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CARBON FOOTPRINTING • COMMENTARY

The contribution of PAS 2050 to the evolution of international greenhouse gas emission standards

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Abstract
Background, aim, and scope The assessment of greenhouse gas (GHG) emissions arising from products (goods and services) is emerging as a high profile application of life cycle assessment (LCA), with an increasing desire from retailers and other supply chain organizations to better understand, and in some cases communicate, the carbon footprint of products. Publicly Available Specification 2050:2008, *Specification for the assessment of the life cycle greenhouse gas emissions of goods and services*, addresses the single-impact category of global warming to provide a standardized and simplified implementation of process LCA methods for assessing GHG emissions from products. This paper briefly reviews the development process followed for PAS 2050, before examining the treatment of GHG-specific contribution of PAS 2050 to product carbon footprinting.
Materials and methods PAS 2050 was jointly sponsored by the Carbon Trust and the UK Department for Environment, Food and Rural Affairs and was published by the British Standards Institution on 29 October 2008. An independent steering group oversaw the development of the specification, including the establishment of an expert workgroup program, comprehensive international consultation, and expert input on the requirements of the specification.
Results The development process for PAS 2050 resulted in a specification that includes specific requirements that limit the interpretation of the underlying LCA approach to product carbon footprinting. These requirements, including goal setting and life cycle inventory assessment, aspects of system boundary identification and temporal aspects of GHG emissions, clarify the approach to be taken by organizations implementing product carbon footprinting, and simplify the application of LCA procedures in relation to product carbon footprinting.
Discussion Assessment of the emissions arising from the life cycle of products has a clear international component, and delivering consistent results across the supply chain requires the application of consistent methods. There is an emerging recognition that further standardization of methods for product carbon footprinting is needed, and the specific requirements resulting from the PAS 2050 development process make a valuable contribution across a range of GHG assessment issues.
Conclusions The widespread interest in PAS 2050 from individuals and organizations, together with the development of similar guidance by other organizations, confirmed that there is a need for clarification, certainty, and requirements in the field of product carbon footprint analysis. The use of PAS 2050 to refine, clarify, and simplify existing LCA methods and standards has resulted in specific approaches to key GHG assessment issues being developed; it is important that future standards development work considers the impact of these approaches and their further refinement.
Recommendations and perspectives It is the consumption of goods and services by individuals around the world that drives global GHG emission, and PAS 2050 is a first

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attempt to provide integrated, consistent approaches that directly address the role of consumption at the product level in contributing to GHG emissions. Climate science and GHG assessment techniques are both evolving areas and it will be necessary to review the approach taken by PAS 2050 in the future: a formal review process for PAS 2050 will commence towards the end of 2009 and practitioners are encouraged to participate in this review process.

Keywords Carbon footprinting · GHG assessment · Goods and services · Greenhouse gas emissions · PAS 2050 · Process LCA · Product carbon footprinting · Simplified LCA · Supply chain

1 Background, aim, and scope

The assessment of greenhouse gas (GHG) emissions arising from products (goods and services) is emerging as a high profile application of life cycle assessment (LCA). There is an increasing desire from retailers and other supply chain organizations to better understand, and in some cases, communicate a consumption-based (Carbon Trust 2006a) perspective of the carbon footprint of products. In response to this interest, the Carbon Trust[1] and the UK Department for Environment, Food and Rural Affairs jointly sponsored the development of Publicly Available Specification 2050:2008, *Specification for the assessment of the life cycle greenhouse gas emissions of goods and services* (PAS 2050), as a mechanism for simplifying and standardizing the methods used in the assessment of the carbon footprint[2] of products.

PAS 2050 sets out for the first time a standardized method for assessing product carbon footprints, providing organizations with a consistent approach to assessing the life cycle GHG emissions of products. While PAS 2050 is based on existing LCA approaches, it clarifies, simplifies, and adapts these approaches to the specific objective of determining the carbon footprint of products across their life cycle.

