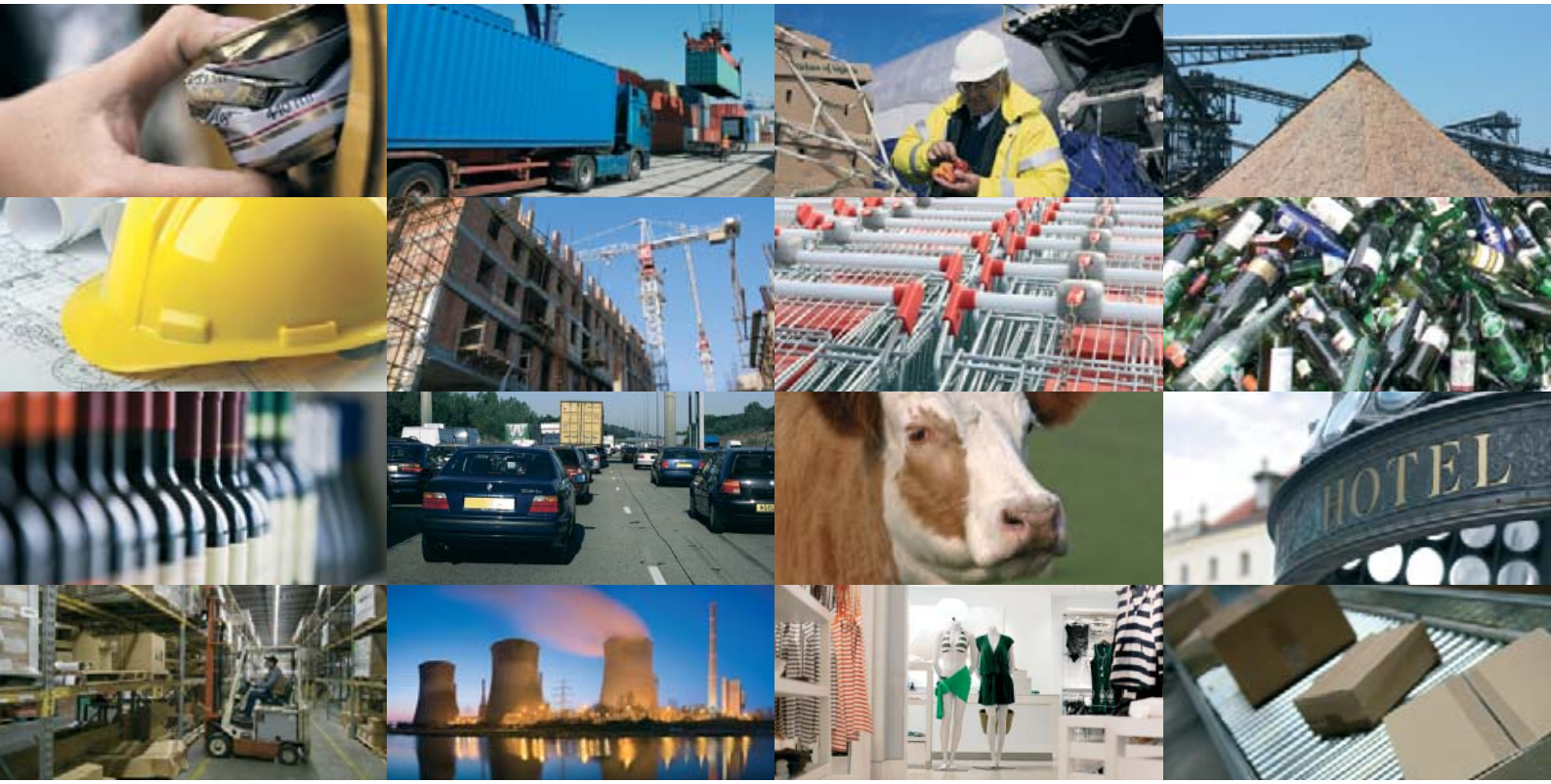
PUBLICLY AVAILABLE SPECIFICATION

PAS 2050:2011

Specification for the assessment of the life cycle greenhouse gas emissions of goods and services



