White Paper

WHOLE LIFE CARBON ASSESSMENTS FOR DATA CENTRES

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DATA CENTRE OPERATORS

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Whole Life Carbon Assessments

Whole life carbon assessments (WLCA) can offer the data centre industry the ability to understand the bigger picture in relation to the carbon impact of data centres and offer key insights into where the hot spots are so efforts can be made to reduce these.

With the detailed insight that comes from WLCA, project teams can be compelled to place greater emphasis on carbon in early site selection, design choices and material specifications. Through WLCA, carbon can and should be treated in the same manner as CAPEX & OPEX, a key, tangible unit of measurement that is paramount to business decision-making.

WLCAs offer greater awareness not only for the decisions a business can make now, but also for decisions in the future. They enable the benefits of foresight to become tangible, for example, demonstrating the impact of an enhanced maintenance programme.

This paper will explain the background on why WLCAs are relevant, what it is and some of the methodologies and reporting frameworks that currently exist. It will provide an example of a typical data centre compared to other building types and how WLCA can offer value to data centre operators at a time when there is a growing focus on decarbonization and embodied carbon. Finally, it will highlight some of the challenges the data centre industry faces in relation to WLCA and Arup's recommendations on how to tackle these.

Why WLCA?

Over the last few years there has been a growing industry focus on decarbonisation. Decarbonisation refers to the process of reducing greenhouse gas (GHG) emissions resulting from human activity, with the aim of fully removing them.

The substantial reduction of GHG emissions will contribute to holding the increase in global temperature to well below 2°C (if possible, 1.5°C) above preindustrial levels, in line with the Paris Agreement.

There are seven main greenhouse gases, but when it comes to climate change, the focus is on carbon dioxide (CO_2) as the main contributor to global warming as it is responsible for 82% of the warming influence.

Buildings are currently estimated to account for 37% of global energy-related carbon emissions. 27% of these emissions are estimated to be from operational energy. The remaining 10% is accounted for through materials and construction.[1]

From a 2018 report studying the emissions of the Information and Communication Technology (ICT) and Entertainment & Media (E&M) sectors, the digital technology sector is said to account for approximately 1.5% of global emissions[2]. Figure 1illustrates what this approximation includes, and it extends far beyond just data centres, to access networks and equipment.

It is important to note that the statistic of how data centres contribute to global emissions varies widely in the industry. Whilst it is important to have a better understanding of this statistic, it is far more important to acknowledge that the data centre industry contributes to global emissions, demand for data is growing and if nothing changes, the result is an even greater contribution to these global emissions. The focus needs to be on radically reducing emissions associated with the design, construction and operation of data centres and whole life carbon assessments provide a means to having a better understanding of what these emissions are.

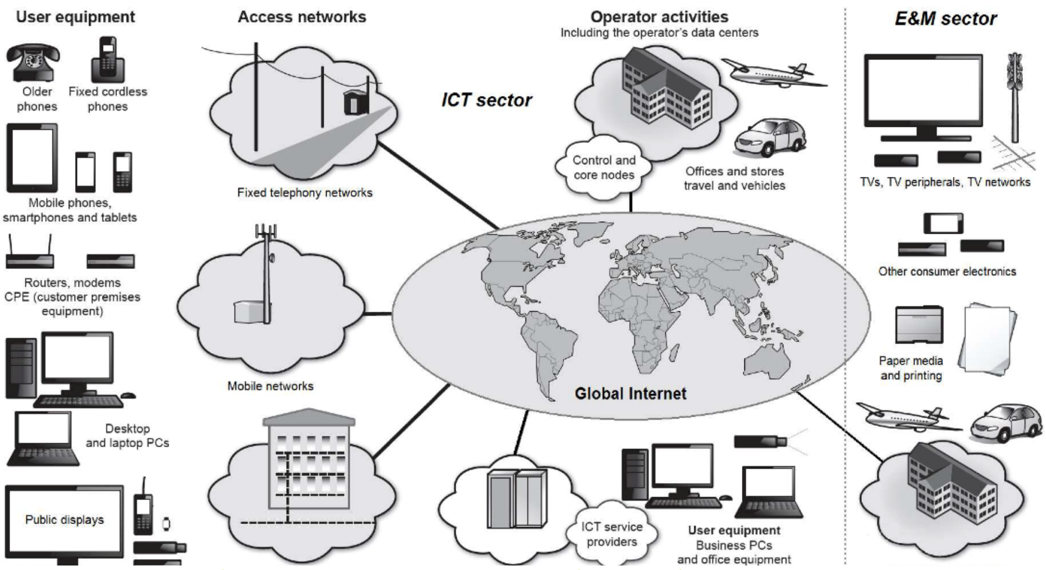


Figure 1 - Scope of study looking at energy and carbon footprint of the ICT and E&M sectors globally

[1] GlobalABC Global status report (2021), https://globalabc.org/resources/publications/2021-global-status-report-buildings-and-construction

[2] The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010–2015 (2018), Jens Malmodin, Dag Lunden, https://www.mdpi.com/2071-1050/10/9/3027/htm

Commitments, Policy and Legislation

In response to the Paris Agreement and the recognition of the need to substantially reduce emissions, there has been a huge shift across all industries to sign up to commitments and pledges and changes to policy and legislation. Figure 2 outlines global and building targets that have been set out and Table 1 provides more detail on some of the key commitments and pledges that exist at the time of writing.

