Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 134 (2017) 452–461

Procedia Engineering

www.elsevier.com/locate/procedia

9th International Conference on Sustainability in Energy and Buildings, SEB-17, 5-7 July 2017, Chania, Crete, Greece

Inclusion of on-site renewables in design-stage building life cycle assessments

C. Galpin[a,*], A. Moncaster[a]

[a]*Department of Engineering, University of Cambridge, Trumpington Street, Cambridge CB2 1PZ, UK*

Abstract

This paper investigates the inclusion of renewables in building life cycle assessments. On-site renewable electricity generation is increasingly common in the built environment, but existing guidance for the inclusion of these renewable systems in design-stage life cycle assessment is limited. The life cycle assessment of a building with 42.8 kW_{peak} solar photovoltaic array is used as a case study to investigate the effect of different assumptions on the assessment outcome. The case study results are then used to suggest good practice. The paper also highlights where further research is required to provide reliable design-stage assessments in future.

Peer-review under responsibility of KES International.

Keywords: renewable; solar; energy; design; life cycle analysis

1. Introduction

1.1. Background

The built environment is a significant contributor to global carbon emissions. In Europe, it is responsible for 42% of final energy consumption and 35% of the greenhouse gas emissions (GHGs) [1]. The built environment accounts for an even greater proportion of emissions in the developing world, where construction is booming. The motivation for reducing carbon emissions is both clear and urgent; anthropogenic carbon emissions are the primary cause of global climate change, which is the greatest threat to both human life and economic prosperity of this century.

* Corresponding author. Tel.: +44 7547 879978
E-mail address: chris.galpin@outlook.com

Peer-review under responsibility of KES International.
10.1016/j.egypro.2017.09.603

Policy and design to reduce carbon emissions associated with the built environment has historically focused on the reduction of carbon emissions resulting from operational use [2]. However, in many cases, embodied carbon impacts are also significant, particularly in relation to the built environment [3]. Embodied carbon refers to the GHG emissions associated with the other stages of a product's life cycle, including (but not limited to): resource extraction, manufacture, transport, construction, maintenance and disposal [4].

1.2. Life cycle assessment

Life cycle assessment attempts to consider the total impacts attributable to a product, considering the combined effects of both operational and embodied impacts. Many of the measures proposed to reduce a building's operational GHG emissions result in an increase in embodied emissions [2]. Therefore, reporting practices which consider only the operational impacts of these actions may result in an overestimate of their effectiveness. Consequently, life cycle assessments are a useful tool to ensure a holistic view of environmental impacts.

As well as a tool for reporting and documenting the impacts of buildings after their construction, there is growing interest in the use of preliminary life cycle assessments as a design tool [5,6,7]. Carbon emissions and other sustainability indicators are increasingly desirable as design criteria, and life cycle assessments offer an opportunity to consider these criteria in a quantitative manner. The ability to compare different building options using simple, fast, and reliable life cycle analyses would allow for the calculation of an environmental cost estimate to be produced alongside estimates of financial cost.

However, aspects of the existing guidelines for building life cycle assessments can pose challenges at the design stages due to uncertainties regarding how the construction and operation of the building will be conducted. In order to use life cycle assessment as a practical tool during these stages, it must be possible without knowledge of details which are only decided later in the design process. The method should also provide an answer which is not orders of magnitude different from the results of an assessment conducted once these details are included. An understanding of the assumptions to which the assessment has the greatest sensitivity is invaluable in determining where guidance should be focused [8].

1.3. On-site Renewables

On-site renewable generation is one approach to reducing the operational environmental impacts of a building, and small-scale photovoltaic arrays and wind turbines are an increasingly common feature in the built environment. Indeed, the European Union (EU) requires member states to implement legislation which mandates the usage of on-site renewables as part of its initiative for "nearly Zero Energy Buildings" [9], and similar initiatives are in place around the world to encourage wider usage of decentralised, low carbon electricity generation. However, usage of these technologies implies an increase in embodied carbon emissions which will partially offset the intended reductions in operational emissions. These policies therefore rest on assumptions that on-site renewables are always an effective measure for achieving carbon emission reductions. The strength of this received wisdom can lead designers to make choices without proper consideration of their true impacts, potentially resulting in higher than expected carbon emissions [2].

This paper will firstly explain the existing guidance for accounting for on-site renewables in life cycle assessments. A case study life cycle assessment will then be conducted of an office building in Cambridge, UK, which has 42.8 kW_{peak} of solar photovoltaics installed; Greenwich House. Discussion of the results of this case study will then be used to inform recommendations on how the assessment of these systems should be approached in future.

2. Existing guidance for the life cycle assessment of buildings

The EU has issued formalised guidance for the assessment of environmental performance of buildings in the form of a suite of European Standards, CEN TC350, the English version implementation of which is BS EN 15978 [10]. As the case study falls under this guidance, and this standard is used across Europe, this paper is primarily framed with reference to the method set out in this EU standard. However, this paper should remain applicable to life cycle assessments conducted using similar alternative methods. BS EN 15978 defines a modular approach for the life cycle