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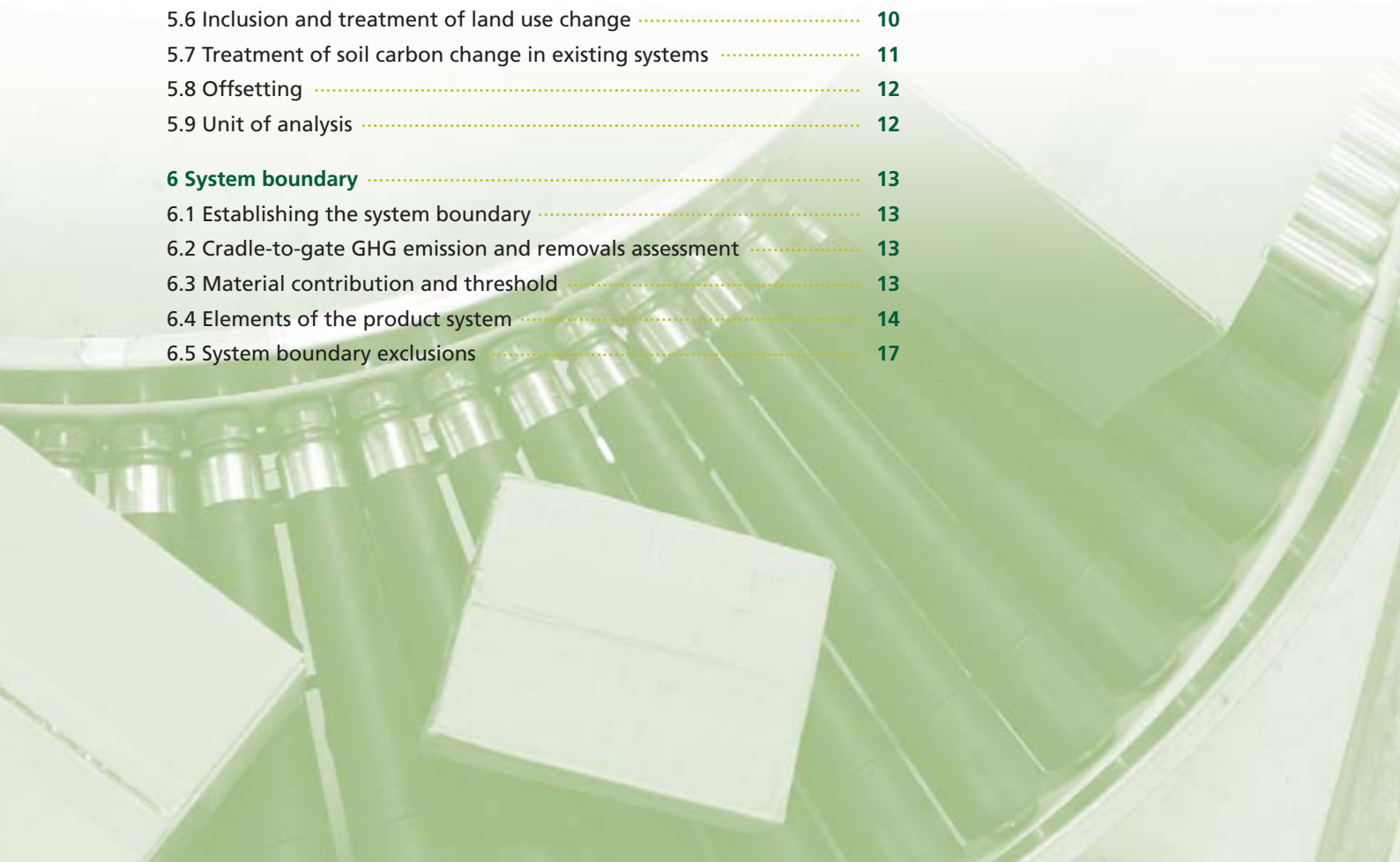

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Foreword

The revision of this Publicly Available Specification (PAS) has been undertaken by BSI to update the specification for quantifying the life cycle greenhouse gas (GHG) emissions of goods and services in line with the latest technical advances and current experience.

The development of this PAS was co-sponsored by:

- Defra (Department for Environment, Food and Rural Affairs, UK);
- DECC (Department of Energy and Climate Change, UK);
- BIS (Department for Business, Innovation and Skills, UK).

Acknowledgement is given to the following organizations and individuals that assisted with the development of this specification:

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Comments from other parties were also sought by BSI. The expert contributions from all the organizations and individuals consulted in the development this PAS are gratefully acknowledged.

Supersession

This Publicly Available Specification supersedes PAS 2050:2008, which is withdrawn.

Use of this document

It has been assumed in the preparation of this PAS that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

This PAS has been prepared and published by BSI, which retains its ownership and copyright. BSI reserves the right to withdraw or amend this PAS on receipt of authoritative advice that it is appropriate to do so. This PAS will be reviewed at intervals not exceeding two years, and any amendments arising from the review will be published as an amended Publicly Available Specification and publicized in *Update Standards*.

This PAS is not to be regarded as a British Standard, European Standard or International Standard. In the event that this PAS is put forward to form the basis of a full British Standard, European Standard or International Standard, it will be withdrawn.

Presentational conventions

The provisions of this PAS are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall". Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material (e.g. Notes) is presented in italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with this PAS does not in itself confer immunity from legal obligations.

0 Introduction

0.1 General information

Climate change continues to be one of the greatest challenges facing nations, governments, business and citizens and will influence the way we live and work in future decades (IPCC 2007 [1]). Past and current actions, including the release of carbon dioxide (CO_2) and other greenhouse gases through human activities such as the burning of fossil fuels, emissions from chemical processes and other sources of anthropogenic greenhouse gases, will have an effect on future global climate.

While greenhouse gas (GHG) emissions are often viewed at global, national, corporate or organizational levels, emissions within these groupings can arise from supply chains within business, between businesses and between nations. The GHG emissions associated with goods and services reflect the impact of processes, materials and decisions occurring throughout the life cycle of those goods and services.

PAS 2050 was developed in response to broad community and industry desire for a consistent method for assessing the life cycle GHG emissions of goods and services. Life cycle GHG emissions are the emissions that are released as part of the processes of creating, modifying, transporting, storing, using, providing, recycling or disposing of such goods and services. PAS 2050 offers organizations a method to deliver improved understanding of the GHG emissions arising from their supply chains, but the primary objective of this PAS is to provide a common basis for GHG emission quantification that will inform and enable meaningful GHG emission reduction programmes.

During the first two years of its use, this PAS has been shown to be generically applicable to a wide range of goods and services and therefore does not itself make provision for the special treatment of particular product sectors. However, it is recognized that the availability of supplementary requirements could aid consistent application of the PAS to products within specific product sectors by providing:

a) a sector or product group focus for aspects of the PAS 2050 assessment where options are permitted;
b) rules or calculation requirements that are directly relevant to the main sources of emissions for a specific sector or product group;
c) clarity on how to apply specific elements of the PAS 2050 assessment within a specific sector or product group.

To facilitate this, this new edition of PAS 2050 includes a set of principles (see **4.3**) governing the development of supplementary requirements for the application of PAS 2050 to particular product types. These principles are intended to ensure that such supplementary requirements are not in conflict with the requirements of this PAS.

Although there is no requirement for, or standardization of, communication techniques in this specification, this PAS supports the assessment of life cycle GHG emissions of goods and services in a manner that can be later disclosed. For this reason, great emphasis is given to proper recording of processes and outcomes. Where an organization implementing this PAS chooses to disclose all or part of the results of an assessment of GHG emissions, all relevant supporting information should also be made available.

