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Practice Information Note

SC205
Embodied carbon in construction – setting the scene for Scotland.

This Practice Note is extracted from a report written in March 2020 for Zero Waste Scotland by Dr Francesco Pomponi, Edinburgh Napier University, Dr Jannik Giesekam, University of Leeds and the Centre for Research into Energy Demand Solutions (CREDS), Jim Hart, Principal of JH Sustainability Ltd, and Dr Bernardino D'Amico, Edinburgh Napier University. It was edited by Clive Bowman, Zero Waste Scotland. This report was part funded by the European Regional Development Fund.

The RIAS Practice Department are grateful to Clive Bowman for sharing this extract with Practice Services subscribers. Clive is Circular Economy Construction Project Manager at Zero Waste Scotland, and this is his second article in the series, following on from Practice Note 'SC201 Circular Economy building assessment, accreditation and performance evaluation'.

Environmental impacts of buildings and infrastructure, including the greenhouse gas (GHG) emissions that contribute to climate change, can be linked to all stages of a building's lifecycle. Extracting raw materials, transforming them into products, transporting them to site, the construction process, use and maintenance, and demolition and disposal activities all demand energy. A substantial proportion of this energy is currently derived from fossil fuels, and therefore such activities are direct drivers of GHG emissions.

For decades, policy and regulations designed to target GHG emissions from construction have been primarily focused on energy demand for heating and powering buildings during their operational lifetimes. Little attention has been paid to the emissions associated with the materials and processes required to construct, maintain and ultimately decommission the buildings. These two categories of emissions are referred to as **operational carbon** (heat and power) and **embodied carbon** (everything else) respectively. The term 'embodied carbon' can be interpreted differently depending on perspective and project information and data, but most would fall into one of the following categories:

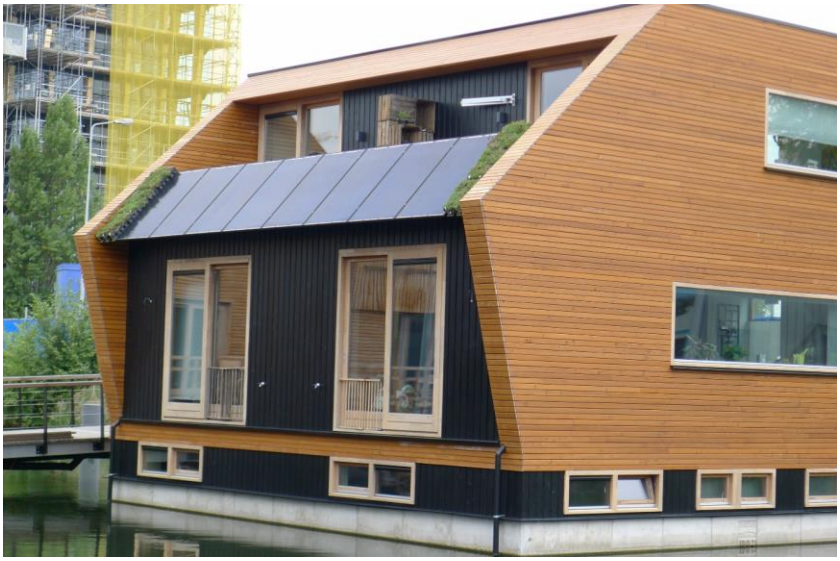
1. Cradle to gate. GHG emissions associated with extracting and processing materials into construction products.
2. Cradle to site. As 1. Plus transport of the materials to the construction site.
3. Cradle to practical completion. As 2. Plus construction processes.
4. Cradle to grave. As 3. Plus repair and maintenance and, ultimately, demolition and disposal.

Assessment of carbon emissions associated with construction can extend even beyond these boundaries to include, for instance, the impacts on subsequent product systems when materials are recovered at the end of a product's life.

Measures such as the targeting of heat loss through the building envelope, alongside technology improvements such as LED lighting and the increasing role of renewables in electricity production, have made it possible to achieve significantly lower operational carbon figures for a building. Despite progress on waste management, and sustainable procurement, there is little data to support overall progress in the embodied carbon of new construction. In fact some interventions to target operational carbon can actually increase the embodied carbon. As a result, embodied carbon represents an increasingly significant proportion of the whole-life GHG emissions of new buildings.

Scotland's current built stock consists of around 2.45 million homes, 200,000 non-domestic buildings and a wide range of infrastructure assets, including some 10,800 km of major roads and a further 60,000 km of minor roads (Department for Transport, 2019; Scottish Government, 2018a). This stock is expected to expand in line with a slow growth in population driven by inward migration. At the same time, delivering reductions in operational carbon emissions and other policy objectives (such as reducing fuel poverty) will necessitate an unprecedented scale of retrofit of the existing building stock. This implies that, without intervention, embodied carbon from new construction, maintenance and retrofit are all set to expand over the coming years.