This paper briefly reviews the development process followed for PAS 2050, before examining the contribution of PAS 2050 towards the treatment of GHG-specific issues in product carbon footprinting. The paper examines the approach of PAS 2050 to specific requirements related to the assessment of product GHG emissions, and how these requirements simplify and standardize the implementation of LCA techniques in relation to product carbon footprinting. While some organizations may use this information to inform internal decision-making, others may wish to publicly communicate the information. PAS 2050 itself does not provide requirements beyond those needed to determine the carbon footprint of products, but further guidance on communicating and reducing product carbon footprint information is presented in the *Code of Good Practice for Product Greenhouse Gas Emissions and Reduction Claims* (Carbon Trust 2008a)

Recently, the path set out by PAS 2050 has been followed by the World Resources Institute/World Business Council for Sustainable Development and the International Standards Organization. Current initiatives from these institutions are focussing on the assessment of GHG emissions from the life cycle of products, and PAS 2050 is informing the development and evolution of these initiatives.

2 Materials and methods

2.1 Standard development

PAS 2050 was published by the BSI on 29 October 2008 and includes detailed requirements for the assessment of GHG emissions arising from goods and services. The Carbon Trust, Defra, and BSI also jointly published the *Guide to PAS 2050* (Carbon Trust et al. 2008), which provides assistance to organizations seeking to implement PAS 2050. At the same time, the Carbon Trust published the *Code of Good Practice for Product Greenhouse Gas Emissions and Reduction Claims* (Carbon Trust 2008a) to support the robust communication of product carbon footprint information and *Product Carbon Footprinting: The New Business Opportunity* (Carbon Trust 2008b), which presented experiences from leading companies in implementing product carbon footprinting.

PAS 2050 builds on initial work carried out by the Carbon Trust (2006b) on carbon emissions in the supply chain, and the original method published by Carbon Trust (2007) formed the seed document for the first draft of PAS 2050. This specification was developed between June 2007 and October 2008 and included:

- The establishment of an independent steering group;
- Two rounds of public, international stakeholder consultation;
- Input from workgroups consisting of international experts in a wide range of fields; and
- Practical experience gained from pilot companies' trialing the implementation of draft versions of PAS 2050.

[1] The Carbon Trust is a not-for-dividend company limited by guarantee and was established by the UK Government in 2001. Its mission is to accelerate the move to a low carbon economy.

[2] The term "carbon footprint" is used in this paper to mean the impact of greenhouse gases arising from the life cycle of products. Decisions regarding the gases included, GWP factors, and other aspects of the carbon footprint of products are discussed in this paper.

The steering group for PAS 2050 included 11 representatives from business and industry, academia, government, and nongovernment organizations. The terms of reference for the steering group included directing the overall content of PAS 2050; by following this approach, decision-making regarding the content and requirements included in PAS 2050 was carried out via a consensus-building approach within the steering group, independent of the Carbon Trust and Defra.[3] Management of the international stakeholder consultation was carried out by the BSI, ensuring that there was independent oversight of the treatment of comments received during the development of PAS 2050. In addition, small groups of experts were invited to participate in work groups that considered a wide range of issues relevant to product carbon footprinting: the Carbon Trust supported these work groups and the results were made available to the steering committee and used to inform development of the specification. To ensure the business relevance of the methods being developed, a pilot program including approximately 20 companies was supported by the Carbon Trust. Draft versions of PAS 2050 were trialed with these companies to determine the feasibility and practicality of implementing the emerging specification (see Carbon Trust 2008b for further details of participating companies and case studies).

2.2 The scope of PAS 2050

Product carbon footprinting The scope of PAS 2050 is the assessment of the GHG emissions arising from a life cycle perspective of goods and services (collectively termed products). PAS 2050 is an assessment specification, providing a single set of requirements to be met irrespective of the intended purpose of the study; it does not adopt a multiple tier approach to product carbon footprint assessment. Furthermore, PAS 2050 does not provide requirements regarding the use of the assessment arising from the implementation of the specification; however, it is recognized in PAS 2050 that there are a wide range of potential uses for information on the carbon footprint of products, including:

- Allowing the internal assessment of the existing life cycle GHG emissions of goods and services;
- Facilitating the evaluation of alternative product configurations, sourcing and manufacturing methods, raw material choices, and supplier selection on the basis of the life cycle GHG emissions associated with goods and services;
- Providing a benchmark for ongoing programs directed at reducing GHG emissions;
- Allowing for a comparison of goods or services using a common, recognized, and standardized approach to life cycle GHG emissions assessment;
- Supporting reporting on corporate responsibility;
- Provides a common basis for reporting and communicating the results of life cycle GHG emissions assessments that supports comparison and uniformity of understanding; and
- Provides an opportunity for greater consumer understanding of life cycle GHG emissions when making purchasing decisions and using goods and services (after PAS 2050:2008, 0.2).