Where communication is directed to the consumer, the user should refer to additional specifications or further guidance on environmental claims (e.g. ISO 14021 [1] or UK Department of Environment Food and Rural Affairs Green Claims Guidance [7] [2]).

Using PAS 2050 to quantify the life cycle GHG emissions from goods and services aids informed decision-making when considering reducing emissions for products and services.

This PAS is focused on a single environmental issue (i.e. GHG emissions and their contribution to climate change), but this is only one of a range of possible environmental impacts from specific goods or services. The relative importance of those impacts can vary significantly from product to product, and it is important to be aware that decisions taken on the basis of a "single issue" assessment could be detrimental to other environmental impacts potentially arising from the provision and use of the same product.

[1] http://www.iso.org/iso/catalogue_detail?csnumber=23146
[2] http://www.defra.gov.uk/publications/2011/06/03/pb13453-green-claims-guidance/

0.2 Background, benefits and context of PAS 2050

PAS 2050 builds on existing life cycle assessment methods established through BS EN ISO 14040 and BS EN ISO 14044 by giving requirements specifically for the assessment of GHG emissions within the life cycle of goods and services. These requirements further clarify the implementation of these standards in relation to the assessment of GHG emissions of goods and services, and establish particular principles and techniques, including:

a) cradle-to-gate and cradle-to-grave GHG emissions assessment data as part of the life cycle GHG emissions assessment of goods and services;

b) scope of greenhouse gases to be included (see **5.1**);

c) criteria for global warming potential (GWP) data (see **5.3**);

d) treatment of emissions and removals from land use change and biogenic and fossil carbon sources;

e) treatment of the impact of carbon storage in products and offsetting;

f) requirements for the treatment of GHG emissions arising from specific processes;

g) data requirements and accounting for emissions from renewable energy generation.

This PAS benefits organizations, businesses and other stakeholders by providing a clear and consistent method for the assessment of the life cycle GHG emissions associated with goods and services. Specifically, this PAS provides the following benefits:

a) for organizations that supply goods and services, this PAS:
   - allows internal assessment of the existing life cycle GHG emissions of goods and services;
   - facilitates 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 is to be used as a basis for comparison of services;
   - provides a benchmark for programmes aimed at reducing GHG emissions;
   - allows for the quantification, management and potential comparison of GHG emissions from goods or services using a common, recognized and standardized approach to life cycle GHG emissions assessment; and
   - supports reporting (e.g. on corporate responsibility).

b) for consumers of goods and services, this PAS provides a common basis for understanding the assessment of life cycle GHG emissions when making purchasing decisions and using goods and services.

1 Scope

This Publicly Available Specification (PAS) specifies requirements for the assessment of the life cycle GHG emissions of goods and services (collectively referred to as "products") based on key life cycle assessment techniques and principles. This PAS is applicable to organizations assessing the GHG emissions of products across their life cycle, and to organizations assessing the cradle-to-gate GHG emissions of products.

Requirements are specified for identifying the system boundary, the sources of GHG emissions associated with products that fall inside the system boundary, the data requirements for carrying out the analysis, and the calculation of the results.

This PAS addresses the single impact category of global warming. It does not assess other potential social, economic and environmental impacts or issues arising from the provision of products or issues associated with the life cycle of products, such as non-GHG emissions, acidification, eutrophication, toxicity, biodiversity or labour standards. The life cycle GHG emissions of products, as calculated using this PAS, do not provide an indicator of the overall environmental impact of these products, such as may result from other types of life cycle assessment.

PAS 2050 is generically applicable to a wide range of goods and services. However, this revision includes principles for the preparation and use of supplementary requirements to provide a focused approach for specific industry sectors or product categories in a manner that will facilitate consistent application of PAS 2050 within the particular sector or product category.

This PAS does not specify requirements for the disclosure or communication of the results of a quantification of the life cycle GHG emissions of goods and services.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN ISO 14021, *Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling)*

BS EN ISO 14044:2006, *Environmental management – Life cycle assessment – Requirements and guidelines*

IPCC 2006, *Guidelines for National Greenhouse Gas Inventories*. National Greenhouse Gas Inventories Programme, Intergovernmental Panel on Climate Change

Note *Subsequent amendments to IPCC 2006 also apply.*

IPCC 2007, *Climate Change 2007: The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon S, Qin D, Manning M, Chen Z, Marquis M, Avery KB, Tignor M, Miller HL (editors)]. Cambridge, UK: Cambridge University Press, 996 pp.

Note *Subsequent amendments to IPCC 2007 also apply.*

3 Terms and definitions

For the purposes of this PAS, the following terms and definitions apply.

3.1 allocation

partitioning the inputs to or emissions from a shared process or a product system between the product system under study and one or more other product systems

3.2 anticipated life cycle greenhouse gas emissions

initial estimate of greenhouse gas (**3.19**) emissions for a product (**3.35**) that is calculated using secondary data (**3.41**) or a combination of primary activitity data (**3.34**) and secondary data, for all processes used in the life cycle of the product

3.3 biogenic

derived from biomass, but not from fossilized or fossil sources

3.4 biogenic carbon

carbon that is contained in biomass

Note *For the purpose of calculations in accordance with this PAS, CO_2 from air converted to non-biomass carbonates is calculated as biogenic carbon.*

3.5 biomass

material of biological origin, excluding material embedded in geological formations or transformed to fossil

[Adapted from CEN/TR 14980:2004, 4.3]

3.6 capital goods

goods, such as machinery, equipment and buildings, used in the life cycle of products

3.7 carbon dioxide equivalent (CO_2e)

unit for comparing the radiative forcing of a greenhouse gas to carbon dioxide

[BS ISO 14064-1:2006, 2.19]

