The Hawkins\Brown Emission Reduction Tool

It is now globally accepted that human activity has caused rapid climate change. The Paris Climate Agreement - the first ever universal and legally binding agreement on global climate change - was adopted at the Paris climate conference (COP21) in December 2015, recognising that urgent action was needed by all countries to limit temperature rises and address the climate and biodiversity emergency. The built environment is one of the biggest contributors to carbon emissions worldwide, with the UK Green Building Council stating that the sector accounts for 40% of total annual emissions within the UK.[1] The construction industry therefore has a collective responsibility to reduce emissions swiftly and effectively.

There are primarily two ways in which the built environment generates carbon emissions: from energy used during operation (operational carbon) and from the materials used for building and maintenance (embodied carbon). While the industry is increasingly interrogating the operational carbon of construction projects due to energy use, embodied carbon has historically been less understood and less monitored. This is for several reasons:

- difficulties establishing an agreed method of measurement;
- defining the boundaries of measurement;
- gaining data about the sheer variety of different materials and products.

Quantifying the full carbon emissions of an individual project over its lifetime has historically been a complex task carried out by specialists on a project-by-project basis. If the data is calculated at all, it is reported late in the design process and is rarely used to guide decision-making on materials that influence a project's carbon emissions.

In 2012, Hawkins\Brown and the University College London (UCL) Institute for Environmental Design and Engineering (IEDE) agreed to co-fund an Engineering Doctorate (EngD) project seeking to improve the visualisation of embodied carbon and its impact on the whole life carbon (WLC) of a project. The aim was to improve the understanding of - and discussion about - the retention, refurbishment, and creative re-use of existing buildings as a contribution to the reduction of overall emissions.

One output of this research was the Hawkins Brown Emissions Reduction Tool (H\B:ERT) – a BIM based tool for a rapid reporting of embodied carbon in buildings. This paper outlines the tool's development and initial lessons learned from its use at Hawkins\Brown.

H\B:ERT's development

As part of an evidence-based approach to sustainability, Hawkins\Brown signed up to the RIBA 2030 Climate Challenge and 'Architect's Declare' commitments. Architects Declare is a network of like-minded architectural practices that have signed a declaration committing to collectively combat the climate and biodiversity emergency. As part of these, we committed to 'Target net zero whole life carbon for new and retrofitted buildings by 2030, by following the RIBA 2030 Climate Challenge targets'[2] and to 'include life cycle costing, whole life carbon modelling and post occupancy evaluation as part of our basic scope of work, to reduce both embodied and operational resource use.'[3]

To significantly improve early stage decision-making in projects focussing on low carbon strategies, a design approach was needed that encouraged architectural and engineering teams to work in tandem to balance carbon loads from energy and materials over the whole lifecycle of a project.

H\B:ERT was therefore developed as an important way of measuring, tracking, reporting, and sharing knowledge to reduce carbon emissions as part of a wider industry imperative.

RIBA guidance around Whole Life Carbon (WLC), specifically the publication of *Embodied and Whole Life Carbon Assessment for Architects*[4] and the recently updated RIBA Plan of Work were used to guide the development of H\B:ERT, which has been specifically developed to fit into the design process and involve the minimum workload at each stage to achieve the maximum results. This enables embodied carbon analysis on all Revit projects in the practice at early design stages, something that is crucial to achieve maximum carbon reductions.

The tool has so far developed over three phases.

The first phase: manual Revit input embodied carbon calculation
As part of Hawkins\Brown's initial research collaboration with Dr Yair Schwartz at UCL IEDE, embodied carbon was measured manually. This was done by retrieving materials and quantities data from a BIM model and then manually calculating the embodied carbon of different building components. The shortcomings of this labour-intensive process made it clear that a tool could be developed to automate the calculation of Embodied Carbon and the immediate reporting to the design team.

The second phase: H\B:ERT v1 Revit plugin
Developments in 3D modelling packages and improved internal workflows allowed the development of a digital tool that could be plugged into Revit to measure material volumes directly through the creation of custom schedules, the foundations of which were discussed in Schwartz et.al (2016).

