Decarbonisation of the Built Environment: using ICMS integrated life cycle and carbon emissions reporting

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Abstract

The built environment sector must significantly reduce carbon emissions throughout the design, construction, operation, maintenance, and end-of-life stages. As decarbonisation targets and regulations are announced, construction professionals must implement workflows that allow stakeholders to make prudent decisions. The cost of decarbonisation is one such workflow that needs to be addressed so options can be compared and capital expenditure and operational expenditure decisions can be made.

The International Cost Management Standard (ICMS) 3rd edition provides an integrated taxonomy for classifying, defining, measuring, recording, analysing, presenting, and comparing entire life cycle costs and carbon emissions of constructed assets at a regional, national, or international level. With the help of two case studies, the importance of internationally agreed standards to achieve decarbonisation targets and decarbonise the construction sector cost-effectively will be discussed. The discussion will also highlight the role of downstream experts such as quantity surveyors, facility managers, and project managers in the decarbonisation efforts.

ICMS-based solutions support sustainable investment strategies by bringing much-needed transparency and cross-border comparability of embodied and operational carbon across the life cycle of construction projects. The use of ICMS benefits all construction stakeholders who wish to reduce carbon for compliance, market, and societal reasons and drive innovation in alternative designs and solutions.

1. Decarbonising the built environment

The built environment sector is estimated to generate approximately 40% of energy-related global greenhouse gas (GHG) emissions [1]. Achieving the decarbonisation targets will require considering emissions from the built environment sector. Therefore, the built environment sector will play an important role in reversing the growth of GHG emissions. To reduce carbon emissions, the sector must consider new and existing assets. This will require the sector as a whole to consider decarbonisation while regulating, initiating, designing, constructing, operating, maintaining, and deconstructing the built environment assets [2]. While there is an increase in awareness and activities in the sector, significant progress is still required. For example, during the COP27 meeting, it was reported that operational emissions from the built environment increased by 5% last year compared to 2020 levels [2]

The emissions from the built assets over their whole life can be divided into two categories, namely embodied carbon emissions and operational carbon emissions. Embodied carbon emissions are the GHG emissions arising from the extraction of raw materials, transport, manufacturing, installation, maintenance, and disposal of construction materials, products, and systems used to construct buildings, roads, and other infrastructure [3,4]. On the other hand, operational carbon is the carbon emissions resulting from the operational or in-use phase of the constructed asset [5]. This includes the operation and maintenance of the asset. Together these two emissions are also called life cycle carbon emissions. Sometimes in practice, embodied carbon is divided into two sub-categories. Namely, upfront embodied carbon and life cycle embodied carbon. Upfront embodied carbon emissions are the emissions that correlate to emissions from the cradle to the turnover or handover of the asset [6,7]. Life cycle carbon includes the upfront embodied carbon emissions and the emissions resulting from the replacement, repair, refurbishment, and end-of-life stages [7].

With significant attention on the built environment sector, it is vital to consider a whole-of-life, asset, and industry approach. The sector's decarbonisation program would require several actions, including setting targets with appropriate milestones, standards to classify, measure, and report, digital tools to support work processes, databases and benchmarks, and a skilled workforce. The authors address some of these actions in this paper and describe a path forward. In section 2, the need for this study is described. Section 3 describes the details of ICMS, and sample projects in ICMS are provided in section 4. Section 5 discusses the role of a quantity surveyor in decarbonisation, and the concluding section summarises the paper's contents.

2. Need statement

Decarbonising the built environment sector is top of the mind for most industry professionals. Several initiatives are being announced to meet the targets announced by the governments and other entities. However, several issues remain to be addressed. In this research, three such issues are highlighted.

2.1. Focus on embodied carbon emissions

Over the past several decades, the construction industry has successfully created a program to reduce the operational energy use of assets. Research shows that most current environmental assessment methods focus solely on operational carbon emissions [8]. While this is important, an equal emphasis is now needed on efforts to reduce embodied carbon emissions. As the energy grid decarbonises and more energy efficiency measures are adopted, operational carbon emissions will continue to reduce. Embodied carbon emissions, therefore, will become an important area to address.

Approximately 11% of global GHG emissions come from embodied carbon emissions from the built environment sector. Table 1 shows the mapping of these emissions with various product life cycle stages as defined in EN 15978:2011.

Table 1: Embodied carbon emissions and product life cycle stages based on EN 15978:2011.