Note 1 *The term carbon dioxide (CO_2) used throughout this PAS should not be confused with carbon dioxide equivalent (CO_2e).*

Note 2 *The CO_2e is calculated by multiplying the mass of a given GHG by its global warming potential (see **3.23** for a definition of global warming potential).*

Note 3 *Greenhouse gases, other than CO_2, are converted to their CO_2e on the basis of their per unit radiative forcing using 100-year global warming potentials defined by the Intergovernmental Panel on Climate Change (IPCC).*

3.8 carbon storage

retention of carbon from biogenic or fossil sources or of atmospheric origin in a form other than as an atmospheric

3.9 combined heat and power (CHP)

simultaneous generation in one process of usable thermal, electrical and/or mechanical energy

3.10 consumable

ancillary input that is necessary for a process to occur but that does not form a tangible part of the product or co-products arising from the process

Note 1 *Consumables differ from capital goods in that they have an expected life of one year or less, or a need to replenish on a one year or less basis (e.g. lubricating oil, tools and other rapidly wearing inputs to a process).*

Note 2 *Fuel and energy inputs to the life cycle of a product are not considered to be consumables.*

3.11 consumer

user of goods or services

3.12 co-product

any of two or more products from the same unit process or product system

[BS EN ISO 14044:2006, 3.10]

Note *Where two or more products can be produced from a unit process, they are considered co-products only where one cannot be produced without the other being produced.*

3.13 cradle-to-gate

life cycle stages from the extraction or acquisition of raw materials to the point at which the product leaves the organization undertaking the assessment

3.14 cradle-to-grave

life cycle stages from the extraction or acquisition of raw materials to recycling and disposal of waste

3.15 data quality

characteristics of data that relate to their ability to satisfy stated requirements

[BS EN ISO14044:2006, 3.19]

3.16 downstream emissions

GHG emissions associated with processes that occur in the life cycle of a product subsequent to the processes owned or operated by the organization implementing this PAS

3.17 economic value

market value of a product, co-product or waste (see **3.49** for a definition of waste) at the point of production

3.18 emission factor

amount of greenhouse gases emitted, expressed as CO_2e (**3.7**) and relative to a unit of activity

Note *For example, kgCO_2e per unit input. Emission factor data would be obtained from secondary data sources.*

3.19 (GHG) emissions

release to air and discharges to water and land that result in GHGs entering the atmosphere

3.20 food and feed

substances in solid or liquid form intended to be consumed by humans or animals

3.21 fossil carbon

carbon that is contained in fossilized material

Note *Examples of fossilized material are coal, oil and natural gas. For the purposes of this PAS, peat is also to be treated as fossilized material with regard to its combustion.*

3.22 functional unit

quantified performance of a product system for use as a reference unit

[BS EN ISO 14044:2006, 3.20]

Note *For the purposes of GHG emissions assessment, the functional unit can be a single item of product or a generally accepted sales quantity (e.g. 1 rose or 1 dozen roses).*

3.23 global warming potential (GWP)

factor describing the radiative forcing impact of one mass-based unit of a given greenhouse gas relative to an equivalent unit of CO_2 over a given period of time

[BS ISO 14064-1:2006, 2.18]

Note *CO_2 is assigned a GWP of 1, while the GWP of other gases is expressed relative to the GWP of CO_2. Annex A contains global warming potentials for a 100-year time period produced by the Intergovernmental Panel on Climate Change (IPCC).*

3.24 greenhouse gases (GHGs)

gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds

Note *The GHGs included in this PAS are specified in Annex A.*

3.25 input

product, material or energy flow that enters a unit process

[BS EN ISO 14040:2006, 3.21]

3.26 intermediate product

output from a unit process that is an input to other unit processes involving further transformation within the system

3.27 land use change

change in the purpose for which land is used by humans (e.g. between crop land, grass land, forest land, wetland, industrial land)

Note 1 *Change in the use of land at the location of production of the product being assessed is referred to as direct land use change.*

Note 2 *Change in the use of land elsewhere is referred to as indirect land use change.*

3.28 life cycle

consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to end of life, inclusive of any recycling or recovery activity

[Adapted from BS EN ISO 14040:2006, 3.1]

3.29 life cycle assessment (LCA)

compilation and evaluation of inputs, outputs and potential environmental impacts of a product system throughout its life cycle

[BS EN ISO 14040:2006, 3.2]

3.30 life cycle GHG emissions

sum of greenhouse gas emissions resulting from all stages of the life cycle of a product and within the specified system boundaries of the product

Note *This includes all emissions and removals associated with the processes within the boundary of the life cycle of the product, including obtaining, creating, modifying, transporting, storing, operating, using and end-of-life disposal of the product. To avoid undue repetition, reference to removals is not always included in the text, but it is intended that assessment should include removals wherever they occur.*

3.31 material contribution

contribution from any one source of GHG emissions of more than 1% of the anticipated total GHG emissions associated with the product being assessed

***Note** A materiality threshold of 1% has been established to ensure that very minor sources of life cycle GHG emissions do not require the same treatment as more significant sources.*

3.32 offsetting

mechanism for claiming a reduction in GHG emissions associated with a process or product through the removal of, or preventing the release of, GHG emissions in a process unrelated to the life cycle of the product being assessed

***Note** An example is the purchase of Certified Emission Reductions generated by Clean Development Mechanism projects under the Kyoto Protocol [3].*

3.33 output

product, production material or energy that leaves a unit process

[Adapted from BS EN ISO 14044:2006, 3.25]

***Note** Production materials may include raw materials, intermediate products, co-products, products and emissions.*

3.34 primary activity data

quantitative measurement of activity from a product's life cycle that, when multiplied by the appropriate emission factor, determines the GHG emissions arising from a process

***Note 1** Examples of primary activity data include the amount of energy used, material produced, service provided or area of land affected.*

***Note 2** Primary activity data sources are typically preferable to secondary data sources as the data will reflect the specific nature/efficiency of the process and the GHG emissions associated with the process.*

***Note 3** Primary activity data do not include emission factors.*

3.35 product

good or service

***Note** Services have tangible and intangible elements. The provision of a service can involve, for example, the following:*

a) an activity performed on a consumer-supplied tangible product (e.g. automobile to be repaired);

b) an activity performed on a consumer-supplied intangible product (e.g. the income statement needed to prepare a tax return);

c) the delivery of an intangible product (e.g. the delivery of information in the context of knowledge transmission);

d) the creation of ambience for the consumer (e.g. in hotels and restaurants);

e) software, which consists of information and is generally intangible and can be in the form of approaches, transactions or procedures.