H\B:ERT initially launched in 2018 as an open-source Revit plugin designed to measure embodied carbon and raise awareness of the decision-making potential of the data if gained early enough in the design process. Distinct from other freely available tools, H\B:ERT created instant visualisations of the embodied carbon within various materials in the model. Furthermore, H\B:ERT was designed to deliver robust analysis for non-experts. As such, it works seamlessly, without interrupting the users' design workflow.

The tool was uploaded to the Hawkins\Brown website[5] and has been available, free of charge, for other practices willing to share data to help aid the development. Our view was that sharing knowledge across the industry and providing tools that are more suitable for use by designers making critical decisions about building materials would be an effective way to reduce the industry's impact on the environment.

The third phase: H\B:ERT v2 Revit export to Webtool
A further iteration of the tool was delivered in 2020. This transformed H\B:ERT into a WLC tool that monitors and visualises the balance between both operational carbon and embodied carbon of buildings and components through new bespoke visualisation in Revit, and a web app. This is currently for use within Hawkins\Brown only.

How does it work?
The main aim of this latest version of H\B:ERT was for it to be quick and simple to use. This involved fully integrating the H\B:ERT approach into the Hawkins\Brown's BIM workflows. Our Sustainability and BIM teams collaboratively developed the existing suite of Revit templates to include a carbon material library, the numerous parameters required to calculate a project's whole life carbon and the WLC splash screen, which sits front and center in all our Revit models (Fig 1).

By foregrounding the data, we have raised awareness of the importance of monitoring, measuring, and reducing WLC on every project in the office, placing the power to reduce carbon emissions within the control of the project designers rather than specialist consultants.

Adding this functionality required the Digital Design team to develop several tools using the Revit API to circumvent numerous limitations imposed by Revit's own functionality. For example, calculating the volume of all elements in the model proved problematic, as certain elements, such as curtain wall mullions, do not return a volume. Not including these elements in the calculations could potentially skew H\B:ERT's output. Though it was possible to manually bypass this in previous iterations, it was a long process. We addressed this by developing workflows while automating a range of functionalities within the H\B:ERT workflow, reducing the time required to set up models and run H\B:ERT by 70%.

H\B:ERT's workflow is as follows (Fig. 2):

1. The user applies materials from a central library to all elements in a project.

2. All elements are assigned to an elemental category, for example, 'external envelope'.

3. On running H\B:ERT the material, volume, and category of every element in the model is recorded along with general project information (Name, Location, Client)

4. All recorded data is pushed to a central database.

5. The user then logs into the H\B:ERT website to view and analyse the captured embodied carbon data.

The biggest technological changes for H\B:ERT v2 have been the shift to its web-based platform and decoupling aspects of H\B:ERT from Revit. Previously, Revit limited how we could visualise and analyse the embodied carbon data. In this iteration, moving the data into a centralised database enabled us to store WLC data from all our projects in a consistent format. The front end of the web app allows this data to be visualised in a more appropriate graphic style, breaking down complex information into simple, legible graphs.

Other benefits of storing the data in a centralised database are how quickly data runs can be compared and analysed against each other and the ability to measure projects against set benchmarks and other projects in the database. These benefits allowed greater flexibility and scalability overall. Over time, this database will grow and provide further insight on the impact of whole life carbon across all sectors and project types.

Visualising Whole Life Carbon

H\B:ERT makes the decision-making process surrounding the optimisation of operational carbon and embodied carbon easier by translating complicated data into simplified graphs and charts. It also offers the use of benchmarking to actively encourage the reduction of carbon emissions, in turn contributing to better benchmarks as the database of projects grows.

Focusing on H\B:ERT v2, this paper demonstrates how data visualisation can help reduce overall carbon emissions and energy use by making the WLC analysis of a project accessible to both architects and the wider design team during all design stages.

H\B:ERT v1 integrated embodied carbon (EC) calculations seamlessly into the design process by allowing the designer to visualise the data as they designed in Revit. This encouraged users – even those who lack the resources and knowledge of EC - to make informed decisions about EC during the design process. This initial version displayed which materials emit the most EC, allowing the user to consider this in their design decisions and reduce the EC throughout the design process.