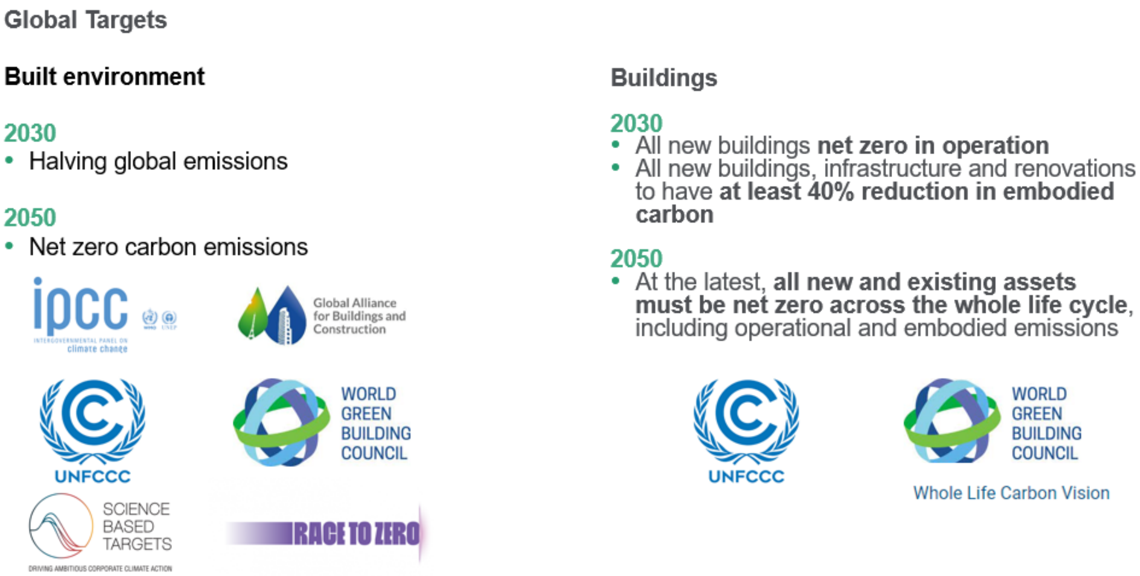


Figure 2 - Summary of global and building specific targets for reducing emissions

Commitment	Description
Race to Zero – UNFCCC	Head-of-organization pledges to reach net-zero GHGs as soon as possible, and by mid-century at the latest, in line with global efforts to limit warming to 1.5C. Interim targets are also set which reflects maximum effort toward or beyond a fair share of the 50% global reduction in emissions by 2030.
Science Based Targets Initiative	Science-based targets provide companies with a clearly defined path to reduce emissions in line with the Paris Agreement goals. 'Science-based' relates to alignment with latest climate science deemed necessary to meet the goals of the Paris Agreement.
World Green Building Council Net Zero Building Commitment	• Assets under direct control to reduce (and compensate where necessary) all operational carbon emissions by 2030. • New developments and major renovations under direct control to reduce and compensate (for residual upfront emissions) embodied carbon emissions by 2030.
Climate Neutral Data Centre Pact	To ensure data centres are an integral part of the sustainable future of Europe, data centre operators and trade associations agree to make data centres climate neutral by 2030

Table 1 - Industry commitments and pledges

Many data centre providers have announced their participation in one of more of the above. As a result of this, there is increasing interest in WLCA which are needed to realise these aspirations and commitments.

What is a WLCA?

A Whole Life Carbon Assessment (WLCA) is an assessment of all building-related emissions over a building's entire life. Assessing carbon allows you to identify hotspots and subsequently identify the most effective reduction measures. It is the most comprehensive approach to achieving reductions in emissions.

WLCA is used to measure a building's lifetime impacts and, at the same time, quantify the impact of a single material in the building.[3] The structure of a WLCA and the calculations rules are set out in EN15978. The standard splits the building lifecycle down into distinct modules with A1-A5, B1-5 & C1-C4 covering embodied carbon and operational carbon is covered in modules B6 & B7. Figure 3**Error! Reference source not found.** outlines these lifecycle stages.

The calculations mainly consist of multiplying volumes of materials by emissions factors. These emissions factors can be found in a range of sources including Environmental Product Declarations (EPD), LCA tools or from regional industry-wide carbon studies on a particular product or material.