[Adapted from BS ISO 14040:2006, 3.9]

3.36 product category

group of products that can fulfil equivalent functions

[BS ISO 14025:2006, 3.12]

3.37 product system

collection of unit processes with elementary and product flows, performing one or more defined functions, that models the life cycle of a product

[BS EN ISO 14040:2006, 3.28]

3.38 production material

primary or secondary material that is used to produce a product

***Note** Secondary material includes recycled material.*

[BS EN ISO 14040:2006, 3.15]

3.39 (GHG) removals

absorption and isolation of greenhouse gases from the atmosphere

***Note** Removals typically occur when CO_2 is absorbed by biogenic materials during photosynthesis. Removals may also occur when a product absorbs CO_2 during use.*

3.40 renewable energy

energy from non-fossil energy sources: wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases

[Adapted from Directive 2001/77/EC, Article 2 [4]]

3.41 secondary data

data obtained from sources other than direct measurement of the emissions from processes included in the life cycle of the product

Note *Secondary data are used when primary activity data are not available or it is impractical to obtain primary activity data.*

3.42 supplementary requirement

life cycle greenhouse gas emissions quantification requirements applicable to a particular product type or product sector, to enhance the application of PAS 2050

3.43 system boundary

set of criteria specifying which unit processes are part of a product system

[BS EN ISO 14040:2006, 3.32]

3.44 unit process

smallest portion of a life cycle for which data are analysed when performing a life cycle assessment

3.45 upstream emissions

GHG emissions associated with processes that occur in the life cycle of a product prior to the processes owned, operated or controlled by the organization implementing this PAS

3.46 use phase

that part of the life cycle of a product that occurs between the transfer of the product to the consumer and the point of transfer to recycling and waste disposal

Note *For services, the use phase includes the provision of the service.*

3.47 use profile

criteria against which the GHG emissions arising from the use phase are determined

3.48 useful energy

energy that meets a demand by displacing another source of energy

Note *For example, where heat production from a CHP unit is utilized to meet a demand for heat that was previously met by another form of energy, or meets a new demand for heat that would have required additional energy input, then the heat from the CHP is providing useful energy. Had the heat from the CHP not met a demand, but instead been dissipated (e.g. vented to the atmosphere), the heat would not be considered useful energy (in which case no emissions from the CHP would be assigned to the heat production).*

3.49 waste

materials, co-products, products or emissions that the holder discards or intends, or is required to, discard

4 Principles and implementation

4.1 General requirements

Assessment of the GHG emissions of products shall be carried out using LCA techniques (see Note). Unless otherwise indicated, the assessment of the life cycle GHG emissions of products shall be made using the attributional approach, i.e. by describing the inputs and their associated emissions attributed to the delivery of a specified amount of the product functional unit.

***Note** LCA techniques are specified in BS EN ISO 14040 and BS EN ISO 14044. Where the approach described in these standards is incompatible with the requirements of this PAS, the requirements of this PAS take precedence.*

4.2 Principles

Organizations claiming that an assessment conforms to this PAS shall ensure that the assessment of the life cycle GHG emissions of a product is complete and applies only to the product for which the assessment is conducted. They shall be able to demonstrate that the following principles have been adhered to when carrying out the assessment:

a) **Relevance:** GHG emissions and removals data and methods appropriate to the assessment of the GHG emissions arising from specific products have been selected.

b) **Completeness:** all product life cycle GHG emissions and removals arising within the system and temporal boundaries for a specified product which provide a material contribution to the assessment of GHG emissions arising from that product have been included.

c) **Consistency:** assumptions, methods and data have been applied in the same way throughout the quantification and support reproducible, comparable outcomes.

d) **Accuracy:** bias and uncertainty have been reduced as far as practical.

e) **Transparency:** where the results of life cycle GHG emissions assessment carried out in accordance with this PAS are to be disclosed to a third party, GHG emissions-related information is made available that is sufficient to support disclosure and allow such a third party to make associated decisions with confidence.

***Note** The above principles are adapted from BS ISO 14064-1:2006, Clause 3.*

4.3 Supplementary requirements

Provision for the development and use of supplementary requirements has been included in this revision of PAS 2050 because it is recognized that their use could enhance the application of PAS 2050 for some product sectors or categories. Where supplementary requirements are available and are in accordance with the principles a) through i) of this clause, those requirements should be used to support the application of PAS 2050 to the product sectors or categories for which they were developed.

Supplementary requirements used in support of PAS 2050 should be:

a) **supplementary:** requirements and related guidance for which specific provision is made in this PAS and that are supplementary to and not in conflict with it;

b) **broadly recognized:** internationally, nationally, industry or sector wide;

c) **inclusive and consensus-based:** developed through a transparent process that is open to stakeholders;

d) **scoped appropriately:** having scope and requirements that are directly applicable to the specific stakeholder base;

e) **harmonized:** developed after having regard to relevant existing product sector or category rules, guidance or requirements by adopting, referencing or building on these. Where there is a valid reason for them not being adopted, the reason shall be clearly justified and referenced within the supplementary requirements.

f) **comprehensive:** address all stages of the relevant product life cycle either by the inclusion of specific requirements where permitted by PAS 2050 or by deference to it;

g) **justified:** by the inclusion of rationales identifying and explaining the supplements to the assessment method provided in PAS 2050 and confirming how the principles set out in a) through h) of this clause have been met;

h) **publicly available:** free from use restrictions and in the public domain;

i) **maintained:** ensuring validity over time.