The direction of the current RICS and RIBA guidance promotes the principle of conducting whole building analyses. While these are useful, they can only be done once the design is complete and sufficient information is available to carry out a full calculation. We have therefore found elemental analysis at an early design stage to be a very powerful use of H\B:ERT (Fig 3).

From reviewing our whole building results carried out at RIBA Stages 4 and 5 (Technical Design and Manufacturing and Construction), we found that certain elements have more effect on the final result than others. This allowed us to focus elemental studies at earlier design stages 2 and 3 (Concept Design and Spatial Coordination) to compare material options. Using the project analyses from the first version of H\B:ERT to establish targets related to the RIBA 2030 Climate Challenge targets, and breaking them down into elemental targets, we identified that the 'big wins' at the early stages of a project are clearly the structure and façade (Fig 4).

This is, however, only one part of the wider picture and does not include the WLC elements such as operational energy, carbon sequestration, and energy generation. H\B:ERT v2 addresses this omission by allowing for comparisons and breakdown of the data not only by material, but by building element (Fig 5). This encourages a holistic approach to EC and WLC reduction, allowing the designer's focus to be on making reductions to high carbon elements such as the façade or structure. Furthermore, the visualisation of the lifecycle stages - which integrates the operational carbon - encourages the designer to both think about the project's lifespan and collaborate with the design team to reduce the total carbon emissions.

This is done by monitoring the data, then making sensible, iterative, and collaborative design decisions based on the information available in H\B:ERT v2. As the data is live in each of the Revit models, the process is quick, allowing continuous improvement to the design. Once the design is analysed, the graphic representation allows the design teams, clients, and consultants to easily understand the 'big wins' and what improvements can be made. For example, different wall build-ups or façade materials generate different operational energy loads, so an optimum can be found through iterative design. This, in turn, encourages collaboration, as it makes the seemingly complicated ideas of embodied and whole life carbon manageable and understandable.

Databases and libraries

In partnership with the UCL Institute for Environmental Design and Engineering (IEDE), Hawkins\Brown integrated embodied carbon custom parameters within the standard materials used by the practice in Revit. We further developed this into standard templates and eventually into H\B:ERT v1.

To increase the uptake of the tool, a core part of its development has been ensuring that the input of embodied carbon is as straightforward as possible. It cannot interrupt the usual design workflow. The embodied carbon measurement works by measuring the volume of all materials tagged in the Revit model before applying carbon coefficients, broken down into lifecycle stages (product, construction, use, and end of life) in line with BS EN 15978:2011, RICS, and RIBA guidance.6 It currently uses the Circular Ecology ICE (Inventory of Carbon and Energy) database by default but can also work with alternative datasets where available.

The UK is behind other countries in providing available data sources, specifically as there is no centralised, free database. A database can be gathered from collecting relevant Environmental Product Declarations (EPDs) which are independently verified documents that follow a standard method of calculation and reporting to provide clear and concise data on the environmental impacts of a product or material – a life cycle assessment. EPDs are provided by manufacturers for either products or materials to International Organization for Standardization (ISO) and/or European (EN) Standards, for example, EN15804 standards. The EN15804 standards make sure that EPDs provide data for each different life cycle stage of a product through a set of environmental indicators. This information can then be calculated to assess the impact of using that product or material within a specific project. Each tool has had to either generate its own database or pay for the use of an external one, which is problematic as it inhibits wide-scale use. In response to this, we have researched reliable and free data sources for H\B:ERT.

1. Its default is the ICE (Inventory of Carbon and Energy, Circular Ecology) database initially developed from research at the University of Bath. This database is related to materials rather than products, therefore ideal for generic early-stage measurements. It has been generated in part by using an average of EN15804 EPDs and Life Cycle Assessment (LCA) data sources for each material through a large literature review which defines a 'cradle to (factory) gate' scope.
2. As the industry has developed its knowledge and need for product data, an increasing number of EPDs have been made freely available. They can be procured from suppliers as teams develop the detail of their project and integrate specific products into their design.