2.3 Basis and contribution of PAS 2050 to GHG emissions assessment

Central to the contribution PAS 2050 makes to the field of LCA and GHG emissions assessment is the development of specific requirements within the specification. PAS 2050 builds on the LCA guidance and requirements articulated in ISO 14040:2006 and ISO 14044:2006, adopting a life cycle approach to emissions assessment and the functional unit (PAS 2050:2008, 4.1) as the basis of any reporting. In addition, PAS 2050 brings together key principles from these documents with other relevant methods and approaches in the field of GHG assessment, including ISO 14064:2006, IPCC publications (IPCC 2006, 2007) and the GHG Protocol (WRI/WBCSD 2004).

As the steering group sought to clarify the method for product carbon footprint assessment, the specific requirements of PAS 2050 emerged as one of the key contributions of this specification to the continuing evolution of assessment techniques in this area. The key requirements resulting from this process are discussed in the following section.

3 Results

3.1 Key carbon footprinting issues addressed by PAS 2050

The published version of PAS 2050 included specific requirements for establishing the goal of the assessment, system boundaries and the extent of the life cycle, temporal boundaries and delayed emissions, and carrying out the life cycle impact assessment. In addition, PAS 2050 established new procedures and rules for the assessment of partial GHG emissions assessments and the subsequent use of this

[3] The steering group included a representative from Defra, ensuring that the steering group was inclusive of government as a stakeholder in the development process, and a Carbon Trust director acting as an independent expert. A separate steering group was established for the development of the Code of Good Practice; this steering group included some shared membership with the PAS 2050 Steering Group.

information within the supply chain, refinement of the treatment of allocation to coproducts, the approaches to be taken in relation to data, data quality and uncertainty, and the treatment of offsetting within the specification. The resulting treatment of each of these areas of the LCA is described in this section.

3.2 Goal of the assessment

A central component of LCA is establishing the goal of the study, which then allows for a wide variety study objectives to be addressed. However, in product carbon footprinting, the goal of the study could be considered to be an integral component of the decision to carry out the study. For example, ISO 14044:2006 (4.2.2) establishes four requirements for the goal of a LCA study: intended application; reasons for carrying out the study; the intended audience; and the use of the results in comparative assertions that are publicly communicated. Recognizing the business audience, PAS 2050 simplifies the approach to goal setting for product carbon footprinting:

- Intended application: The requirements of PAS 2050 provide a single-tier approach to product carbon footprinting that supports third-party communication of results, together with a wide range of other potential applications.
- Reason for carrying out the study: For a company seeking to assess the GHG emissions arising from the life cycle of a product, the reason for implementing PAS 2050 is self-evident: to assess the GHG emissions arising from the life cycle of a product.
- Intended audience: Linked with the intended application, PAS 2050 is designed to support third-party communication of results. Of course, where organizations do not intend communicating results to third parties, compliance with any given standard is at the discretion of the organization.
- Comparative assertions: PAS 2050 does not support comparative assertions, but recognizes that individual stakeholders may compare results that are placed in the public domain.

The approach PAS 2050 has taken towards clarifying the goal of the study simplifies the implementation of the specification for businesses seeking to understand the carbon footprint of their products. This approach establishes limits to the applicability of PAS 2050 and clearly articulates the goal of the study. However, there may be circumstances in which organizations seek a different goal (for example, high-level assessments that are not published); in such circumstances, organizations need not make any assertion about the approach taken, even though it may be guided by PAS 2050.