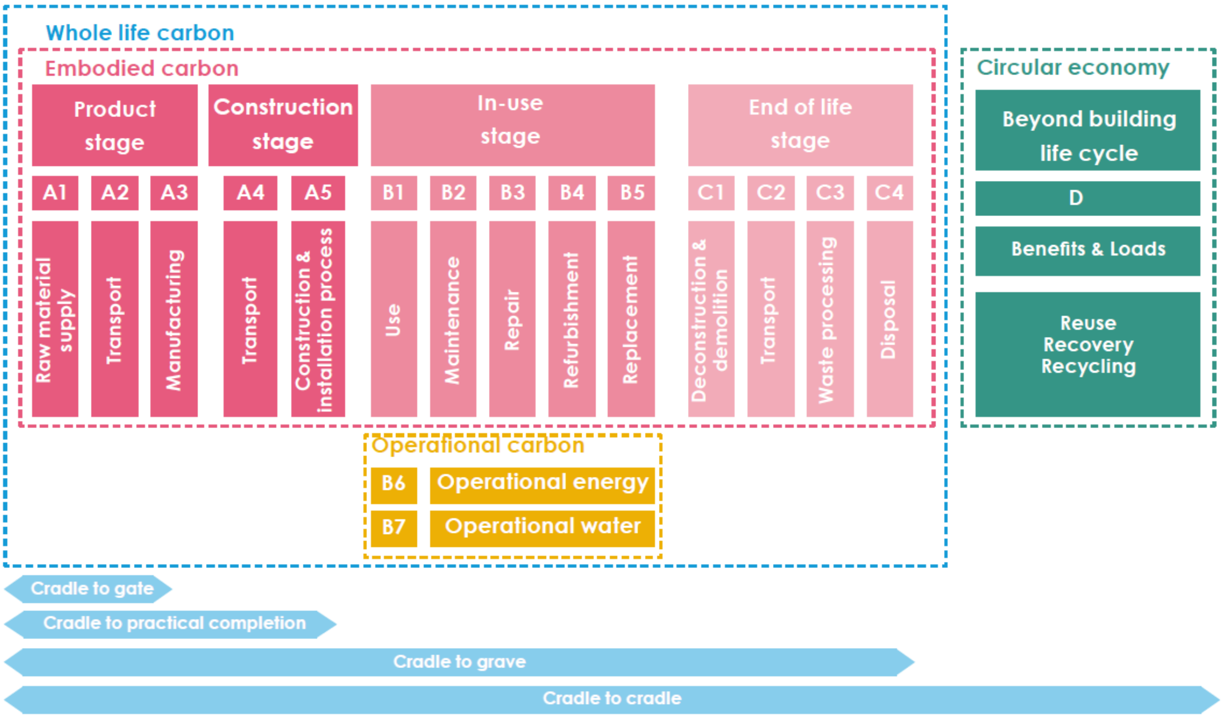


Figure 3 - Carbon Lifecycle - LETI Embodied Carbon Primer based on EN 15978:2011

WLCAs are often undertaken at two stages:

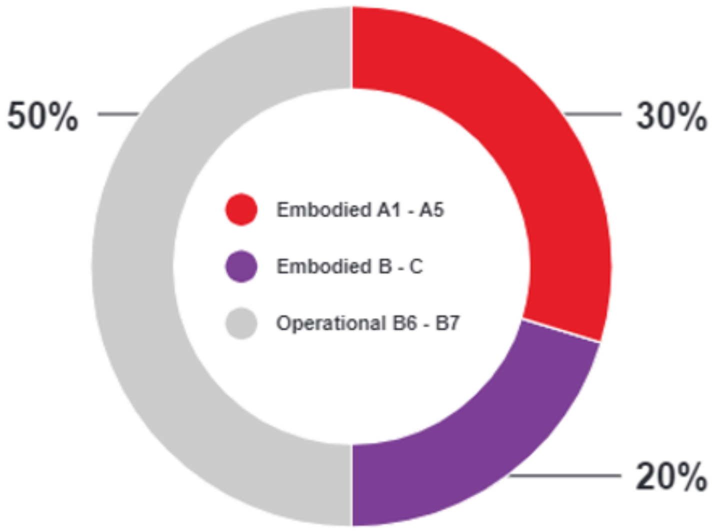
- Early-stage assessments are recommended to establish a baseline carbon estimate for the project, to integrate whole life carbon into the design process and to identify carbon reduction potential while there is significant capacity to influence decisions. This is to enable project teams to engage and understand the impacts of whole life carbon assessments on the project.

- Further assessments at later project stages are advisable for monitoring the carbon budget progress as the project develops and providing the actual carbon footprint at practical completion.

