment as part of their services. When asked what tool is used for this service, the most popular choice was the software tool SimaPro, as illustrated in Figure 8 below. eTool, an Australian designed tool, was only 4% behind SimaPro in terms of popularity. Approximately 19% of the respondents used in-house developed tools.

For the database used for EC assessment, both the Australian AusLCI and databases within SimaPro were stated as the most popular, closely followed by in-house, eTool and Ecoinvent preferences.

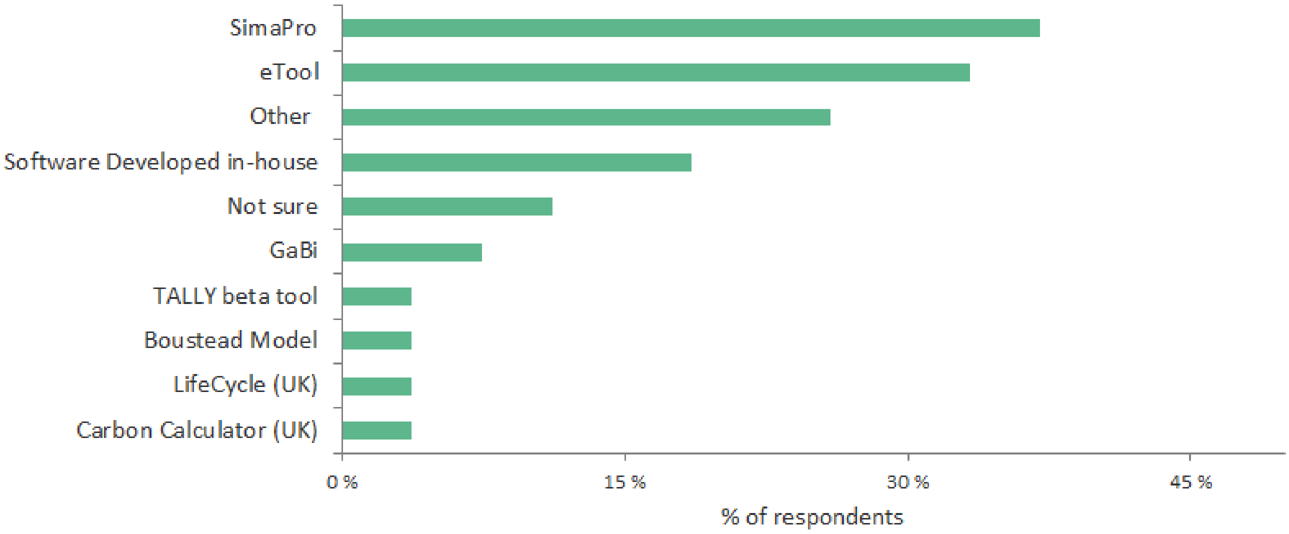

Figure 8: Tools used for embodied carbon assessment, by percentage of respondents

The theme of whole life cycle assessment was echoed throughout the interview process, where it was often stated that there is a need to focus on the carbon assessment holistically. This ethos can clearly be seen in the respondents stating that they mostly assess embodied carbon at either a 'cradle to grave' or 'cradle to cradle' system boundary in Figure 9 below.

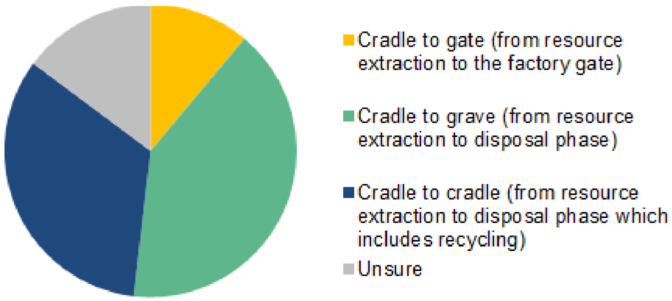

Figure 9: Life cycle stage considered when conducting embodied carbon assessment

When asked to list the strengths and weaknesses of current EC assessment tools used by the organisation the following five themes became most evident (as detailed in Table 1 below) – data; method; usability; regulation and outcomes. Tool users prefer having the option to access multiple databases through a simple online tool that performs comprehensive analyses. Tools that are compliant with ISO standards are preferred along with the option to include multiple impact reporting through nested templates able to compare scenarios. However, there is an overall concern about the lack of Australian data and the inconsistent methodology employed for this assessment. In addition to the data weaknesses, some of the tools are considered to be time-consuming and requiring expert knowledge to use, presenting considerable barriers for their uptake. Desired outcomes include the availability of benchmarks, 3D visualisation and integration of life cycle costing into the analyses.

Table 1: Strengths and weaknesses of current EC assessment tools

Theme	Strengths	Weaknesses
Data	Ability to access multiple databases; comparable metric	Lack of Australian data; lack of product specific data; data source questionable
Method	Comprehensive and in-depth analysis; integrated with thermal performance	Inconsistent methodology; not a holistic assessment
Usability	Affordable, simple and online platform	Time consuming; requires expert knowledge and additional training; no Building Information Modelling (BIM) integration
Regulation	Compliant with existing ISO standards	Boundary and accuracy questionable
Outcomes	Multiple impact reporting; ability to model recommendations; nested templates; ability to compare scenarios	Lack of benchmarks; inability to compare building products; no 3D integration; Life Cycle Cost Model

Embodied Carbon Assessment: New Tool Recommendations

When asked to indicate the top features desired in EC assessment tools, ‘material cost’ was deemed the most popular with 80% of respondents selecting this option, as illustrated in Figure 10 below, followed by ‘data on recycled materials’ (62%) and then ‘source of materials’ (57%). When asked to rank important features and functionality, ‘reliability of findings’ and ‘ease of use’ came out on top along with a need for a ‘list of mitigation measures’ and ‘comparison against a benchmark’.