There are a few things we have noticed and continue to investigate:

- It is important to make sure that the chosen EPD matches the product, as there can be variations between panel sizes and thicknesses and production location. Furthermore, some suppliers do not yet provide an EPD for each and every product.

- The ICE database provides consistently higher embodied carbon for most products, meaning H\B:ERT generally reports a higher figure than other tools which utilise paid databases and more EPD data.
- Suppliers tend to benefit from low values on their EPDs, so at Hawkins\Brown we compare with the ICE database to take a balanced view, choosing the most appropriate data source per project.

The overall aim is to use the data as a design tool to make the right low-carbon decisions. Therefore, we continue to use the ICE database to include a carbon contingency at the early design stages, prior to introducing EPDs as the project evolves.

The development of H\B:ERT v2 included generating a centralised material library, along with hybrid build-ups for use at early design stages. This is key to making the experience easy for the user and ensuring the carbon data used is consistent, especially before specific products are chosen.

The embodied carbon figures calculated through H\B:ERT v2 are used to coordinate WLC calculations with inputs from other consultants such as services and structural engineers. This approach enables each discipline to take ownership of their impact on the total WLC of a project with the architect leading the coordination of these separate studies in a WLC model.

The British Standard EN 15978:2011 and RICS guidance breaks down embodied carbon data into different building element categories that are within the control of the design team. H\B:ERT aligns to these categories, adding more detail to which elements sit in each category for consistency purposes, to ensure a full analysis scope (Fig. 6).

The assessment scope of an LCA analysis will define which life cycle stages have been included and which building elements have been analysed. Figure 7 illustrates the life cycle stage modules A-D used to define the assessment scope. The current RICS and RIBA guidance does not provide sufficiently rigorous guidance in several areas of LCA calculation. For example, the RIBA guidance describes the unit of measurement to be reported in Net Internal Area (NIA)7 however the RICS guidance notes the unit of measurement for the floor area in terms of Gross Internal Area (GIA)8.

Whilst there are emerging standard formats for reporting the results and assessment scope of an LCA analysis such as the Greater London Authority draft Whole Life Carbon assessment template v.1.1[9], there can still be a discrepancy in the data sources used for each material. For example, EPDs can range from being product-specific or industry-wide (generic) based either on a specific product or a broad product type or material. Not all EPDs are verified by a third party, and some manufacturers may not report against all life cycle stages, for example by omitting much of stage B (use stage). It appears possible for manufacturers or architectural teams to report total whole life carbon figures that are inconsistent between products and projects due to the current lack of clarity within the guidance available and lack of regulation.

To try and combat this manipulation of results, H\B:ERT takes a very different approach by creating a centralised material library containing more than fifty default materials based on the free, publicly accessible ICE database of construction materials' embodied carbon. This allows the user to compare the results from any project using like-for-like materials, so they can assess the impact of form and material choice at an early design stage.

The material and component library is a live resource, accessible from a centralised part of the H\B:ERT v2 web tool. Each time a component build-up (e.g. a wall made of different layers of materials and products) is tested, it is added to our in-house 'component library', ensuring a consistent method of measuring and indicating thermal performance. H\B:ERT relies on Revit modelling, which is crude at the early design stages and can give misleading information, but having data for specific build-ups allows teams access to a more accurate set of knowledge on which to base their decisions. As a result, rarely used materials, which may appear as low-carbon specifications, can gain traction.

Using H\B:ERT to reduce carbon

The phased development of H\B:ERT has allowed us to continuously review our approach to sustainable design across the practice and beyond. Alongside the technical developments of H\B:ERT v2, we have also devised an approach using H\B:ERT that reduces whole life carbon emissions while enhancing the local environment and ensuring the wellbeing of a building's users. We call this approach 'whole life design'.