3.3 System boundaries and the extent of the life cycle

Under the existing LCA guidance, "the selection of the system boundary shall be consistent with the goal of the study" (ISO 14044:2006, 4.2.3.3.1). In addition, there is a presumption that the assessment of the life cycle includes all stages in the life cycle; however, processes, inputs, and life cycle stages can be deleted if they do not "significantly change" the overall conclusions of the study (ISO 14044:2006, 4.2.3.3.1).

For product carbon footprinting under PAS 2050, the goal is already clear: the assessment of the GHG emissions arising from the life cycle of products. With the goal clearly understood and with no need to revisit the definition of the goal for each product being assessed, there is the opportunity to further refine the boundary setting for the product carbon footprint assessment. PAS 2050 provides requirements for identifying the system boundary: both inclusions within the system boundary and exclusions from the system boundary (see PAS 2050: 2008, Section 6). In addition, PAS 2050 clarifies "significantly change" by establishing a materiality threshold for the inclusion of GHG emissions from all inputs that contribute more than 1% of the life cycle GHG emissions of the product. Inputs not meeting this threshold may be excluded (up to a cumulative maximum of 5% of the total life cycle GHG emissions of the product); however, the final result being scaled up to account for any excluded emissions (for further materiality threshold requirments, see PAS 2050:2008, 6.3).

While PAS 2050 provides some clarification over boundary setting, it must be recognized that a single standard cannot address specific issues that relate to individual product categories or individual products. For this reason, PAS 2050 makes reference to product category rules (PCRs), which provide a mechanism for agreeing specific rules in relation to individual product categories. PCRs are established under ISO 14025:2006 with the aim of improving comparability: where a PCR exists for a product category and the provisions of the PCR do not conflict with those in PAS 2050, then the product category-specific information contained in PRCs is used under PAS 2050 for the identification of the system boundary (and selected other roles).

3.3.1 Use stage

Despite the guidance in ISO 14044, the inclusion of emissions from the use stage in the assessment of GHG emissions from products proved to be a significant cause of concern. In the early stages of the development of PAS 2050, there was considerable debate over the treatment of emissions arising from the use stage of products and whether this should be included or excluded. Under the draft method

published by Carbon Trust (2007), emissions from the use stage of products was excluded from the assessment method; however, further investigation of this particular aspect of carbon footprinting was continued through the pilot program, expert workgroups, and consultations.

One of the key arguments against the inclusion of use stage emissions was the lack of certainty over the manner in which products would actually be used, and therefore, there would be uncertainty over the use stage emissions of the product. Countering this argument, product carbon footprint information would not be effective at supporting decision-making if potentially significant stages of the life cycle were excluded, as the true GHG impact of the product would not be revealed.

To address these issues, PAS 2050 requires the development of a use profile (PAS 2050:2008, 6.4.8.2) for any product that may have emissions arising from the use stage. The use profile would describe the assumptions underlying the assessment of emissions from the use stage, ensuring that there is both clarity of the decisions taken, and the opportunity for other product carbon footprint assessments to use the same use profile for assessing similar products. While PAS 2050 cannot require that a particular use profile is used, this approach facilitates comparability by ensuring transparency and encouraging consistency in the development and application of use profiles.

3.3.2 Capital goods emissions

Emissions from capital goods (i.e., the emissions arising from the construction of shared infrastructure such as electricity transmission networks that are used to deliver electricity to the processes within the system boundary of the study) are outside the boundary of PAS 2050, and therefore, not included in the carbon footprint of products. This in part reflects the experience of pilot companies in implementing draft versions of PAS 2050 in which emissions from capital goods were included; however, it is recognized that, in some product categories, emissions from capital goods may make a material contribution to the carbon footprint of products.

3.4 Life cycle impact assessment

ISO 14044:2006 specifies three mandatory elements for inclusion in the life cycle impact assessment: selection of impact categories, category indicators, and characterization models; assignment of life cycle inventory results to the selected impact categories; and calculation of category indicator results.