Life cycle embodied carbon emissions	A1 Raw material supply	Upfront embodied carbon emissions
	A2 Transport	
	A3 Manufacturing	
	A4 Transport	
	A5 Construction-installation process	
	B2 Maintenance	
	B3 Repair	
	B4 Replacement	
	B5 Refurbishment	
	C1 De-construction demolition	
	C2 Transport	
	C3 Waste processing	
	C4 Disposal	

It is estimated that over time the proportion of embodied carbon emissions will become a more significant proportion of emissions from buildings. More importantly, embodied carbon emissions cannot be reversed. This can be seen (figure 1) from a study conducted in Australia by the Green Building Council of Australia (GBCA) and thinkstep-anz [9].

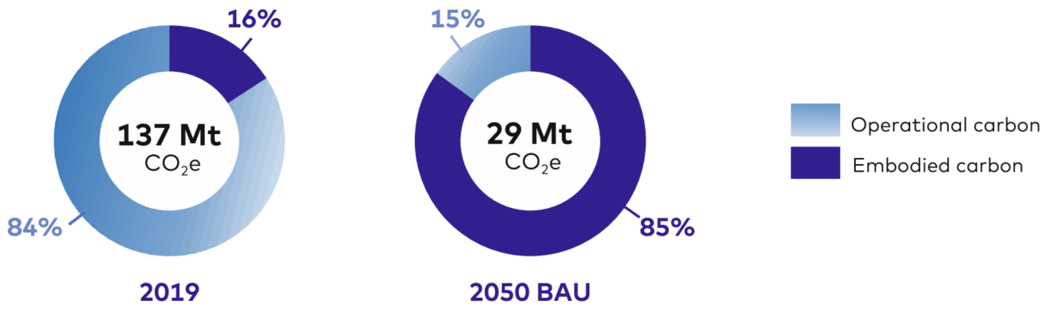

Figure 1: Changing proportion of embodied carbon emissions in buildings (source: [9]).

2.2. Need for standards to classify, measure, and report emissions

As reduction targets are being set, it is essential that the sector follows an international standard for classifying, measuring, and reporting emissions. The annual research conducted by the Royal Institution of Chartered Surveyors (RICS) reported that less than 30% of the respondents (see figure 2) currently measure embodied and operational carbon emissions [10,11].