***Note 1** It is expected that in developing supplementary requirements for a given product or product sector a wide cross-section of stakeholders will have been given the opportunity to contribute to their development.*

Note 2 *Development of supplementary requirements should not be undertaken without consideration having first been given to adopting or modifying existing rules (such as PCRs under ISO 14025). There may be a valid reason for not adopting existing rules in their entirety (e.g. where rules are in conflict with the PAS 2050). Such reasons should be clearly justified and documented within the rationales supporting the supplementary requirements.*

Note 3 *Supplementary requirements could include product category rules (PCRs) (see ISO 14025), product rules, product footprint rules or sector-specific standards where these can be demonstrated to meet the above principle.*

Note 4 *It is envisaged that, in line with PAS 2050, supplementary requirements would be made available free of charge.*

Note 5 *Independent verification that supplementary requirements have been developed in accordance with the principles established in a) through i) of this clause is recommended and will increase their credibility significantly. The creation of a common registration facility for verified supplementary requirements would greatly facilitate their use. The BSI PAS 2050 web-pages[3] will provide information in this area (verification and registration) as it becomes available.*

4.4 Record-keeping

Data supporting an assessment undertaken using this PAS, including but not limited to those identified in Annex B and other data required in this PAS, shall be documented and maintained in a format suitable for analysis and verification.

Records shall be kept for a minimum of three years.

4.5 Implementation

The quantification of life cycle GHG emissions and removals for products shall be identified as either:

a) a cradle-to-grave quantification, which includes the emissions and removals arising from the full life cycle of the product; or

b) cradle-to-gate quantification, which includes the GHG emissions and removals arising up to the point at which the product leaves the organization undertaking the assessment for transfer to another party.

[3] www.bsigroup.com/PAS2050

5 Emissions and removals

5.1 Scope of GHG emissions and removals

5.1.1 GHG emissions and removals to be included

Both emissions to the atmosphere and removals from the atmosphere shall be accounted for in the assessment of the overall GHG emissions of the product being assessed. This assessment shall include the gases listed in Annex A arising from both fossil and biogenic sources for all products, with the exception of human food and animal feed products.

For food and feed, emissions and removals arising from biogenic sources that become part of the product may be excluded. This exclusion shall not apply to:

a) emissions and removals of biogenic carbon used in the production of food and feed (e.g. in burning biomass for fuel) where that biogenic carbon does not become part of the product;

b) non-CO_2 emissions arising from degradation of waste food and feed and enteric fermentation (**5.1.1.1**);

c) any biogenic component in material that is part of the final product but is not intended to be ingested (e.g. packaging).

Note 1 *This permitted exception avoids the need to calculate the CO_2 emissions and removals caused by the consumption and digestion of food and feed and from human and animal waste.*

Note 2 *It is unlikely that food and feed will persist for more than the 100 years assessment period; however, where it does, the carbon storage implications need to be addressed (**5.2** and **5.5**).*

Note 3 *Where food and feed is excluded the assessment of products that could have both food and non-food use (e.g. vegetable oil) are likely to give rise to different outcomes. The GHG emissions for a given product can therefore differ according to the intended or actual use of the product.*

Note 4 *Carbon incorporated in plants or trees with a life of 20 years or more (e.g. fruit trees) that are not products themselves but are part of a product system should be treated in the same way as soil carbon (**5.7**), unless the plants and trees are resulting from a direct land use change occurring within the previous 20 years (**5.6**).*

5.1.1.1 Inclusion of non-CO_2 emissions arising from food and feed

Non-CO_2 emissions arising from food and feed shall be included in the calculation of GHG emissions from the life cycle of products. Where emissions and removals from biogenic sources have been excluded, the GWP factor for non-CO_2 emissions originating from biogenic carbon sources (e.g. CO_2 removed from the atmosphere and subsequently emitted as CH_4) shall be corrected to take into account the removal of the CO_2 that gave rise to the biogenic carbon source.

5.1.1.2 Inclusion of CH_4 emissions used for energy

Where CH_4 emissions are captured and used to produce energy with emission of CO_2, the treatment of such emissions shall be in accordance with **8.2.2**.

5.1.2 Product life cycle processes to be included

The assessment of GHG emissions and removals during the life cycle of products shall include emissions and removals as identified in **5.1.1** from processes including but not limited to:

a) energy use (including energy sources, such as electricity, that were themselves created using processes that have GHG emissions associated with them);

b) combustion processes;

c) chemical reactions;

d) loss to atmosphere of refrigerants and other fugitive GHGs;

e) process operations;

f) service provision and delivery;

g) land use and land use change;

h) livestock production and other agricultural processes;

i) waste management.

Note *See **6.2** for the assessment of the emissions arising from part of the life cycle of the product for cradle-to-gate assessment purposes, and Clause **7** for data sources.*

5.2 Time period for inclusion of GHG emissions and removals

The assessment of the GHG emissions and removals arising from the life cycle of products shall include the GHG emissions and removals identified in **5.1** occurring during the 100-year period following the formation of the product (i.e. the 100-year assessment period).

Where supplementary requirements relating to the assessment period have been developed for the product being assessed in accordance with the principles set out in **4.3**, they should be used.