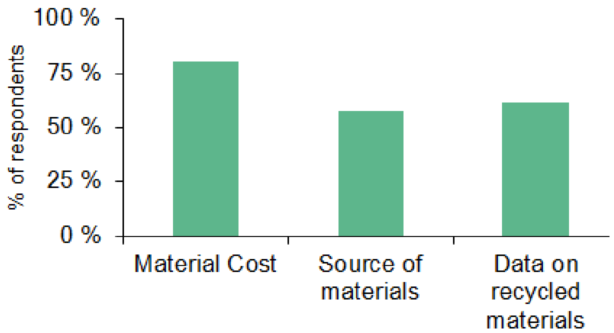

Figure 10: Top feature desired specifically for an embodied carbon assessment tool

Based on the interview results, the three most common themes (as illustrated in Figure 11 below) mentioned when talking about carbon (and if relevant embodied carbon) tools, were the ‘impact of cost’, ‘compare options’ and ‘benchmark’. Users want to be able to understand what the cost implications of various embodied carbon methods will be along with understanding the return on investment. Next they want to be able to quickly and efficiently model and analyse development options and select the most suitable option. And a benchmark provides something to strive towards.

Impact of cost	Compare Options	Benchmark	Real time feedback
Green Star	Policy consideration	Residential market	Other impacts
EPDs	Precinct scale	Recycling information	BIM compatibility

Figure 11: New embodied carbon assessment tool features and functionality considerations

The recommendations provided by the respondents for future EC assessment tools can be classified under the same themes as earlier, namely data, method, usability, regulation and outcomes (Table 2). Users want a tool that relies on sound data that is easy to update. A consistent and transparent methodology is needed that looks at EC holistically while adhering to Australian standards and practices. These findings suggest that either a new tool or improvements to existing tools are needed as none of the existing tools adequately address all of these user needs.

Table 2: Recommendations for embodied carbon assessment tools

Theme	Recommendations
Data	Sound data; access to a broad range of databases; easy to update; data quality measures are in place
Method	Transparent and consistent; comprehensive; whole footprint; integration with existing tools
Usability	Streamline user interface that is simple to use with Building Information Modelling (BIM) compatibility
Regulation	Adherence to Australian policies, standards and procedures
Outcomes	Option for ‘quick’ analyses; comparison against a benchmark and compatibility with Green Star

Discussion of Results

This study provides necessary insight into the construction industry's current approach to EC assessment, identifying which tools and services are the most prominent along with providing vital insight into what features these users would want from new and improved EC assessment tools.

It was interesting to note the large percentage of respondents that provide EC assessment as part of their organisations services. A further 65% of the organisations that don't provide EC assessment are considering including it as part of their services in the future. This prevalence of EC assessment reflects the growing awareness of tackling EC emissions within the built environment. There are still a few hurdles to overcome in order to evolve EC assessment uptake, such as lack of project budget, client disinterest, no clear cost incentive and lack of set standards. This 'lack of set standards' is further evidenced by the overall concern towards data, especially the lack of Australian data. This concern towards data is further reflected in similar international studies which emphasise the need for a consistent calculation method for EC assessment.

When looking specifically at services provided, EC assessment still has a greater percentage outsourced than OC assessment. This can possibly be due to either a lack of skill within the organisation, lack of time or lack of available resources. Another option for the prevalence of outsourcing is the possible extra validation a third party might provide. Further research will be required to support this reasoning.

With regards to tools, international tools and databases still dominate with SimaPro (Netherlands) most commonly used. However the survey highlights the fact that eTool, an Australian designed tool, has a significant following.

Another interesting aspect that the survey highlighted is the prevalence of in-house developed tools and data. Further research will have to be conducted regarding this issue to determine the reasoning and how the in-house tools differ from available tools such as SimpaPro and eTool and the benefit that they provide.

Even though there were several strengths associated with these existing EC assessment tools, the amount of weaknesses identified emphasise the fact that there is still much room for improvement. There is a need to improve the data quality and ensure Australian specific data is available for accurate calculations that follow a transparent and consistent methodology. There is a need to ensure these tools, often blighted by complexity and requiring additional training, are simple and easy to use. Several features will have to be integrated in order to satisfy users' needs, such as benchmarks, mitigation measures, 3D integration and BIM compatibility.

These weaknesses either need to be addressed and improved in existing tools or new tools have to lead the way. One recommendation was to collaborate with existing tools and 'assess and redress the deficiencies'. Regardless of what approach is used, this survey has demonstrated that there is a clear interest in conducting EC assessment and that there are several industry organisations who already provide this as a service, but that there is a desperate need to address some critical deficiencies in the current approaches used. Many of these deficiencies in existing EC assessment tools highlighted above aim to be addressed by the Integrated Carbon Metrics (ICM) project as part of the Cooperative Research Centre for Low Carbon Living (CRCLCL).

"The tool needs to be a great communicator"

– Consultancy

"Simplicity as an output, even if behind those results there is a big black box"

- Govt. organisation

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