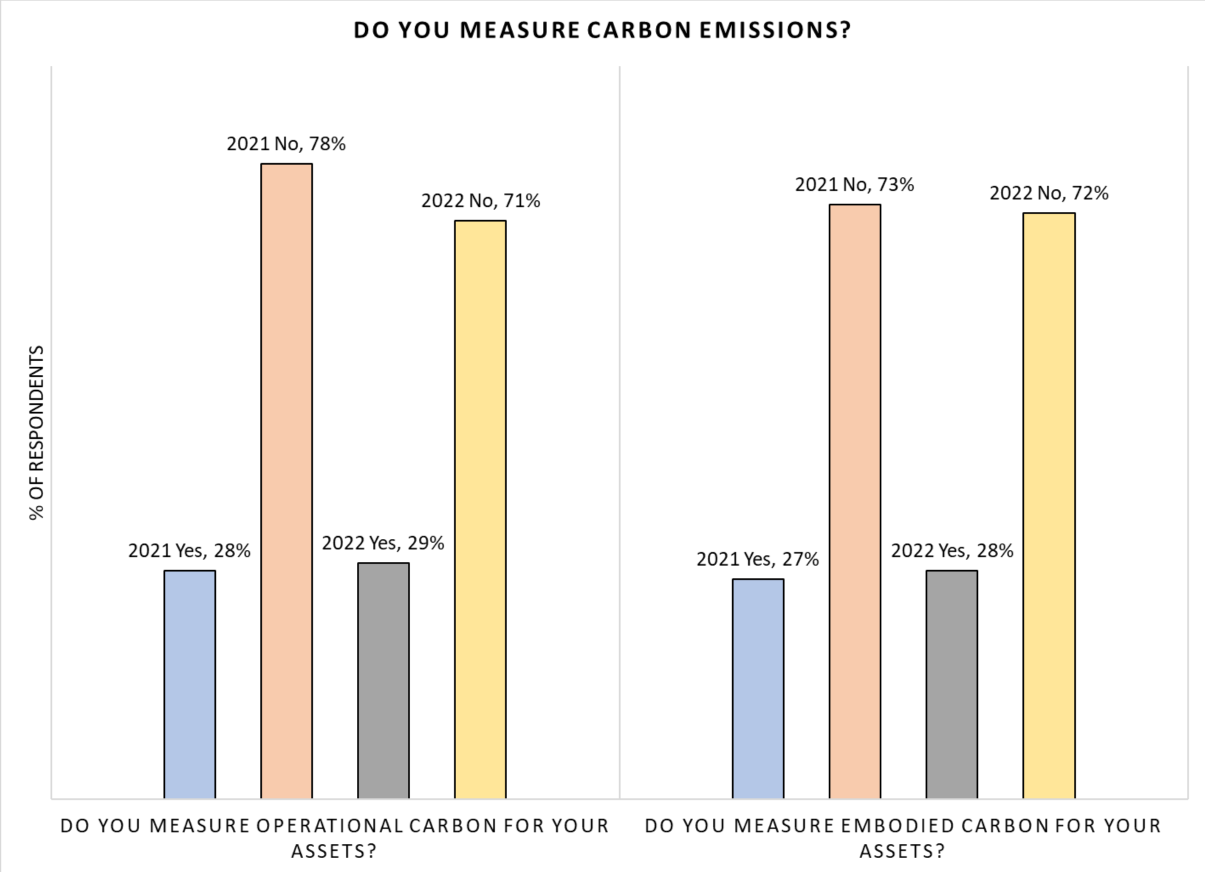

Figure 2: Currently, do you measure carbon emissions over the expected life cycle of assets? (Source: adapted from RICS Sustainability Report 2021 [11] and 2022 [10]).

It is not easy to manage and improve carbon emissions from constructed assets without measuring them. For various stakeholders to calculate the carbon footprint of new and existing assets, a set of artefacts, such as international standards for classifying, measuring, and reporting carbon emissions and standard calculation methodologies, are needed [7,12].

2.3. Integration of life cycle costs and carbon emissions

Embodied carbon emissions need to be incorporated into the design and construction decisions of projects and assets. Important decisions must be made considering the life cycle costs and carbon emissions. Not including life cycle costs would unnecessarily burden the project stakeholders with expensive options without careful analysis.

In previous studies, it has been established that there is a correlation between embodied carbon emissions and the cost of a building [13]. This signifies the importance of ensuring that life cycle costs are measured in sync with how life cycle carbon emissions are measured and reported. By using low-carbon materials can reduce embodied carbon emissions, reduction in the cost of construction materials, local sourcing with reduced transportation requirements, and optimise construction operations and processes [5]. All these strategies have cost implications over the asset's life; therefore, studying these in conjunction with the total cost of ownership is crucial. A consistent shared taxonomy of construction information pertaining to cost and carbon is needed.

3. International Cost Management Standards (ICMS)

To address the issues highlighted in the previous section, a coalition of global professional bodies came together to develop a life cycle cost and carbon emissions taxonomy. This taxonomy is described in the International Cost Management Standards (ICMS) that is available on the ICMS Coalition website at https://icms-coalition.org/.

ICMS provides a high-level structure and format for classifying, defining, measuring, recording, analysing, and presenting life cycle costs and carbon emissions associated with construction projects and constructed assets [14]. Figure 3 shows the taxonomy of ICMS.