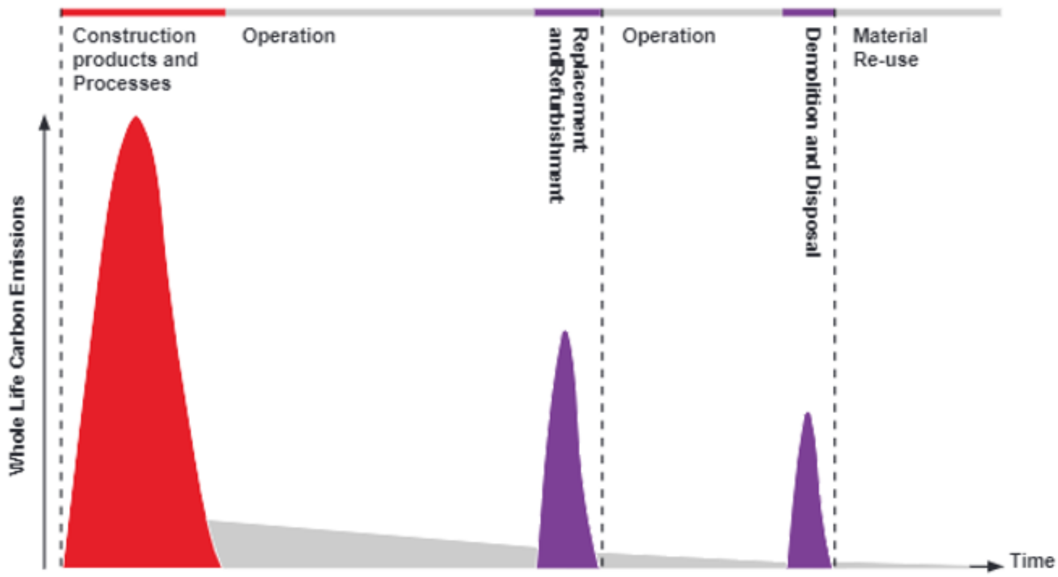
[3] OneClick LCA – A guide to Life-cycle assessment for green building experts. https://www.oneclicklca.com/life-cycle-assessment-explained/

Figure 4 highlights the relevant stage breakdown of a WLCA for a generic building, showing the proportions of embodied and operational carbon.

The initial red spike highlights emissions relating to products and construction, whereas the purple elements demonstrate the embodied carbon associated with maintenance, replacement and end of life. The linear grey element is an illustrative indication of operational carbon over the life cycle of a building, notably on a downward trajectory due to grid decarbonisation.



Estimated distribution of carbon emissions per life cycle stage
Net Zero Carbon Buildings: Three Steps to Take Now



Whole life carbon emissions, Arup (2020)
Net Zero Carbon Buildings: Three Steps to Take Now

Figure 4 - Whole life carbon split of emissions over lifecycle

It is possible to carry out a carbon assessment at any stage of the design and construction process to support design making. This could be comparison of different design options for example:

- Comparing different building footprints and storey heights as shown in Figure 5
- Comparison of different cooling systems
- Comparison of locating plant on the roof versus plant on an external gantry

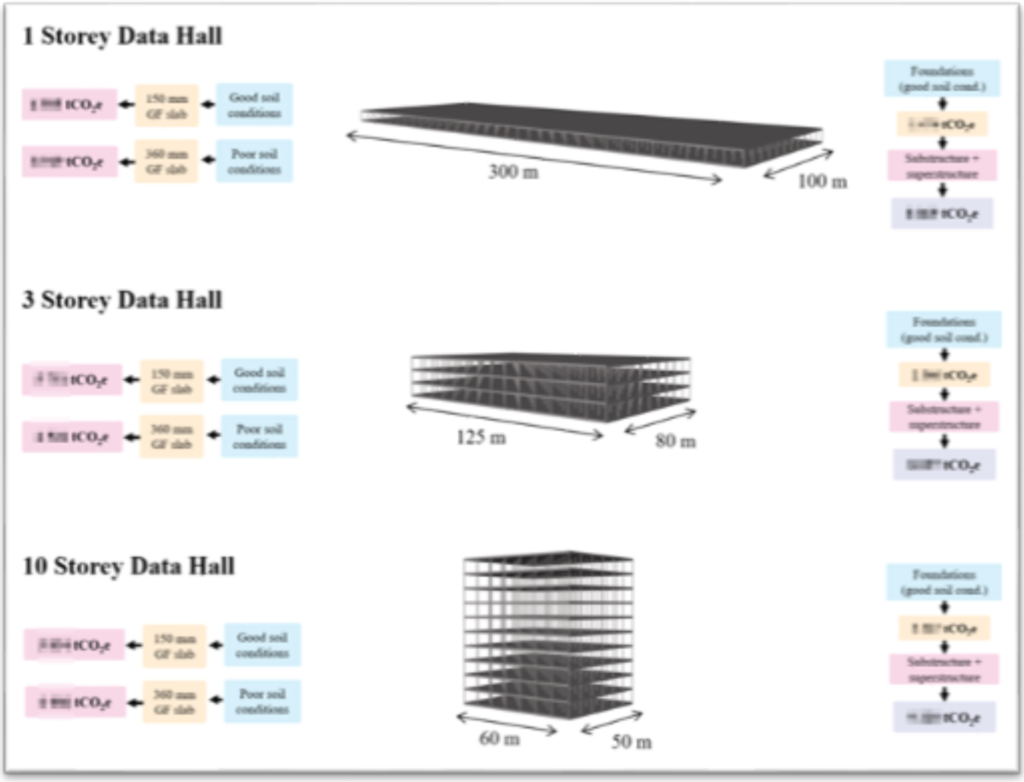


Figure 5 - Example of comparison study on different building heights and footprints

These may be carried out with limited amounts of information and for only part of the carbon lifecycle shown in Figure 3. They may focus primarily on embodied carbon or incorporate embodied and operational considerations. The overarching purpose is to guide the design and construction designs towards the lower carbon option.