Note *Where significant emissions are expected to occur beyond 100 years for specific product groups or sectors, supplementary requirements should provide for the inclusion of these emissions.*

5.3 Global warming potential (GWP)

GHG emissions and removals shall be measured by mass and shall be converted into CO_2e using the latest IPCC 100-year global warming potential (GWP) coefficients (**Annex A**), except where otherwise specified.

Note *For example, methane has a GWP coefficient of 25, and 1 kg of methane is equivalent to 25 kg CO_2e in terms of its GWP.*

5.4 Aircraft emissions and removals

No multiplier or other correction shall be applied to the GWP of emissions and removals arising from aircraft transport.

Note *The application of a multiplier for aircraft emissions was further considered in the revision of this PAS, but given the lack of expert agreement regarding the approach to be taken the position taken in the 2008 version of PAS 2050 has been retained. Entities wishing to account for radiative forcing should do this separately from their PAS 2050 conformity assessment. Information on an appropriate multiplier is provided in* 2010 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors*. If radiative forcing is accounted for in a parallel assessment, then the outcome including radiative forcing should be recorded separately and clearly differentiated.*

5.5 Carbon storage in products

5.5.1 Treatment of stored carbon

Where some or all removed carbon will not be emitted to the atmosphere within the 100-year assessment period, the portion of carbon not emitted to the atmosphere during that period shall be treated as stored carbon.

Note 1 *Carbon storage might arise where biogenic carbon forms part or all of a product (e.g. wood fibre in a table), or where atmospheric carbon is taken up by a product over its life cycle (e.g. cement).*

Note 2 *Storage of biogenic carbon in products varies depending on the type of product, the mean life span of the product, its rate of recycling and its disposal route (e.g. landfill, incineration).*

Note 3 *Non-CO_2 emissions, such as CH_4, can arise through the decomposition of the product in any form or location, such as in landfill.*

Note 4 *While forest management activities might result in additional carbon storage in managed forests through the retention of forest biomass, this potential source of storage is not included in the scope of this PAS.*

Note 5 *The use of a weighting factor to assess delayed emissions is no longer a requirement of this PAS. However, for entities wishing to undertake such assessment, provision is made in **6.4.9.3.2** and **Annex E**.*

5.5.2 Recording the basis of carbon storage assessment

Where the assessment of the life cycle GHG emissions of a product includes some carbon storage, the data sources from which the quantity of stored carbon was calculated, together with the carbon storage profile of the product over the 100-year assessment period, shall be recorded and retained (**4.4**).

5.6 Inclusion and treatment of land use change

5.6.1 General

The GHG emissions and removals arising from direct land use change shall be assessed for any input to the life cycle of a product originating from that land and shall be included in the assessment of GHG emissions of the product.

Where supplementary requirements relating to land use change have been developed for the product being assessed in accordance with the principles set out in **4.3**, they should be used.

Where such supplementary requirements are not used, the emissions arising from the product shall be assessed on the basis of the default land use change values provided in **Annex C**.

For countries and land use changes not included in **Annex C**, the emissions arising from the product shall be assessed using the included GHG emissions and removals occurring as a result of direct land use change in accordance with the relevant sections of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*.

The assessment of the impact of land use change shall include all direct land use change occurring not more than 20 years, or a single harvest period, prior to undertaking the assessment (whichever is the longer). The total GHG emissions and removals arising from direct land use change over that period shall be included in the quantification of GHG emissions of products arising from this land on the basis of equal allocation to each year of the period.

Note 1 *Where it can be demonstrated that the land use change occurred more than 20 years prior to the assessment being carried out in accordance with this PAS, no emissions from land use change should be included in the assessment as all emissions resulting from the land use change would be assumed to have occurred prior to the application of the PAS.*

Note 2 *Large emissions of GHGs can result as a consequence of land use change. Removals as a direct result of land use change (and not as a result of long-term management practices) do not usually occur, although it is recognized that this could happen in specific circumstances. Examples of direct land use change are the conversion of land used for growing crops to industrial use or conversion from forest land to crop land. All forms of land use change that result in emissions or removals are to be included. Indirect land use change refers to such conversions of land use as a consequence of changes in land use elsewhere.*

Note 3 *While GHG emissions also arise from indirect land use change, the methods and data requirements for calculating these emissions are not fully developed. Therefore, the assessment of emissions arising from indirect land use change is not included in this PAS. The inclusion of indirect land use change will be considered in future revisions of this PAS.*

5.6.2 Limited traceability of products

The following hierarchy shall apply when determining the GHG emissions and removals arising from land use change occurring not more than 20 years or a single harvest period, prior to making the assessment (whichever is the longer):

a) where the country of production is known and the previous land use is known, the GHG emissions and removals arising from land use change shall be those resulting from the change in land use from the previous land use to the current land use in that country;

b) where the country of production is known, but the former land use is not known, the GHG emissions arising from land use change shall be the estimate of average emissions from the land use change for that crop in that country;

c) where neither the country of production nor the former land use is known, the GHG emissions arising from land use change shall be the weighted average of the average land use change emissions of that commodity in the countries in which it is grown.

Note *Countries in which a crop is grown can be determined from import statistics, and a cut-off threshold of not less than 90% of the weight of imports may be applied.*

5.6.3 Limited knowledge of the timing of land use change

Where the timing of land use change cannot be demonstrated to be more than 20 years, or a single harvest period, prior to making the assessment (whichever is the longer), it shall be assumed that the land use change occurred on 1 January of either:

a) the earliest year in which it can be demonstrated that the land use change had occurred; or

b) on 1 January of the year in which the assessment of GHG emissions and removals is being carried out.

5.6.4 Recording the type and timing of land use change

Data sources, location and timing of land use change associated with inputs to products shall be recorded and retained (**4.4**) by the organization.