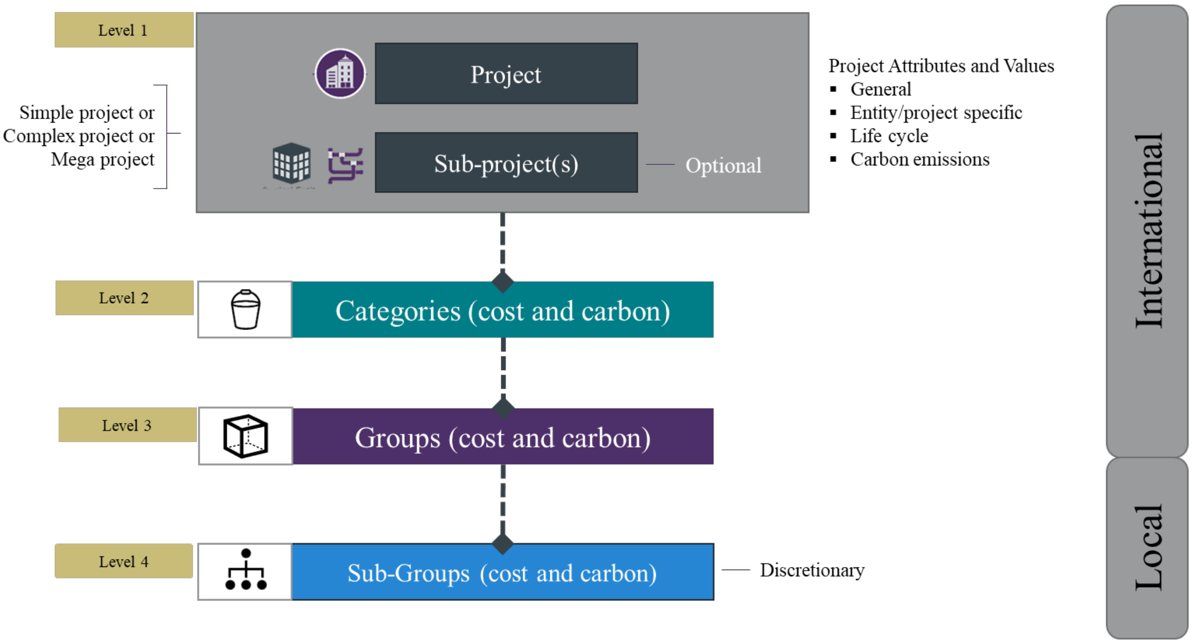

Figure 3: High-level taxonomy of ICMS.

ICMS offers a high-level framework against which life cycle costs and carbon emissions can be classified, defined, measured, recorded, analysed, presented, and compared. The hierarchical framework has four levels [14]:

- Level 1 Projects or Sub-Projects: A single or series of construction intervention(s) with a single purpose or common purposes to create a series of or single constructed assets commissioned by a client, or group of clients, with a defined start and end date. A project may comprise several sub-projects.
- Level 2 Categories: a division of project or sub-project costs and carbon emissions into Acquisition, Construction, Renewal, Maintenance, Operation, and End of Life (ACROME).
- Level 3 Groups: A division of a category into broad groups to enable easy estimation or extraction of cost and carbon emissions data for quick, high-level comparison by design discipline or common purpose
- Level 4 Sub-Groups: A division of a group solely according to its functions, services, or common purposes to enable alternatives serving the same function to be compared, evaluated and selected

Each Category, Group and Sub-Group are used to report costs and carbon emissions. The composition of Levels 2 and 3 is mandated for all projects and sub-projects, although discretion is allowed at Level 4.

To enable consistent and concise evaluation and comparison between different projects or different design schemes, ICMS provides a set of Project Attributes and Values describing the principal characteristics of each project or sub-project. These attributes have been carefully selected and are limited to those that have a direct bearing on the costs and carbon emissions. Comparisons are made possible within project types by these Project Attributes and Values.

Figure 4 shows the taxonomy used in ICMS for life cycle costs and carbon emissions. The A-CROME structure at level 2 (categories) is the summary level where project and sub-project level costs and emissions are provided. Below level 2, a common set of reporting groups and sub-groups is used to provide details for each category consistently.

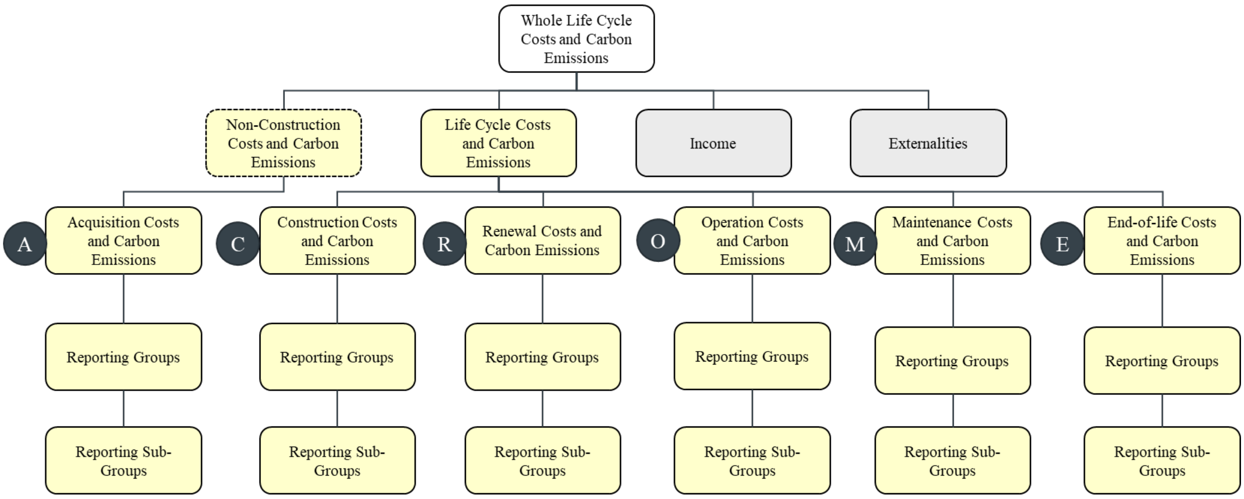

Figure 4: Integrated taxonomy for life cycle costs and carbon emissions.