The ideal scenario is for these studies to be followed up with a full WLCA for recording and tracking purposes.

Standards, Methodologies and Frameworks

WLCAs are underpinned by international standards which are designed to contribute to consistency and reliability. Table 2 is an extract from a table in "Whole Life Carbon Assessment for the built environment", Royal Institution of Chartered Surveyors (RICS) 2017, showing an overview of the key standards that form the foundations of the WLCA framework.

The RICS document, **Whole life carbon assessment for the built environment** is a professional statement which sets out specific mandatory principles and supporting guidance for the interpretation and implementation of BS EN 15978.

Standard	Full Title	Regional Jurisdiction
EN 15978: 2011	Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method	European standard
EN 15804: 2012	Sustainability of construction works - environmental product declarations - core rules for the product category of construction products	European standard
ISO 14025: 2010	Environmental labels and declarations - type III environmental declarations - principles and procedures	International standard
ISO 14040: 2006	Environmental management – Life cycle assessment – Principles and framework	International standard
ISO 14044: 2006	Environmental management – Life cycle assessment – Requirements and guidelines	International standard
ISO 21930: 2017	Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services	International standard

Table 2 - Overview of Key European and International Standards for WLCAs

Despite the existence of standards and guidance, measurement and reporting of embodied carbon are not universally mandated on construction projects. Where it is undertaken, 'what' is measured and 'how' it is measured are not consistent - meaning we cannot be confident we are making the right choices to drive toward net zero. This inconsistency also means that it is not easy to compare, improve and learn from other projects.[4]

The summary in Table 3 outlines some of the reporting frameworks that currently exist which aim to tackle the issue of inconsistency in the 'what' and 'how' of WLCAs. The examples span across different parts of the world and vary from mandatory to voluntary. They aim to improve understanding of carbon assessments, establish benchmarks, and encourage progress towards decarbonisation however despite the good intentions behind each of these, even these examples lack consistency across inputs and terminology.

[4] BECD. Philosophy and Programme. November 2021 https://becd-cms.uksouth.cloudapp.azure.com/uploads/BECD_white_paper_85cc064670.pdf

What is important for the data centre industry is to establish which frameworks should be adopted to make sure the 'what' and 'how' of WLCAs in a data centre context are addressed and promoted widely across the industry to achieve some level of consistency for comparison and improvement in this sector.

Reporting Framework	Description	Regional Relevance
Greater London Authority (GLA) Whole Life Cycle Carbon Assessments	London Plan Policy SI 2 sets out a requirement for development proposals to calculate and reduce WLC emissions as part of a WLC assessment. The WLC Assessment guidance document explains how to prepare a WLC assessment and how and when to submit it.	UK
The Built Environment Carbon Database (BECD)	The Built Environment Carbon Database (BECD), which was previously called the WRAP database, then RICS Embodied Carbon Database) is being designed and developed by a consortium of industry bodies in the UK. It recognises the RICS assessment methodology. The first section contains data at entity level, providing benchmark-type data points to support the feasibility, early design and end of life stages. The second one contains data at product level to support the evolving and detailed design, construction and operational stages, and provide good-quality product data to conduct reliable assessments.	UK
Structural Engineers 2050 Commitment Program (SE2050)	SE 2050 is the response to the SE 2050 Challenge issued in 2019 by the Carbon Leadership Forum (CLF). It has set out expectations regarding the inputs, assumptions, and accuracy of life cycle assessment (LCAs) performed for projects submitted to the SE 2050 Database.	US
WBCSD The Building System Carbon Framework	This framework was proposed in 2020 as a common language for carbon emissions, by all actors of the built environment. It provides a building element/system categorisation for reporting emissions (Structure, substructure, envelope, space plan, etc.), which is different to the RICS building element categorisation.	Global
LEED	LEED and BREEAM (Mat 01 credit) are sustainability assessment rating schemes which include carbon assessment reporting criteria. These schemes dictate the scope that should be included.	US
BREEAM		Various worldwide

Table 3 - Overview of frameworks for reporting WLCA results

There are various industry tools and software available for supporting WLCA calculations e.g., OneClick LCA, Simapro, GaBi, eTool.

WLCA for Data Centres

For many years, the focus for data centres has heavily leaned towards operational energy and energy efficiency. The operational carbon that results from powering data centres can be huge in comparison to initial embodied carbon estimates, with some estimates putting this at 95% of the annual carbon consumption. Figure 6 demonstrates typical building types in comparison to data centres as built today.