PAS 2050 addresses each of these mandatory elements, simplifying the implementation of GHG assessment for products by providing clarity as to the decisions and approaches to be taken. However, PAS 2050 does not seek to replicate the language of ISO 14044:2006 in this respect: rather, PAS 2050 clarifies each of these mandatory elements in a manner that does not introduce unnecessary complexity into the language of product carbon footprinting.

3.4.1 Selection of impact categories, category indicators, and characterization models

The selection of gasses for inclusion in the carbon footprint of a product will, in some particular product categories, have a significant impact on the assessed impact of the product. For example, in the agriculture sector, the treatment of methane emissions from the carbon footprint assessment will exert a strong influence over the GHG emissions assessment for beef (and other meat) production, and consequently, the ranking of meat versus vegetables on the basis of their product carbon footprint.

Alongside the range of gasses to be included, the time horizon for the global warming potential (GWP) of the gasses needs to be specified. GWP data allows the GHG impact of gasses other than carbon dioxide to be expressed in terms of the equivalent amount of carbon dioxide (CO_2e) that would produce the same GWP over a given impact period. This time component of the GHG impact of releases from the supply chain is crucial, as different gasses have different residence times in the atmosphere. For example, the residence time of methane in the atmosphere is much shorter than that of carbon dioxide; as a result, the *relative* impact of methane emissions on CO_2e declines (compared to carbon dioxide) as the impact time horizon increases.

This time dimension adds a subjective, political aspect to the complexity of deciding the appropriate characterization model for the study, as a product carbon footprint will assess the impact of GHGs over a specific time period following release. The IPCC (2007) provides GWP data for non-CO_2 GHGs over three time horizons, 20-, 100-, and 500-year, and a choice between time horizons needs to be made. Choosing a 20-year time horizon would implicitly value short-term decision-making; it would also increase the relative importance of short-lived GHG releases (e.g., methane) in the assessment of GHG emissions of products. At the other extreme, a 500-year time horizon for assessment lessens the importance of short- and medium-term decision-making; such an approach may lessen the incentive for taking action now to reduce GHG emissions and increase the risk and magnitude of climate change over current and immediate future generations. A 100-year time horizon would reflect both an emerging consensus on the most relevant assessment period and a time horizon which is relevant to contemporary decision-making.

Thus, in developing PAS 2050, three core decisions were taken: PAS 2050 would address the single-impact category

of global warming; the category indicator would be the GWP of the emissions arising from the life cycle of the product; and the characterization model would be as given by the (IPCC 2007) with 100-year time horizon GWP data (PAS 2050:2008, 5.1).

3.4.2 Assignment of life cycle inventory results to the selected impact categories

With a single-impact category of global warming being considered, this mandatory aspect of the ISO 14044:2006 standard becomes trivial: all life cycle inventory results are assigned to one impact category.

3.4.3 Calculation of category indicator results

PAS 2050 specifies that the impact of GHG emissions arising from the life cycle of products is obtained by multiplying the mass of each GHG released in the life cycle of the product by the GWP of the gas and summing the result.

3.5 Temporal boundaries and delayed emissions

PAS 2050 establishes a temporal boundary of 100 years following the formation of the product for the impact assessment of the GHG emissions arising from the product life cycle. This temporal boundary is consistent with the 100-year GWP time horizon established in the scope of emissions covered by PAS 2050 and ensures that the full impact of emissions released during the formation of the product are fully included. However, there are circumstances in which the life cycle of the product includes emissions released after the formation of the product and within the 100-year assessment period (for example, emissions associated with the use stage of a product).

PAS 2050 limits the inclusion of GHG emissions to those occurring within 100 years of the formation of the product and weighs the impact of these emissions according to when the emissions occur. While this is consistent with the 100-year assessment period for GHG emissions adopted in PAS 2050, this approach has been criticized for "discounting" (or more accurately, applying a temporal cut-off to) future emissions associated with the life cycle of products. This criticism has merit; however, the emerging consensus around using a 100-year time horizon for GWP data implies that the impact of emissions during this period, and therefore, the impact of avoided emissions during this period is valued more highly than over other time horizons. Had PAS 2050 taken an alternative approach, such as fully including the 100-year GWP impact of emissions irrespective of when those emissions occur, this would have implied that society does not value decisions taken now that delay GHG emissions. Such an implication would be inconsistent with importance currently placed on the 100-year time horizon for emissions assessment.