Figure 5 shows the groups for each category in ICMS. The construction, renewal and maintenance categories use a common set of groups.

Reporting costs and carbon up to the group level in ICMS is mandatory, and sub-groups for cost and carbon are provided as a recommendation. End-users can utilise their local classification system at this level by mapping to level 3. This feature of ICMS allows the users to map elemental, trade-based or work package-based classification systems to ICMS (see Figure 6). The aim is not to replace existing local standards but to provide an internationally accepted reporting framework into which data generated locally can be mapped and analysed for comparison.

In time, it is expected that ICMS will become the primary basis for both global and local construction cost and carbon emissions reporting.

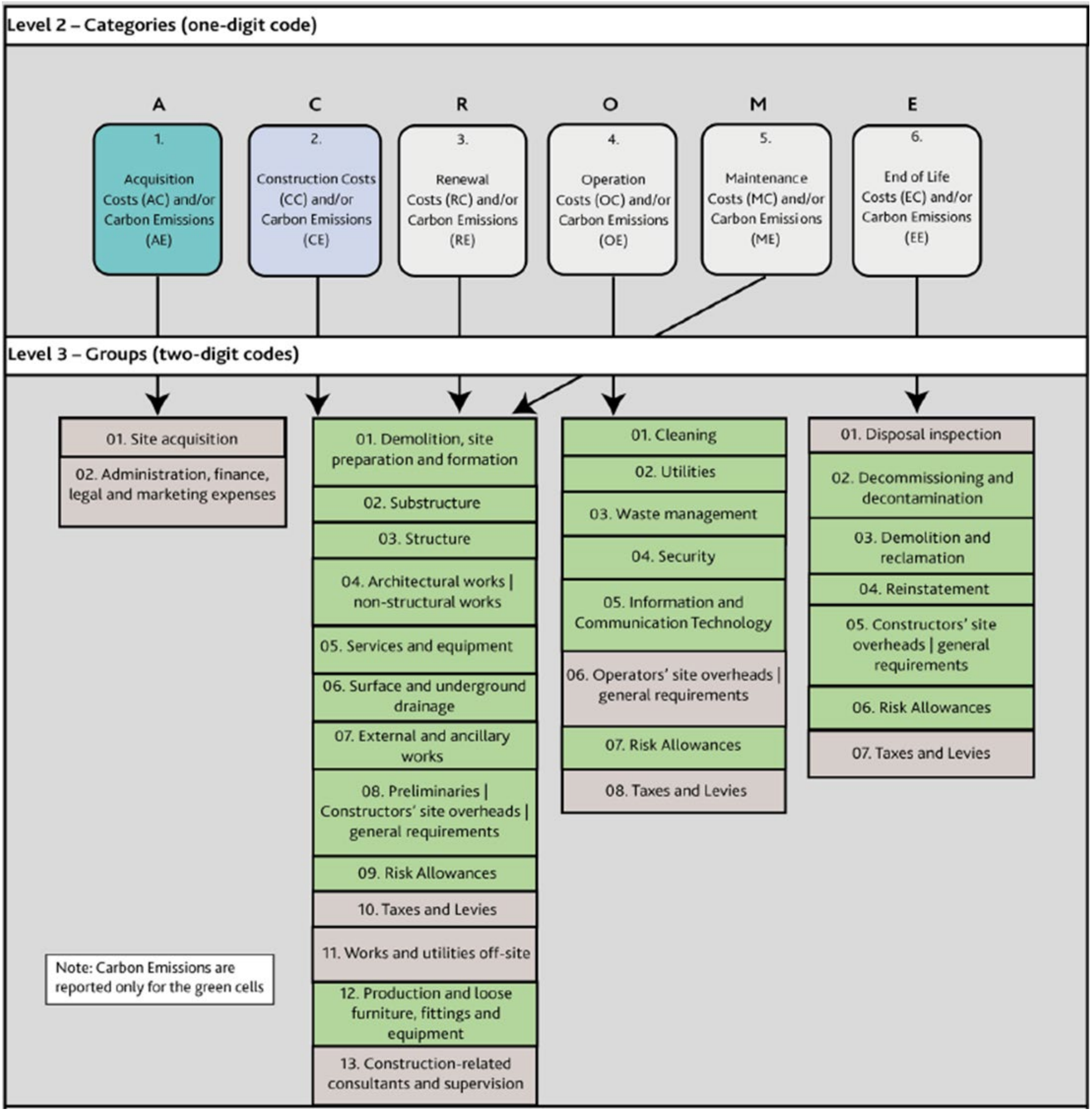

Figure 5: Groups for the ACROME categories.