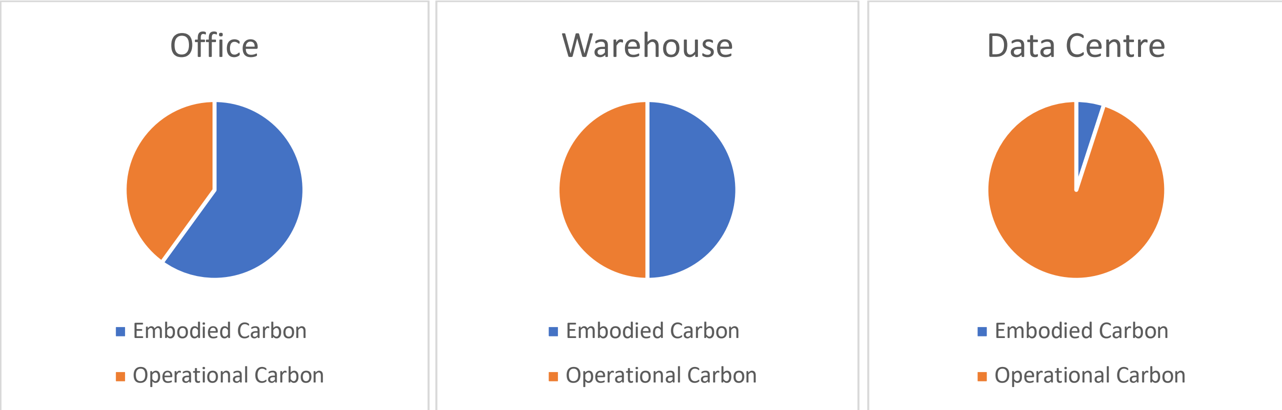


Figure 6 - Graphic showing indicative total whole life carbon emissions for different building types

As energy efficiency measures are potentially reaching their limits and many data centre operators are addressing their operational carbon through power purchase agreements, on-site renewable energy technologies and taking into consideration the decarbonisation of grids (or actively working to decarbonise it themselves!), the next challenge will be achieving net zero embodied carbon. These emissions are emitted into the atmosphere during the manufacture, construction, maintenance, and end of life stages of a data centre's lifecycle and cannot be reversed.

The percentage of embodied carbon impact on a data centre site will naturally rise, making it a more prevalent issue. A visual representation of this, based on anonymised data from a current data centre provider, can be seen in Figure 7 - Graph showing increasing prevalence of embodied carbon in annual carbon reporting over life cycle of a data centre. (Arup, Anonymised industry data)below.

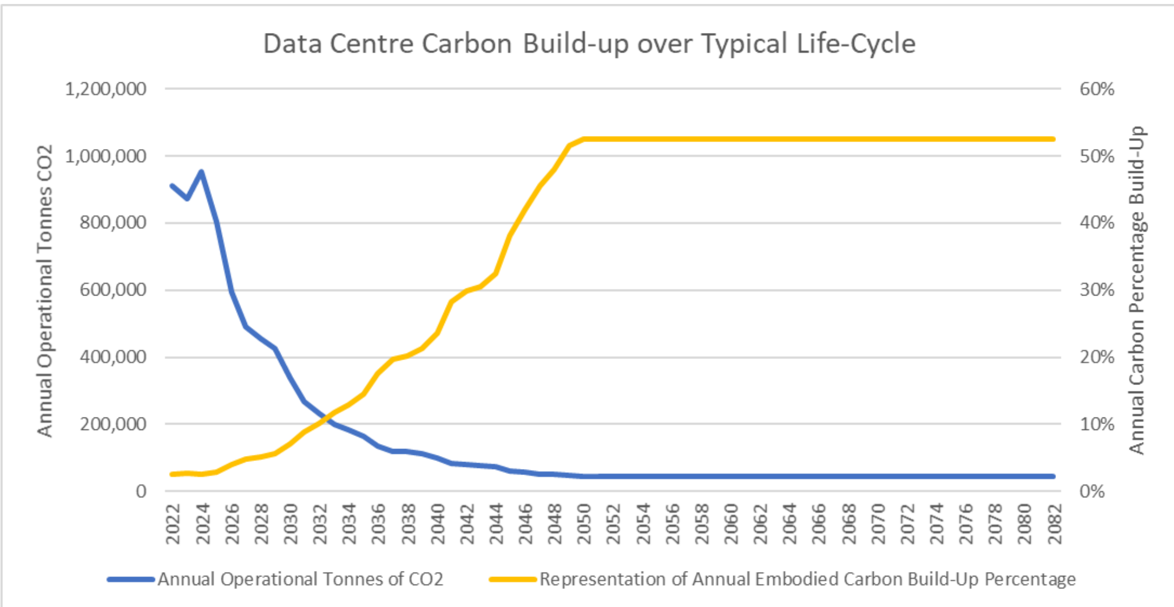


Figure 7 - Graph showing increasing prevalence of embodied carbon in annual carbon reporting over life cycle of a data centre. (Arup, Anonymised industry data)

As carbon is becoming an increasingly important metric for key stakeholders because of commitments and changes in legislation, it is necessary to consider carbon at all stages of design and construction. WLCAs can provide the means to which data centre operations can begin measuring, understanding, and reducing their impacts. They could contribute to an industry wide database that could enable more accurate benchmarking and thus drive more sustainable practice. Operational energy considerations are already well established in the data centre industry and there is a growing understanding and adoption of embodied carbon reporting in the data centre industry.