In order to meet the RIBA 2030 Climate Challenge, buildings designed today must meet zero carbon targets and we believe this should be through a whole life carbon analysis. H\B:ERT allows us to ensure the process is visual and collaborative, contributing to informed decision-making. Implementing this approach across all Hawkins\Brown projects enables us to take a holistic design approach, covering:

- Energy in use
- Embodied carbon
- Energy generation
- Carbon sequestration

By analysing H\B:ERT's outputs, we have established several key actions which architects and design teams can undertake to reduce embodied carbon and, therefore, whole life carbon.

1. Early-stage decision-making in a building project is crucial. This is done by testing comparative options and locking in the low-carbon materials by the end of RIBA Stage 2 (Concept Design). In our experience it is almost impossible to create a low carbon project without doing this.
2. Architects often work on projects from the competition stage and in this context, having a basic understanding of the carbon load associated with different material choices is even more important. Visual decisions are often made very quickly, based on response to a site context. Detailed analyses will not be possible at this stage, but rules of thumb can help good choices to be locked into the design.
3. To focus attention on the 'big wins', it is more useful to concentrate on elemental analyses including the structure and façade at RIBA Stages 2 and 3 (Concept Design and Spatial Coordination).
4. Communication with clients and project managers is essential to ensure the programme is appropriate, that the consultant scopes include the actions required, that appropriate design freeze periods are allowed and that carbon reductions are included in early-stage meetings and workshops.
5. Understanding the larger impact of certain raw materials compared to others is useful. Metals perform the worst and bio-based products generally contain less carbon. However, longevity must be taken into account. With a lot of materials there are ways of reducing the impact, depending on the control the designer has over the supply chain. For example, using recycled metals and designing a project for deconstruction represents a real reduction in carbon. Concrete specifications with cement replacement and recycled reinforcements can save up to 30% compared with a 1990 baseline.[10]

H\B:ERT has allowed us to develop some rules of thumb [Fig. 8] to reduce embodied carbon. We are very aware that the sub- and super-structure have the largest impact on the overall total. As such, over-sized structure, building height, basements, and even steeply sloping site conditions can all increase the overall carbon per square metre. This is the main reason that refurbishment projects perform so well in whole life carbon analysis; in fact, we have found that currently, refurbishment projects are the only ones to be able to meet the RIBA 2030 Challenge embodied carbon targets.

Benchmarking the data against other buildings and best practice targets allows the teams to challenge themselves to reduce the weight of building elements through refinement or lightweight material use. Form factor (the ratio of GIA to the area of envelope) must also be optimised as the façade is the second largest carbon load in a project. These measures have the multiple benefits of reducing structural loading, material use overall and the sub-structure requirements.

On every project we now recommend the testing and visualising of specification changes for materials such as concrete and steel to include cement replacement and recycled content, respectively. In addition, we are exploring alternative internal partition systems to the standard metal stud wall. Showing clients and design teams the scalable effect of small changes can be helpful to drive large carbon reductions.

The relationship of up-front carbon in materials to their replacement cycle can have a large effect when looking at the overall whole life carbon compared to the carbon emitted following project completion. This is one of the major reasons we support whole life carbon analysis over and above the measurement of carbon emissions in only construction (life cycle stage A). Without looking at the whole, there is a risk that a low carbon building will need extensive maintenance and emit more overall.

For the same reason, the use of timber and bio-based materials can be beneficial over the whole life cycle of a building. Bio-based materials tend to have a lower embodied carbon figure per cubic metre, and they store carbon, so it is not released into the atmosphere; also known as sequestration. If disposed of in the correct way at the end of life the sequestration can be taken into account in the whole life calculation, improving the overall figure. Care must be taken not to include the sequestration benefit in the up-front figures only, as the true gains are only realised at the end of life.

A further big impact of H\B:ERT v1 and v2 has been revealing the significant difference between embodied carbon assessments done at the early stages of design and those carried out when more detail is known. For example, it is rarely the final material that has the most impact on the resulting carbon figure. Also, between Stages 2 and 4 (from Concept to Technical Design), a lot of secondary steel can be added. Being aware of this can help with refinement or decisions on systems. This led us to include some contingency and factor support system requirements into the build-up analyses at Stage 2 (Concept Design).