The Climate Change (Scotland) Act 2009 set the initial framework for both long term and annual greenhouse gas emission reduction targets in Scotland (Scottish Parliament, 2009). Following the declaration of a climate emergency in 2019, the 2009 Act's targets were amended by the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 (Scottish Parliament, 2019). The 2019 Act set targets to reduce Scotland's emissions of greenhouse gases to net-zero by 2045 at the latest, with interim reduction targets of at least 56% by 2020, 75% by 2030, and 90% by 2040, as well as annual targets based upon equal percentage point changes between the interim targets.



One of the 46 floating houses in the sustainable development 'Schoonschip' – "Europe's most sustainable floating neighbourhood" – in Amsterdam. © *Clive Bowman, Zero Waste Scotland*

The most recent Monitoring Report (Scottish Government, 2019a), published in December 2019, tracked a series of implementation indicators and policy output indicators. Only 7 of the 29 policy output indicators assessed were on track, with several indicators yet to have sufficient data to yield an assessment of progress. None of the 29 indicators directly address the embodied carbon arising from construction. The four indicators addressing buildings focus exclusively on operational energy and emissions. Other indicators of some relevance to the topic of embodied carbon include: Scottish produced sawn wood and panel boards used in construction; volume of landfilled waste; and a range of the transport indicators (such as average emissions of HGVs per tonne kilometre).

In addition to addressing territorial emissions of greenhouse gases, the 2019 Act stipulates that the Climate Change Plan must also set out Scottish Ministers' "*proposals and policies for taking action to reduce emissions of greenhouse gases (whether in Scotland or elsewhere) which are produced by, or otherwise associated with, the consumption and use of goods and services in Scotland*". As the Scottish construction sector imports around £2bn worth of goods and services (SQW, 2017), including a high proportion of construction materials, reductions in embodied carbon are likely to drive deeper carbon reductions when measured on a consumption basis. However, only reductions incurred within Scotland will contribute to the achievement of national targets.

Though embodied carbon is not addressed through current building standards, awareness of the topic, and proposals to include it, have a long history. As far back as 2007 the Sullivan Report set out recommendations on how the building standards system could be improved to combat climate change (Scottish Building Standards Agency, 2007). These recommendations included an ambition of *"total-life zero carbon buildings by 2030"* and considered the possibility of covering embodied energy in building products. At the time, the panel recommended that the issue be set aside until the European Commission had re-examined the Construction Products Directive. Embodied carbon received little attention in the 2013 update (Scottish Government Building Standards Division, 2013) following a reconvening of the panel, as the industry was still deeply impacted by the recession and more focused on agreeing a deliverable definition of zero-carbon for operational emissions. The debate at that time focused on the role of Allowable Solutions within any zero-carbon definition and the resultant recommendations were for a generally more moderate pace of change. Shortly thereafter in response to the then prospective UK requirements for Zero Carbon Homes, a self-assembled industry task force advocated the inclusion of embodied carbon as an Allowable Solution – publishing a series of detailed proposals in 2014 (Battle, 2014). Unfortunately the long heralded UK requirements were subsequently dropped in July 2015 by a newly elected Government in order to *"reduce net regulation on housebuilders"* (HM Treasury, 2015).

At the beginning of 2019, the Building Standards Futures Board was established to strategically advise and direct a broad programme of work aimed at improving the performance and sustainability of the Scottish building standards framework. The Board operates through a number of Work Streams, amongst which the Technical Strategy Work Stream would be most likely to consider the topic of embodied carbon. Though the Board has undertaken some work

related to other aspects of sustainability, minutes from meetings do not suggest any recent consideration of embodied or whole life carbon.

In the wake of the UK and Scottish Governments' declarations of a climate emergency and announcement of net zero targets, many local authorities have reassessed their climate goals. At the time of writing, 17 Councils in Scotland have declared a Climate Emergency. Several of these local authorities have subsequently set new emissions reduction targets that are typically more ambitious than national goals. These include targets set by Scotland's two most populous council areas, Glasgow City Council and the City of Edinburgh Council, for the cities to be carbon neutral by 2030. Although Edinburgh City Council's current Local Development Plan (The City of Edinburgh Council, 2016) and Design Guidance (The City of Edinburgh Council, 2018) make references to the use of sustainable materials, they do not place any requirements upon assessment or mitigation of embodied carbon. Likewise, Glasgow's City Development Plan and Supplementary Guidance (Glasgow City Council, 2017) encourage developers to *"demonstrate the highest standards of sustainable design and construction"* but do not include any requirements around embodied carbon.

By contrast, the Greater London Authority is currently in the process of introducing requirements to assess embodied carbon in the city's largest category of developments. The August 2018 Draft London Plan (GLA, 2018) includes a new policy SI2 DB which states: *"Development proposals referable to the Mayor should calculate whole life-cycle carbon emissions through a nationally recognised Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions.* The final version of the London Plan is expected to be published shortly.