Industry Challenges

While the benefits of adoption of WLCA within the data centre industry are clear, the implementation presents several challenges. The challenges and possible solutions are outlined below.

1. **Insufficient WLCA understanding within the industry**

WLCA is still an emerging topic for many in the industry and is driven by many data centre operators committing to reducing their carbon emissions. There is a growing understanding particularly within firms who have employed specialist sustainability teams, however there is still often disparity between these teams and project delivery teams who can often make the greatest impact through collaboration of design and construction decisions. Education, continuing to spread awareness and upskilling is key to addressing this.

2. **Lack of clarity across the industry on what should be included in a WLCA.**

A key element of undertaking a WLCA is to define the boundaries of the assessment. Given the current immaturity of the data centre industry in conducting these assessments, this is still a grey area. For example, in many assessments, the MEP systems and externals are excluded from the scope of a WLCA. From some assessments Arup have carried out, the MEP systems ae a huge component of the overall embodied carbon emissions of a data centre and a therefore considered as a prominent factor within the WLCA.

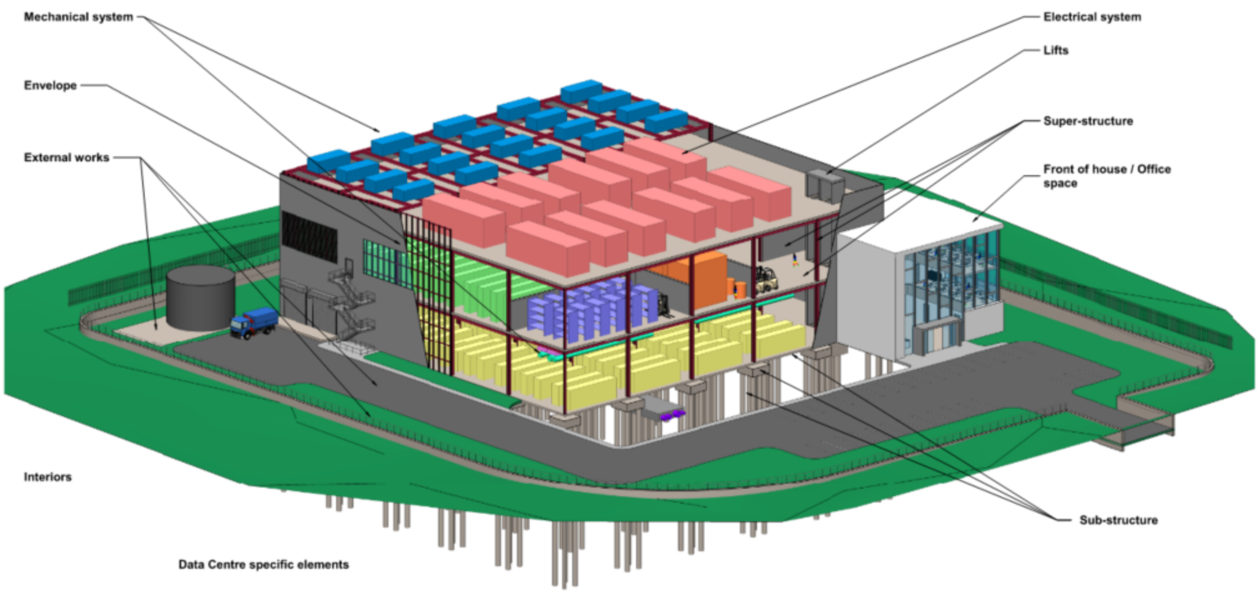


Figure 8 - 3D Visualisation of components to consider in WLCA for data centres

To achieve like for like comparisons, the data centre industry needs to reach a consensus on what should be included as a minimum, what should ideally be included and to strive for consistency in reporting to allow more useful comparison and benchmarking for the data centre sector. When reporting on WLCA for a data centre, it is worth doing this for both gross internal area (GIA) in m2 and by power (MW).

Figure 8 illustrates a typical data centre and the components that contribute to emissions. For data centres, there are several key differentiating elements that are not present in other building types which can contribute quite significantly to overall emissions e.g., racks in the data hall, additional gantry structure for plant and refrigerant, fuel tanks and substations. Wider discussion with the industry facilitated by the EUDCA will be a key step to getting broader industry buy-in on this aspect.

3. Lack of consensus on how the assessments should be conducted and where they should be reported to

Another industry challenge is the lack of regulation and enforcement of WLCAs. Given that conducting a WLCA on a project is not always a requirement, it may not be perceived as a priority or a financial risk. In an ideal world, data centre operators would measure and report to a common database. But which one should they choose? If it does not yet exist, who will build and maintain it, decide on the industry wide standard for data centres and uphold the quality assurance?

4. Global nature of reference designs whereas carbon information tends to be region specific

Data centres operators are often global and have data centres in multiple countries, often based on a reference design. Regional carbon factors mean that if a WLCA were performed on the same building in two different countries, one may register as more 'carbon intensive,' which could be due to genuine differences in construction processes and the grid, but in other instances it may be due to lacking or incomplete data. This points to the need for an industry-wide agreement to harmonise regional approaches and standards to calculating, reporting, and benchmarking.