An integrated sustainable design methodology by RIBA stages

In summary, we have used the H\B:ERT tool to establish a clear sustainable design methodology for the practice. This integrates sustainable design principles during site analysis - before a building is drawn on the site - and monitors it through regular design reviews. Below is a non-exhaustive list of discussion points at each stage:

Start up

- Analyses of site, existing building, and climate are undertaken
- The opportunities and constraints are identified
- The sustainable design narrative is discussed
- EC rules of thumb are employed if at competition stage
- Material Resource Efficiency (MRE) is explored
- RIBA 2030 Climate Change targets are documented
- Establish the Soft Landings process to ensure designs meet client expectations

RIBA Stages 1-2 (Preparation and Briefing and Concept Design)

- Massing models are developed and in-use energy is explored with engineers;
- The main solid and glazed ratios are established in line with brief and site orientation (where it is possible to change)
- Initial comparative energy, sunlight, and daylight models are developed
- Embodied carbon ‘big wins’ are proposed using H\B:ERT
- Access to the centralised material library and early-stage build-ups are encouraged
- Lifecycle costing is useful at this stage to guide big project decisions

RIBA Stage 3 (Spatial Coordination)

- Material choices are defined and tested using embodied carbon tool and MRE principles
- Fabric performance, window arrangement, and overheating strategies are finalised
- Part L calculations carried out to test the energy strategy
- Energy generation options are confirmed
- An understanding of whole life carbon performance is established using H\B:ERT

RIBA Stage 4 (Technical Design)

- Products and materials are selected on the basis of embodied carbon, responsible sourcing, and chemical composition
- MRE is embedded into the technical drawings and specifications
- Site waste management and the products' end-of-life are considered
- Whole life carbon figures are taken again using H\B:ERT to confirm the expected performance in-use

RIBA Stage 5 (Manufacturing and Construction)

- The Contractor Sustainability Champion is appointed
- On-site reporting and testing of performance during the construction stage
- Soft Landings handover training provided
- Site waste is monitored
- Works are reviewed against design information, and any material changes are investigated prior to agreement

Completion and In-Use

- Support is given in energy monitoring and optimisation through Soft Landings or similar
- A 'Building Use Guide' is produced
- Post Occupancy Evaluation is undertaken

Reflection: the impact of H\B:ERT

H\B:ERT v1 is one of the only iterative embodied carbon design tools in the UK that is available free of charge. It is designed to plug into a Revit model so that measuring embodied carbon is not an additional task for the designer – it is a natural part of the design process. The intention was always that the tool was for design, not only reporting.

H\B:ERT v2 enables embodied carbon data to be balanced with that of operational carbon over the lifetime of a building, and poses some difficult questions, such as:

- Are triple-glazed windows better than double-glazed over 60 years? It turns out that for some building types they are, but they could be detrimental for others with high internal heat gains, having the potential to adversely increase cooling loads.
- Is it better to reduce U-values and increase airtightness, but also increase embodied carbon? Again, this requires a collaborative understanding and iterative energy testing at the early design stages of the main energy loads between the architectural and engineering teams.

The tool allows design decisions to be made using real-time visual data attuned to a designer's priorities. Colour-coding each material within a design and presenting them in proportion to each other has enabled the largest contributors to a design's carbon emissions to be easily identified and acted on. This works to educate individual designers during the drawing process as well as encourage collaborative team discussion around reductions in a workshop scenario. In addition, the output can be used to support and illustrate design decisions when presenting to a client.

How is it being used by others?

In order to make H\B:ERT as accessible as possible, the Revit plugin, associated case studies as well as guidance are all available for free from the Hawkins\Brown website.[11]

Since the launch of H\B:ERT v1 in September 2018, it has been downloaded 1072 times, half of which occurred in the last three months of 2020. Users are from around the world and include practitioners as well as Higher Education providers and students (Fig 9). Many practices we have heard from have used the tool for elemental analyses that allow them to guide design decisions on specific projects.