3.1. Aims of ICMS

ICMS has been designed with the following aims [14]:

- construction life cycle costs and carbon emissions to be consistently and transparently benchmarked (comparative benchmarking)
- the causes of differences in life cycle costs and carbon emissions between projects to be identified (option appraisal)
- correctly informed decisions on the design and location of construction projects to be made at the best value for money (investment decision-making)
- data to be used confidently for construction project financing and investment, decision-making, and related purposes (certainty).

3.2. Applications of ICMS

Applications of ICMS include, but are not limited to [14]:

- global investment decisions
- international, national, regional, or state cost and carbon emission comparisons
- feasibility studies and development appraisals
- project work including cost and carbon emission planning and control, setting carbon budgets or reduction targets, cost and carbon emission analysis, cost and carbon emission modelling, and the procurement and analysis of tenders
- dispute resolution work
- reinstatement costs for insurance
- valuation of assets and liabilities

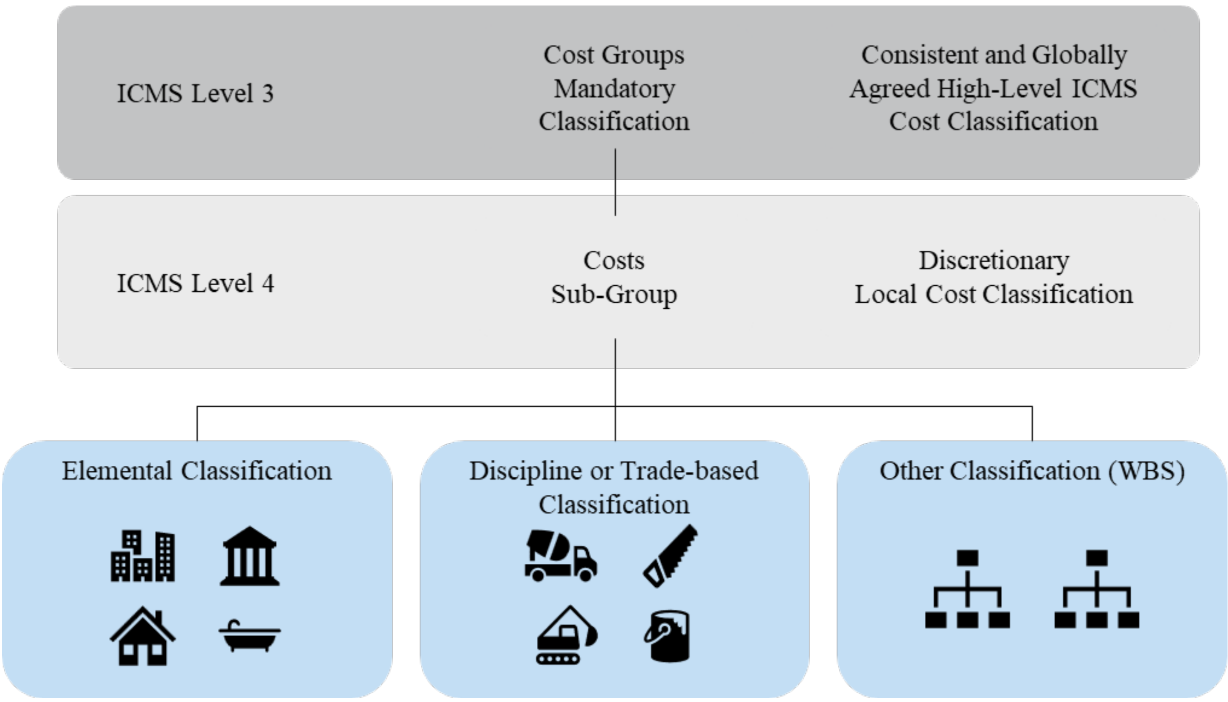

Figure 6: Mapping ICMS to local classification systems.

4. Sample projects

This section of the paper provides two case studies in the ICMS format.