To date there are few examples of reductions in embodied carbon being tied to financial incentives. In 2016 the London Legacy Development Corporation published a supplementary planning document covering carbon offsets for major schemes within the Legacy Corporation area (LLDC, 2016). This allowed for demonstrated reductions in embodied carbon to count against the typical offsetting fee – at the time £60/tCO_2e. This fee will increase to £95/tCO_2e under the new draft London Plan, and a number of boroughs have taken an interest in further applying this precedent (e.g. Islington and Merton). If this link were to be commonly established it would provide a sizeable financial incentive to reduce embodied carbon, although there is a risk of applicants gaming the system by assuming carbon intensive baseline designs.

The Dutch are generally regarded as world leaders in their regulatory approach to new construction. In 2012, the Netherlands introduced a new version of the Building Act (Bouwbesluit), which required all residential and office buildings whose surface exceeds 100m^2 to account for their embodied impacts in the form of a Lifecycle Assessment (LCA) using a national assessment method, associated database, and approved software tools. The method is based on EN 15804 and EN 15978 with national adaptations, including health impact accounting. The assessment method covers 11 LCA impact categories, including embodied carbon, and converts values to a shadow price which is expressed in Euros (embodied carbon is weighted at €50/ tCO_2e). The total impact in monetary terms is divided by the building's gross floor area and assessment period length (75 years for residential, 50 for offices). The regulations were revised

with effect from January 2018 to set a mandatory environmental impact cap for buildings at €1/m^2/ yr. This approach could serve as a template for Scotland.

The extension to Brummen Town Hall in the Netherlands incorporates a timber structure, solar gain and is designed for full deconstruction and material reuse. © *Clive Bowman, Zero Waste Scotland*

An alternative, or potentially complementary, approach to the detailed assessment of a building's impacts is the introduction of product embodied carbon limits to encourage low carbon procurement. This is best exemplified by the Buy Clean California Act. The Act requires the Department of General Services (DGS) to establish maximum acceptable emissions limits in terms of global warming potential (GWP, reported in terms of mass of carbon dioxide equivalent, e.g. $kgCO_2e$) for key materials including structural steel (hot-rolled sections, hollow structural sections, and plate), concrete reinforcing steel, flat glass, and mineral wool board insulation. By this means the highest carbon materials will be omitted from the market, providing a strong incentive for material producers to decarbonise their supply chains or for designers to specify low carbon materials.

Several Scandinavian cities have also introduced requirements that go beyond national standards, including Copenhagen, Stockholm and Oslo. These include earlier commitments to the introduction of life cycle assessment reporting, targets, zero-emission construction sites, and substantial changes in public procurement. Efforts to coordinate actions and harmonise building regulations across the Nordic states are also ongoing through the Nordic Working Group for LCA, climate and buildings launched in 2019.

The public sector in Scotland spends around £4 billion a year on building or civil engineering works and is thus in a strong position to influence the embodied carbon of construction through its procurement. Guidance for Scottish public sector construction procurement is set out in a series of three handbooks. Though the need to consider sustainability issues and take a whole life cycle approach to construction procurement is recognised in the handbooks, there are no explicit requirements around embodied carbon. Guidance in the handbooks suggests use of the Scottish Futures Trust Whole Life Appraisal Tool which can incorporate consideration of embodied carbon from materials only (Scottish Futures Trust, 2016). A more recent toolkit prepared by the Scottish Futures Trust offers further guidance on setting environmental sustainability performance criteria (Scottish Futures Trust, 2018). The toolkit consists of a guidance note and an environmental performance tracker. The guidance notes embodied carbon as an example of a metric against which the client may wish to set a target and references the RICS PS – the Royal Institution of Chartered Surveyors, Professional Statement – (RICS, 2017) as an appropriate methodology.

The C-Beta circular office near Schiphol airport, Amsterdam, is a converted traditional agricultural barn and is a show case for sustainable low carbon and circular ideas, products and technologies. © *Clive Bowman, Zero Waste Scotland*

As can be seen, the increasing relative importance of embodied carbon has led to an increased commercial and academic interest in this area. A variety of data, tools, planning documents, and

guidance from professional bodies has been published. However, there is still relatively little experience of embedding assessment of embodied carbon into construction industry decision-making. Accordingly, there has been no clear template for the Scottish industry to follow that accommodates the Scottish context and recent progress.

Because of this, Zero Waste Scotland commissioned a scoping study in early 2020 by JH Sustainability Ltd with collaborators from Edinburgh Napier University, the University of Leeds and the Centre for Research into Energy Demand Solutions (CREDS). This study will help determine the current situation in Scotland and beyond, and identify the direction the sector should take. The report provides guidance on how Zero Waste Scotland should influence policy and support the industry to make best use of embodied carbon assessment.

This RIAS Practice Note contains an edited summary of this report. It is a report that will be further presented to the industry over coming months alongside the outputs of follow on work by Zero Waste Scotland as it puts in place a plan on how best to support the industry going forward.