Industry engagement and the sharing of knowledge have been important parts of the tool's development and research process. Measuring embodied carbon and whole life carbon is still in its infancy and through organisations such as the RIBA, the UK Green Building Council, LETI (London Energy Transformation Initiative) and WLCN (Whole Life Carbon Network) we have been both sharing case studies, data, and techniques as well as learning from others.

How has it changed Hawkins\Brown's working practices?

H\B:ERT v2 extended the scope of v1 to measure not just embodied carbon but whole life carbon. The tool is now integrated into our in-house BIM workflows to such an extent that offering it externally is not currently feasible. H\B:ERT v2 has had a two-fold effect.

First, the political imperative to reduce carbon emissions to combat climate change has become part of most client briefs and the tool has enabled us to offer a visual evidence-based carbon reduction service to our clients, enabling responsible and transparent design decisions.

Second, the tool has internally provided an impetus to fully integrate a low carbon construction training plan, structure of project reviews, and the consideration of materials in light of sustainable construction has become a more natural part of our everyday design discussion.

How much carbon has it actually saved?

On each project we establish two baselines using the current and 2030 RIBA operational energy and embodied carbon benchmarks. If we reduce the carbon emissions of each project we work on by 40% compared to the current baseline and deliver five buildings per year at an average of 8,000m^2 each, we will save 24,000 tonnes of carbon.

In reality, project drivers are complex and carbon emission reduction is just one of these - but often not the main one. We have also noticed that some typologies are easier to reduce carbon emissions on than others. For example, station buildings and light industrial uses where the footprint is large, but a low energy requirement for internal environmental conditioning are easier to power using renewable energy sources. Typologies where timber and bio-based materials are more acceptable for use will find it far easier to show larger embodied carbon reductions.

What are its drawbacks?

In order to operate H\B:ERT v2 effectively, the sustainability team closely monitor and support design teams in its use. Rigid modelling and material tagging standards must be adhered to in order that the data is accurate and useful (Fig. 10). We have also experienced the drawbacks of Revit itself during the development of the tool, including specific mechanisms for reporting extruded volumes.

Our aim with both H\B:ERT versions has been to reduce the amount of additional work for the designer in creating, accessing, and using the carbon data, but there is a limit to what a tool can do. Achieving major carbon reductions on the scale the industry needs upskilling on a large scale and the improvement of carbon literacy. Sustainable thinking must be embedded into education and all practitioners require this knowledge and expertise from now.

Where does it go from here?

H\B:ERT v2 could be improved in a number of areas, including a more flexible input to account for early-stage analyses or non-Revit projects, reporting the carbon data over the lifetime of a building rather than as a total for reporting purposes, and separating the data into modules so that the balance between up-front emissions and ongoing life cycle emissions can be viewed during the design stages.

As an industry we need to agree on better protocols and defaults for the In-Use and End of Life (modules B and C) as well as how to measure and present Module D [Fig 7], which currently sits outside the WLC boundary. A national embodied carbon database will also be essential in order to ensure the industry measures consistently and responsibly.

Achieving a zero carbon built environment

What the findings from H\B:ERT v2 have shown is how far we still need to go as an industry to deliver a truly zero carbon built environment. Measuring accurately and considering all emissions, over and above just operational ones, is only the start of the journey.

We consider there are several regulatory changes that could change the priority of drivers on a project to encourage further carbon reductions. These would be zero carbon regulations including targets for embodied carbon, annual, publicly accessible, asset reporting on embodied carbon emissions of buildings at the same operational energy as part of a Display Energy Certificate as well as the financial incentive of increased carbon offsetting costs.

Decarbonising the grid will contribute to lower carbon material and product manufacture, but this will not solve the whole problem and may not be quick enough. The UK urgently needs a nationally led roadmap to true zero carbon construction that is linked to our national carbon budget, incorporates science-based reduction targets, transcends political nuance, and is locked in for the long term, enabling investment certainty in new materials and production processes.

H\B:ERT v2 was developed to help architects make whole life carbon evidence-based design approaches at the earliest design stages. These architects need to be a key part of a Net Zero Carbon future.

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