The worked example in Table 2 shows how ICMS categories and groups are typically used for life cycle cost reporting. ICMS provides transparency on the capital costs and the other life cycle or facility management costs in a format that enables easy comparison for analysis and benchmarking by ICMS categories and cost groups [15]. This supports identification of the option that provides the best value for money, in terms of the total life cycle cost, as well as setting the forecast budgets for running the facilities over the defined life cycle period; in this case, 30 years. In ICMS end users can use their local and regional estimating and planning systems and map the final values to ICMS. In addition to providing life cycle cost information users are also required to provide life cycle analysis specific project attributes and values such as period of analysis, discount rate used, renewals planned, and hand-back obligations at end of life or period of analysis.

Having a global standard for the presentation of construction and other life-cycle costings that can be embedded in building information models and other new technologies will transform cost information for projects. ICMS 2 will help to bridge the capital and revenue divide and enable the adoption of whole-life costing as the norm for future construction and related facilities management and procurement decisions.

This supports the identification of the option that provides the best value for money in terms of the total life cycle cost and setting the forecast budgets for running the facilities over the defined life cycle period, in this case, 30 years. The source for this example is an anonymised office project life cycle cost plan provided by Faithful+Gould.

Table 2: Case study showing life cycle costing of alternatives.

ICMS breakdown Cost categories/ sub-cost groups	Alternative 1 Base date Q1 2020, new build base case option, IPMS 2 Internal = 12,000m²	Alternative 2 Base date Q1 2020, acquire/fit-out alternative option, IPMS 2 Internal = 11,800m²	Cost variance
Acquisition costs	Land not included	£18.5m (excluding finance)	–£18.5m
Construction costs	£25.5m	£5. 5m	£20m
Renewal costs over the 30-year life cycle	£6.3m	£6.5m	–£0.2m
Operation costs	Forecast (30 years): £30.1m	Forecast (30 years): £29.2m	Forecast (30 years):
End-of-life costs	Out of scope	Out of scope	N/A
Other facilities management costs (option, if in scope)	Out of scope	Out of scope	N/A
Sustainability (BREEAM rating)	Out of scope	Out of scope	N/A N/A
Rental income	Out of scope	Out of scope	N/A
Service charges	Out of scope	Out of scope	N/A
User-defined (other costs)	Out of scope	Out of scope	N/A
Total life cycle cost	£69.2m	£66.9m	£2.3m

Further this ICMS approach was embraced in the Australian Institute of Quantity Surveyors' (AIQS) 2022 AIQS Information Paper: Life Cycle Cost analysis, 1st edition [16].

Table 3: Case study showing carbon footprint calculations.

Code	Category	Buildings	
		Emissions (tCO2e)	tCO2e/Qty
	Project Quantity		29,127
	Quantity's Units of Measurement		Square meters
1.	Acquisition Carbon Emissions (where significant)	Not significant	Not significant
2.	Construction Carbon Emissions	15,678	0.538
3.	Renewal Carbon Emissions	7,180	0.246
4.	Operation Carbon Emissions	8,005	0.275
5.	Maintenance Carbon Emissions	9,100	0.312
6.	End of Life Carbon Emissions	759	0.026
7.	Benefits and loads beyond the system boundary	-2,106	-0.072

The second example is carbon footprint reporting for a new building project using ICMS. The example is adapted from a Whole Life Carbon Assessment Report for a proposed development of residential and commercial buildings (published in 2020 to support a UK planning application). Carbon emissions are reported across the ICMS categories. The report includes both embodied carbon and operational carbon. The users also provide carbon emissions related project attributes and values such as boundary of carbon reporting, name of carbon assessment tool(s) used, main source(s) of material quantities for carbon emissions assessment, main source(s) of carbon emission factors, and source(s) (and associated percentages) of operational energy.

ICMS provides a reporting framework for carbon emissions to be used in conjunction with existing standards, guidance and tools, and emerging developments that are coming on stream to support decarbonisation. By using a common taxonomy for life cycle costs and carbon emissions decision makers can compare the costs associated with each carbon reduction strategy when compared to the baseline. This allows cost effectiveness of decarbonization strategies.

The project team members can develop these reports with support from an independent quantity surveyor. As more projects and assets are reported in the ICMS format, a benchmarking database can be created for providing early cost and carbon advice to project sponsors.

5. Role of the Quantity Surveyor (QS)

It is essential to undertake decarbonisation studies early in the life cycle of an asset. This generally means decarbonisation is seen as a design and engineering task, especially for new assets. However, without downstream stakeholders' support and participation, achieving the decarbonisation targets may not be possible.