3.5.1 Carbon storage

A closely related topic to delayed emissions is that of carbon storage: the carbon storage component of the PAS 2050 method addresses those circumstances where the formation of the product results in biogenic carbon being retained out of the atmosphere for an extended period of time. This is a controversial aspect of product carbon footprinting: for example, should a wood-based product receive a benefit for retaining what was previously atmospheric carbon in solid form?

Having established that the time horizon for the GWP data used in the assessment is 100 years and that a higher (political, social) value is placed on emissions over the next 100 years than over significantly shorter or longer time horizons, it therefore follows that where a product has prevented carbon from being in the atmosphere during this time, the impact of this delay should be recognized. PAS 2050 approaches this issue by weighting the GWP of biogenic carbon released by the product by the proportion of years within the 100 year assessment period that the biogenic carbon is in the atmosphere (a similar weighting approach is applied to delayed emissions arising from the product life cycle. However, there are limitations to this: the biogenic carbon must be additional to that which would have occurred anyway (for example, timber from managed forests would receive a carbon storage benefit under PAS 2050, while timber from primary forests would not); the impact must represent the average storage duration over the 100-year assessment period; and the product must be durable (lasting more than 1 year) and not a food or feed product. Under these circumstances, PAS 2050 recognizes the impact of carbon storage in lowering atmospheric CO_2 concentrations over the 100-year assessment period.

3.5.2 Land use change

GHG emissions from land use change have the potential to be a significant source of overall GHG emissions in the life cycle of some products, particularly agriculture and biofuel products. PAS 2050 requires that the GHG emissions arising from direct land use change occurring since 1 January 1990 be addressed in the product carbon footprint assessment (PAS 2050:2008, 5.5); indirect land use change emissions are not addressed. PAS 2050 requires the highest tier (IPCC 2006) data available to be used in the assessment, and the total emissions arising from the land use change are divided equally across products arising from the land in the first 20 years following the land use change. Where

knowledge regarding LUC is limited, PAS 2050 requires a 'worst-in-class' approach to be taken.

Importantly, PAS 2050 does not include emissions from land use change within existing agricultural systems, such as changes to crops or tillage practices; this decision will be reviewed in future versions of PAS 2050, as the ability of GHG assessments to reflect the climate benefits of alternative farming practices could provide further encouragement of effective soil carbon management.

3.6 Partial GHG emissions assessment

Product carbon footprinting is often seen from an end-user perspective where the emissions associated with a finished product are assessed. However, many organizations operate within supply chains, providing inputs to processes that result in finished products. For these organizations, assessing the emissions associated with their products (including all downstream emissions) may not be feasible: however, for their customers, information on the emissions associated with the products they are using as inputs to the life cycle of a finished product may be very useful.

PAS 2050 establishes partial (cradle-to-gate) emissions assessment (PAS 2050:2008, 6.2) as a specific outcome for organizations whose activities include the provision of products as inputs to other processes (business-to-business, or B2B, information transfer). By establishing a standard method for assessing GHG emissions within the supply chain and then transferring this information through the supply chain, the provision of supply chain-specific data to a common assessment method is supported in a manner that seeks to minimise overall costs of implementation.

3.7 Allocation to coproducts and recycling

For issues relating to coproduct allocation and recycling (PAS 2050:2008, 8.1.1 and 8.5), the specification builds upon the existing guidance in ISO 14044:2006 by including some modifications of the existing ISO approach to coproduct allocation that provide greater clarity and certainty to those organizations implementing the specification.

In summary, PAS 2050 seeks to avoid allocation by (in order of preference) division of unit processes or expansion of the product system. However, in relation to expansion of the product system, PAS 2050 introduces two requirements: expansion of the product system may be followed only where a displaced product can be identified; and the emissions associated with the displaced product represent the average emissions from the avoided product (i.e., not the marginal emissions). These additional provisions provide for greater certainty and comparability in the treatment of system expansion. In cases where these conditions cannot be met, PAS 2050 requires allocation to coproducts on the basis of economic value, limiting the options provided in the ISO 14044 guidance (specific additional requirements are specified for selected topics).