Reviewing reference designs for carbon efficiency also offers an ideal opportunity to create impact across a whole portfolio. Often carbon efficiency measures will be linked to material reduction (or elimination!) so can offered combined carbon and cost savings.

5. Lack of widely available and accurate industry data

Access to carbon data and its accuracy are key challenges that face all industries when it comes to WLCAs, but it is important that this does not detract from efforts to carry out these assessments entirely. Continued research is developing in gathering carbon data by various industry players including manufacturers, contractors, consultants, and academia. What is important is to note the assumptions being made and where the carbon data has been sourced from so that in the future it can be reviewed and updated if required

6. Cost oriented and time driven industry with limited time for new processes and reporting

The nature of the data centre industry can also present significant challenge to the implementation of WLCAs. As a cost orientated, time-driven industry WLCAs may fall off the priority list when considering other elements of design and construction. This aspect needs a mindset shift to understand the value of doing WLCAs. By measuring and understanding the impact and hot spots in a design it allows decisions to be made that can really drive change. To derive optimal value there needs to be an opportunity to influence design after a WLCA has been conducted. This might mean deviation from a typical reference design, and it will require data centre providers to embrace this change in typical processes to achieve the full value of what WLCAs can offer.

As it can be challenging to gather all the detail, particularly at early stages, it is also possible to adopt simple carbon comparisons to factor carbon into key decision-making processes. This can be followed up with more detailed WLCA as the design develops.

Useful Links

https://www.arup.com/news-and-events/arup-commits-to-whole-lifecycle-carbon-assessments-for-buildings-and-withdrawal-from-fossil-fuels

https://www.arup.com/expertise/industry/science-industry-and-technology/data-centres

https://www.arup.com/expertise/services/advisory-services/sustainable-development-advisory/sustainability-consulting

https://www.arup.com/perspectives/towards-sustainability

https://www.arup.com/expertise/services/buildings/sustainable-buildings-design

Appendix

The following table summarises each life-cycle stage of a WLCA and how these can be directly applicable to data centre buildings.

Stage	Sub-Category	Definition	Data Centre Applicability
Product Stage	A1 – Raw Material Supply	Extracting raw materials (or processing recycled materials)	Raw material extraction used to build hardware, PC/ABS, natural fiber-filled polypropylene
	A2 – Transport	Transporting materials to and from the production facility	Shipping, freight etc
	A3 - Manufacturing	Manufacturing products from raw or recycled materials	Supply chain engagement, welding and powder coating of raw materials
Construction Process	A4 – Transport	Transporting products from the factories to the construction site	Shipping, freight etc
	A5 – Construction Installation Process	Operating equipment to install products and construct the building	Machinery used to build DC, install hardware and MEP systems, hardscaping and excavation (site works)
Use Stage	B1 – Use	Effects of installs products in use	Refrigerants, chillers, leakage rate, CFCs, HFCs, VOCs
	B2 – Maintenance	Maintaining and cleaning the building, including impacts of products used	Maintenance of MEP services, enhanced maintenance options upkeep to façade, green-wall etc
	B3 – Repair	Remembering broken components, including impacts of materials and energy used	Repairing MEP and building services
	B4 – Replacement	Replacing building components if their lifespans are less than the building service life	Replacement of services. WLCA enables insight into the benefit of enhanced maintenance in terms of cost v carbon reduction
	B5 – Refurbishment	Refurbishing the building, including impacts of materials and energy used	Refurbishing the building, client reception areas and soft furnishings as well as externals
	B6 – Operational Energy Use	Using energy during normal operation of the building. Uses such as	Energy consumption, PUE, MEP services, Gas on site

		elevators, appliances and plug loads can be included	
	B7 – Operational Water Use	Supplying and treating water for normal operation of the building	Data Centre water consumption both practically and sanitaryware / staff & client facilities
End of Life Stage	C1 – De-construction/ Demolition	Deconstructing, dismantling, and/or demolishing the building, including temporary works off-site	Deconstruction works, modularity to minimise impact, multi-purpose facilities to encourage re-use rather than deconstruction
	C2 – Transport	Transporting materials from the site to the end-of-waste state, including transportation to/from intermediate processing locations	Waste management, transport of deconstructed materials and waste off-site
	C3 – Waste Processing	Collecting waste flows for reuse, recycling, and energy recovery.	Waste storage and correct segregation to streamline process and minimis impacts
	C4 – Disposal	Pre-treating the waste and managing the disposal site	Hazardous waste treatment, battery disposal and appropriate care for
Beyond the System Boundary Stage	D – Reuse, Recovery, Recycling Potential	Contains miscellaneous items for reuse, recycling, and recovery such as the below: - Biogenic Carbon - Recycling credits - Energy that is generated on-site, exported, and/or substituted for other more common energy types	On-site any generation through renewables. Beyond the modelled boundary benefits but worth understanding as ties into wider Sustainability goals and aspirations

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