A cost management professional or quantity surveyor (QS) is central to calculating embodied carbon emissions [16]. Quantities of materials are used to determine the carbon footprint of the materials used for constructing, renewing, and maintaining constructed assets. These quantities are generally calculated from design and engineering documentation by a QS. Any error in these calculations can provide an incorrect value of the carbon emissions. QSs can help measure embodied carbon and assist in the choice of materials, systems, and components for construction by comparing various alternatives. Approximately 15% of the respondents to an RICS survey in 2022 reported using their skills in measuring embodied carbon emissions and materials selection [10]. However, in another survey conducted by RICS, 31% of the respondents suggested that QS and cost management professionals should take a leading role in carbon calculations for projects and assets. 59% responded that they should play a supporting role, with only 10% of the respondents recommending that they play no role in these calculations (see Figure 7).

More specifically, a QS can help clients and project sponsors with the following services [17,18]:

- Development of sustainability strategy, including decarbonisation strategy for their projects, programs, and portfolio of existing assets
- Conduct life cycle cost appraisal
- Advice on setting targets, adopting a rating system, creating reports, and implementing international standards such as the ICMS
- Compare life cycle costs of low-carbon materials, systems, and components
- Develop a benchmarking database or help access a database
- Advise on digital technologies, data requirements, and information management processes
- Keep track of local policies and regulations related to decarbonisation
- Suggest procurement routes
- Monitor actuals closely during construction

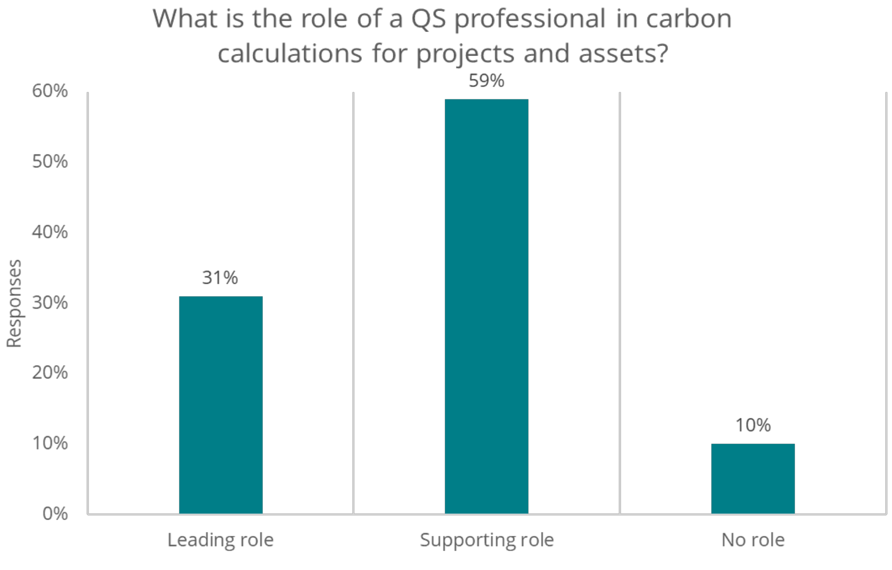

Figure 7: Role of cost management professional or quantity surveyor (QS) in carbon calculations.

This means the QS can easily use ICMS to analyse trade-offs between cost and embodied carbon. In turn, professionals can use this standard to weigh up the total costs of a project against the cost of reducing carbon, a vital piece of information that can be used to make critical decisions in the early stages of construction projects.

6. Conclusions

Decarbonising the built environment sector will be crucial to addressing the climate crisis. Taking a life cycle approach, reducing embodied carbon for new and existing assets, and paying close attention to costs will be important in the decarbonising journey of the sector [10]. With the help of two examples this paper has shown how an integrated taxonomy for life cycle costs and carbon emissions can assist decision makers in making prudent choices. Cost management professionals and quantity surveyors (QS) are poised to take a central role in the process and advise project sponsors on a holistic carbon strategy. The work of the professionals, especially the QS, needs to be improved by a need for accepted standards, tools, databases, benchmarks, and guidance, which is seen as the principal barrier to reducing carbon emissions [10]. Other issues that must be addressed include high costs or low availability of low-carbon products, materials, and components. As professionals expand their roles, critical gaps in knowledge and skill shortages must be filled. The industry needs a decarbonisation toolkit to break down these barriers. The components of this toolkit include standards, data, and skills that the industry can rely on and use. There have been some advancements in this area. For example, ICMS now provides a globally consistent and integrated method for classifying, measuring, and reporting life cycle costs and carbon emissions for buildings and infrastructure projects.

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