PAS 2050 adopts the existing ISO 14044 approach to the treatment of recycling, presenting it in terms of product systems and other systems in preference to the closed and open loop terminology of ISO 14044.

3.8 Data, data quality, and uncertainty

The data requirements for product carbon footprinting can be extensive, and there is a need to provide requirements for the origin and quality of this data; PAS 2050 draws together two existing approaches in its treatment of data.

Firstly, PAS 2050 adapts the ISO 14064-1:2006 concept of financial and operational control to separate between primary activity data (data from processes owned, operated, or controlled by the organization implementing PAS 2050) and secondary data (other data sources). This separation reinforces the need for a minimum level of process-specific data to be used when assessing GHG emissions from products, while recognizing that secondary data sources will continue to play an essential role in carbon footprint assessments. When using secondary data, preference is given to PAS 2050-compliant data (such as that arising from partial GHG assessments described in Section 3.6) over other sources of secondary data, thereby embedding the role data transfer that is facilitated by a consistent approach to boundary selection and other issues.

Secondly, PAS 2050 builds on and adapts the data quality rules given in ISO 14044:2006 (4.2.3.6.2), modifying them such that they better reflect the needs of product carbon footprint assessment studies. While these requirements direct users of the standard to the most appropriate data for their particular situation, they also qualitatively address the issue of uncertainty in the data used in the assessment. Rather than adopt a quantitative, accuracy- and precision-driven approach to uncertainty assessment, PAS 2050 relies on the data quality rules to address uncertainty issues: by ensuring that the most appropriate data is used for all inputs, this approach provides a qualitative assurance that uncertainty has been minimized.

3.9 Offsetting

The specification excludes the use of offsets, such as those flowing from Clean Development Mechanism projects under the Kyoto Protocol, from inclusion within the assessment method. This decision is consistent with the life cycle perspective taken by PAS 2050 to GHG emissions assessment, as activities such as offset generation that are occurring outside the life cycle of the product are not within the boundary of the assessment. Additionally, where an

organization wishes to offset emissions from a product (or activity), the quantity of emissions to be offset must first be determined; PAS 2050 provides the requirements for this assessment, and organizations may subsequently choose to offset product carbon footprint emissions using a PAS 2050-compliant assessment of GHG emissions. However, any decision to offset emissions remains outside the scope of PAS 2050, and reporting of offsets would have to clearly separate the PAS 2050 emissions assessment and the claimed offset.

4 Discussion

The assessment of the GHG emissions arising from the life cycle of products has previously been addressed through the application of ISO 14040 and ISO 14044 to a wide range of LCA questions. This has been entirely appropriate, as these international standards provide sufficient flexibility to allow bespoke approaches to suit the requirements of each individual study. It is this flexibility, however, that may also limit the uptake and applicability of the existing standards in particular circumstances. For example, allowing for a reassessment of the goals and scope of each individual LCA, providing the option to exclude different stages of the life cycle from the system boundary, and mandating the consideration of characterization models and other aspects of the life cycle inventory assessment all combine to allow a variety of (justifiable) solutions to similar questions.

The transparency of the LCA approach ensures that the differences in approach allowed under the existing international standards could be reviewed and researched; this is practical when the expectation is that the number of LCA studies will be limited, and those exposed to the results will be sufficiently expert to examine the results. However, with the desire for organizations to engage in product carbon footprinting, and the emerging interest of consumers in receiving information regarding the carbon footprint of the goods and services they consume, routine exploration of the methodological similarities and differences between LCA studies of different (or similar) products seems increasingly remote.

Furthermore, the expansive nature of supply chains, the integrated nature of production, and the global reach of larger organizations emphasizes the need for an internationally agreed approach to product carbon footprinting methods. While single-country approaches to product carbon footprinting may appear attractive, unless these initiatives are developed on the basis of a common assessment method, then the costs for industry compliance with many disparate approaches will increase. Pilot studies carried out by the Carbon Trust (2008b) demonstrate the global nature of the supply chains that combine to deliver consumer products; application of the requirements of PAS 2050 has ensured that different aspects of the assessment, carried out in different countries, remain compatible.

