

Discussion: Assessing embodied energy of building structural elements

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Contribution by A. Watson

In the paper by Vukotic *et al.* (2010) the timber option has a material embodied energy (EE) of 2.47 GJ/m^2 , which is similar to that of the steel option. It is inferred that this high figure includes the calorific value of the (as grown) timber, and this inflated figure subsequently allows a recovery potential of 56% of the total EE through post-demolition combustion.

While the logic of this is clear, it undermines the authors' apparent definition of EE as the total primary energy used to produce specific goods or services and return any waste safely to earth. The EE of as-grown timber presumably includes only a relatively small amount of primary energy (consumed as a result of forestry operations) while the eventual combustion of that timber will clearly release substantial quantities of carbon dioxide.

Given the need for clarity of terminology, could the authors please clarify the definition of EE as employed by themselves?

Authors' reply

The contributor is right to say that in the Introduction total embodied energy was generally defined as the primary energy used to produce specific goods or services and return any waste safely to earth. The paper, however, breaks this total embodied energy into a number of different life cycle stages, to make the results and methodology transparent. It was hoped that this will then allow other researchers and practitioners to gain a better understanding of where most of the impacts come from.

Each life cycle stage was defined at the beginning of every relevant section in order to make the authors' methodology clear. Material/product embodied energy was defined in Section 4.1.1. 'Material embodied energy and carbon dioxide,' as 'energy related to the acquisition of raw materials, their processing and manufacturing.' Therefore, the number the contributor is referring to would be defined by the first paragraph of Section 4.1.1 and would not include any benefit or impact at the end of building life.

It is also important to clarify how this timber design product/material EE number was derived in order to understand why it had a similar value to steel design option. First, the University of Bath inventory of carbon and energy (ICE), version 1.5 beta was used to obtain values for material embodied energy. The authors specifically mention that the embodied carbon figures for timber do not include sequestration, emphasising the fact that in this first phase of the assessment the timber is being treated as if it were any other type of material, and the fact that it has inherent energy (and carbon) that have the potential to be released, does not matter. This is made very clear in the new Bath ICE database V2.0 (Hammond and Jones, 2011). In section 2.2. 'Feedstock Energy', (i.e. what may be derived from fuel that is used as a material), is not included in the embodied energy for renewable resources, such as timber or biofuels. However, for materials derived from fossil fuels (e.g. plastics), the feedstock energy is included in the embodied energy, as it represents a permanent loss of non-renewable resource.

The value for glulam timber specified in this source is 11 MJ/kg , while the value for average UK steel is 24 MJ/kg . However, the mass of timber required was higher than that of steel. This is mainly because the timber design used in the example calculation utilised solid structural glulam panels while the steel design resulted in the use of a steel frame with steel sheeting. In addition, it is important to note that both design options required identical mass concrete strip foundations and a concrete ground-bearing slab.

Finally, we used a specific embodied energy inventory that gave these results but we have shown in the sensitivity analysis that:

using steel and timber embodied energy figures from the study by Buchanan and Honey (1994), results from this study changed from 2.5 GJ/m^2 to 2 GJ/m^2 for timber and from 2.5 MJ/m^2 to 4.3 MJ/m^2 for steel, revealing that final results are very sensitive to different factors for material embodied energy.

REFERENCES

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