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Carbon brainprint – An estimate of the intellectual contribution of research institutions to reducing greenhouse gas emissions

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ABSTRACT

Research and innovation have considerable, currently unquantified potential to reduce greenhouse gas emissions by, for example, increasing energy efficiency. Furthermore, the process of knowledge transfer in itself can have a significant impact on reducing emissions, by promoting awareness and behavioural change. The concept of the 'carbon brainprint' was proposed to convey the intellectual contribution of higher education institutions to the reduction of greenhouse gas emissions by other parties through research and teaching/training activities. This paper describes an investigation of the feasibility of quantifying the carbon brainprint, through six case studies. The potential brainprint of higher education institutes is shown to be significant: up to 500 kt CO_2e/year for one project. The most difficult aspect is attributing the brainprint among multiple participants in joint projects.

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1. Introduction

The need to reduce greenhouse gas (GHG) emissions is widely, though not universally, accepted. In the Climate Change Act 2008, the UK Government committed the country to reducing its GHG emissions by 34% by 2020 and 80% by 2050. These targets require action to reduce GHG emissions from all sections of the economy, including universities, which are expected to cut their own carbon footprints in line with these national targets (HEFCE, 2010). These emissions vary widely with the size and nature of the institutions: annual GHG emissions by universities from fuel and energy consumption in 2005 were 1–90 kt CO_2e/institution (SQW, 2010). This concern is part of a wider trend for universities, like other business, to study and improve their environmental performance (Baboulet and Lenzen, 2010).

The process of quantifying their own emissions has led universities to consider the possibility of measuring the contribution of research to reducing the emissions of other organisations. Universities could have an impact through research leading to new technologies, the transfer of the results of past research into practice, developing novel ways to promote behavioural change, and training and education to provide the necessary knowledge and skills to effect change. The carbon footprint is a commonly used measure of the total set of GHG emissions caused directly and indirectly by an individual, organisation, event or product, although the definition and the boundaries used vary between studies according to their context and purpose (Pandey et al., 2011). The phrase 'carbon brainprint' was first proposed as an analogue of the carbon footprint to describe the wider impact of universities on GHG emissions by the Deputy Chief Executive of the Higher Education Funding Council for England (HEFCE) during consultation on its GHG emissions reduction targets.

The objectives of the Carbon Brainprint project were to test whether it was possible to quantify the carbon brainprints of university activities, explore the difficulties in doing so, propose procedures and estimate the potential brainprints of several examples. This paper will summarise the general approach, briefly describe the case studies used to develop the concept, discuss what was learned from the case studies and identify some of the remaining problems in developing a general method for all types of university activities.

2. Methods

2.1. Case-study approach

As the objectives required development and testing of a method to quantify a previously conceptual measure, a multiple case-study approach was adopted, in which the method evolved during the case studies. This approach was selected in preference to defining a method in advance, so that it could respond to the insights gained and test the underlying concept not the implementation.

The case studies were selected in advance to provide a diverse set of examples, encompassing technological interventions, training courses, detailed modelling and influencing behaviour (Table 1). All the cases were expected to have some impact on carbon footprint reduction, but only one (training for landfill gas inspectors) had quantified it. In addition to the technical differences between the cases, the type of engagement of the universities with the users varied, including implementation within the university campuses, long term research and development contracts with single customers, 'pure' research that had yet to be put into practice, and public sector consultancy relying on uptake by commerce to implement it. Each case was expected to provide different challenges to the methods being developed.

Table 1 – Initial case studies.

Project	University
Ceramic coatings for jet engine turbine blades to improve engine efficiency	Cranfield
Improved delivery vehicle logistics to save fuel	Cranfield
Training for landfill gas inspectors to improve methane capture	Cranfield
Novel offshore vertical axis wind turbines compared to conventional turbines	Cranfield
Intelligent buildings for energy management	Reading
Optimising defouling of oil-refinery preheat trains to reduce fuel consumption	Cambridge

After completion, the case studies were reviewed individually and collectively to assess the need for revisions to the methods, areas of difficulty and conclusions related to the overall aims.

2.2. Guidelines

A set of initial principles or guidelines for the case studies was drawn up by members of the project team, guided by the project steering committee and revised following the case studies. These principles were based on established approaches to carbon footprinting, including PAS 2050:2008 (BSI, 2008) and the Carbon Trust good practice guide (Carbon Trust, 2009), which are underpinned by guidance from the Intergovernmental Panel on Climate Change (Eggleston et al., 2006) and the methods of life cycle assessment (LCA) (e.g. Pennington et al., 2004; Rebitzer et al., 2004). However, as the intention was to obtain an estimate of a change in total emissions, it was anticipated that the level of detail would be coarser than that needed for an LCA of a specific functional unit, and that parts of the footprint unaffected by the change could be neglected. Indeed, it has been noted that, while footprints generally should be based on LCA, they have different characteristics, because they "have a primary orientation towards non-LCA experts and society in general", whereas LCA is designed for technical experts using indicators that "are not necessarily the lens through which society views environmental protection" (Ridoutt et al., 2015).

The guidelines divided the process of conducting a study into five main stages: system definition, boundary definition, data gathering, assessment and uncertainty analysis.

System definition should begin with an interview with the main academics who carried out the work, from which a general qualitative summary would be written describing the case, its application and expected impact. The *boundary definition* should follow from this, specifying the process, spatial, temporal and conceptual boundaries of the system being considered. It was anticipated that the boundaries would need to be drawn widely: in principle they would include all upstream