PAS 2050 was developed to be internationally applicable, providing a global common method that is unlikely to emerge through single-country approaches as, and the B2B information sharing that it facilitates, it will be more difficult to embed the systems required to support widespread product carbon footprinting activities. Further work in relation to product carbon footprinting is currently being pursued, suggesting that there is now a more widespread recognition of the limitations of the previous international standards and the need for consistency in the methods used. The World Resources Institute and World Business Council for Sustainable Development announced in July 2008 that they would be collaborating on a product carbon footprinting project, while the International Standards Organization voted in November 2008 to proceed with development of a new international standard on product carbon footprinting (ISO 14067:2008). Given the scope of these initiatives, it is clear that the organizations involved recognize similar demand to adapt the existing LCA standards in relation to product carbon footprinting, and by following the lead of PAS 2050, both initiatives are in a position to use the experience gained in developing and applying PAS 2050 to inform their own development activities.[4]

The LCA Steering Committee of the Society of Environmental Toxicology and Chemistry Europe (SETAC Europe), and the recent editorial in this section of this journal (Finkbeiner 2009), have also acknowledged the importance of developing simplified and practical methods for product carbon footprint assessment. SETAC Europe has published nine key points which it considers are needed to ensure that there is no conflict with existing ISO standards (SETAC 2008), including the adoption of a functional unit approach, comprehensive coverage of all life cycle stages, coverage of all relevant GHGs, and the assessment of product carbon footprints in a comparable and consistent manner (such as through PCRs). Many of these issues have already been considered in the development of PAS 2050, and it will be important for the processes currently in progress to learn from and incorporate, as necessary, the experience gained so far in the application of PAS 2050 across multiple countries, companies, and product categories.

The approach of PAS 2050 to product carbon footprinting has demonstrated the potential for refinement, clarification,

[4] The Carbon Trust is represented in the Steering Group for the WRI/WBCSD product carbon footprinting initiative, and ISO/TC207/SC7 Working Group 2 that is developing a new ISO standard on product carbon footprinting [membership is personal (at least in ISO), therefore, I would use different wording].

and simplification of the existing LCA standards. There are key issues within LCA that have unique applicability to the assessment of GHGs from products, such as the temporal scope of the impact assessment, where a common approach is essential for delivering comparable, repeatable results. Some of the approaches adopted in PAS 2050 may not be universally agreed; however, PAS 2050 provides the first ever attempt to combine approaches to a variety of GHG specific assessment issues to deliver a globally applicable product carbon footprinting method, and it is important that other initiatives continue to learn from and incorporate the experiences gained through the application of PAS 2050 to different product categories and supply chains.

5 Conclusions

PAS 2050 provides for the first time an internationally consulted, standardized method for the assessment of GHG emissions from the life cycle of goods and services. In developing this specification, significant clarification and simplification of the existing LCA requirements and guidance was undertaken; this supports the underlying goals of PAS 2050 of being practical to implement, and supporting comparability of results and assists organizations in understanding the life cycle GHG emissions associated with their products. In combination with the associated Code of Good Practice, Guide to PAS 2050, and Business Case for Product Carbon Footprinting, PAS 2050 has demonstrated that refinement, clarification, and simplification of the existing LCA standards can support organizations in delivering product carbon footprints for widely varying products originating from complex, international supply chains.

6 Recommendations and perspectives

It is the consumption of goods and services by individuals around the world that drives global GHG emission, and a wide range of policies will be required to meaningfully impact on these emissions. PAS 2050:2008 is a first attempt to provide a globally applicable, integrated, consistent approach to the assessment of GHG emissions arising from the life cycle of goods and services, and therefore directly address the role of consumption at the product level in contributing to GHG emissions. Climate science and GHG assessment techniques are both evolving areas, and it will be necessary to review the approach taken by PAS 2050 in the future: a formal review process for PAS 2050 will commence towards the end of 2009, and practitioners are encouraged to participate in this review process.

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