Note *Knowledge of the prior land use can be demonstrated using a number of sources of information, such as satellite imagery and land survey data. Where records are not available, local knowledge of prior land use can be used.*

5.7 Treatment of soil carbon change in existing systems

Where not arising from land use change (**5.5**), changes in the carbon content of soils including both emissions and removals shall be excluded from the assessment of GHG emissions under this PAS unless provided for in supplementary requirements in accordance with the principles set out in **4.3**.

Where supplementary requirements relating to soil carbon change have been developed for the product being assessed in accordance with the principles set out in **4.3**, they should be used.

Note 1 *This exclusion refers to changes such as tilling techniques, crop types and other management actions taken in relation to agricultural land. It does not refer to the impact of land use change on carbon emissions, which is included in* ***5.6****.*

Note 2 *Soils are important in the carbon cycle, both as a source and a sink for carbon, and it is acknowledged that scientific understanding is improving regarding the impact of different techniques in agricultural systems. For this reason, provision is made for future supplementary requirement or revision to the PAS 2050 requirements that could facilitate the inclusion of emissions and removals arising from changes in soil carbon.*

5.8 Offsetting

GHG emissions offset mechanisms, including but not limited to voluntary offset schemes or nationally or internationally recognized offset mechanisms, shall not be used at any point in the assessment of the GHG emissions of the product.

Note *It is the intention that this PAS reflects the GHG intensity of the production process prior to the implementation of external measures to offset GHG emissions. The use of an energy source that results in lower GHG emissions to the atmosphere and therefore achieves a lower emission factor, such as renewable electricity (see **7.9.4**) or conventional thermal generation with carbon capture and storage, is not a form of offsetting.*

5.9 Unit of analysis

Assessment of the GHG emissions arising from the life cycle of products shall be carried out in a manner that allows the mass of CO_2e to be determined per functional unit for the product. The functional unit shall be recorded to two significant figures.

Where a product is commonly available on a variable unit size basis, the calculation of GHG emissions shall be proportional to the unit size (e.g. per kilogram or per litre of goods sold, or per month or year of a service provided).

Where supplementary requirements establishing a preferred unit of analysis have been developed for the product being assessed in accordance with the principles set out in **4.3**, they should be used.

Note 1 *For services, the appropriate reporting unit may be established either on the basis of time (e.g. annual emissions associated with an internet service) or event (e.g. per night emissions associated with a hotel stay).*

Note 2 *The functional unit may differ according to the purpose of the assessment activity. For example, the functional unit for internal organizational reporting may differ from the functional unit communicated to consumers.*

6 System boundary

6.1 Establishing the system boundary

The system boundary shall be clearly defined for each product under assessment and shall include all of its material life cycle processes (**6.3**) in accordance with **6.4** and subject to the exclusions in **6.5**.

Where supplementary requirements specifying a system boundary have been developed for the product being assessed in accordance with the principles set out in **4.3**, they should be used.

Note 1 *It is important that in setting the system boundary the points during the product life cycle where removals are likely to occur are clearly identified so as to enable the relevant removal data to be collected in the inventory process. The amount of removal calculated for a material of biogenic origin should reflect only the amount of carbon embedded in that material, consistent with **5.1**.*

Note 2 *Consideration should be given to the material contribution that different processes within the system boundary will make to the total GHG emissions of a product (see **6.3**).*

6.2 Cradle-to-gate GHG emission and removals assessment

6.2.1 Cradle-to-gate system boundary

The system boundary for an assessment identified as cradle-to-gate shall include the emissions and removals identified in **5.1** that have occurred up to and including the point where the product leaves the organization undertaking the assessment for transfer to another party that is not the consumer. For products that use recycled content as an input, the emissions and removals associated with the processing of that material shall be included as defined by **Annex D**.

6.2.2 Cradle-to-gate GHG emissions assessment recording

Cradle-to-gate GHG emissions assessment information shall be clearly identified as such so as not to be mistaken for a full assessment of the life cycle GHG emissions of a product.

Note 1 *Records for all stages of the assessment should be maintained and all relevant information, including separate reference to any end-of-life emissions, is provided where cradle-to-gate assessments are made available to support downstream assessments (**4.4** and **Annex B**).*

Note 2 *Cradle-to-gate GHG emission and removals assessment can facilitate the provision of consistent GHG emission information within the supply chain for products and services. This cradle-to-gate perspective of the supply chain enables incremental addition of GHG assessments at different stages of the supply until the product or service is made available to the consumer (where the assessment will include the emissions and removals arising from the entire life cycle).*

Note 3 *Examples of system boundaries for services are further described in the* Guide to PAS 2050*.*

Note 4 *Where cradle-to-gate emissions assessment information is disclosed to another business, it should be clearly identified as not representing a full assessment of the lifecycle GHG emissions of the product and therefore as not being appropriate for issue to consumers.*

6.3 Material contribution and threshold

Calculations carried out in accordance with this PAS shall include all emissions and removals within the system boundary that have the potential to make a material contribution to the assessment of GHG emissions of the product (see **3.31**).

For GHG emissions and removals arising from the life cycle of a product, the assessment shall include:

a) all sources of emissions and processes for removal anticipated to make a material contribution to the life cycle GHG emissions of the functional unit; and

b) at least 95% of the anticipated life cycle GHG emissions and removals associated with the functional unit.

Where a preliminary assessment is carried out to assist in the determination of system boundary for the product under assessment, the selection of any secondary data used shall be undertaken in accordance with **7.2**.

Note *A preliminary assessment of the sources of GHG emissions in the life cycle of a product may be undertaken using secondary data or through an Environmentally Extended Input–Output (EEIO) approach. This preliminary assessment could provide an overview of the key sources of GHG emissions within the life cycle of the product and identify major contributors to the GHG emissions assessment.*

6.4 Elements of the product system

6.4.1 General

The life cycle elements covered in **6.4.2** to **6.4.10** shall be included in the system boundary for the assessment of the life cycle GHG emissions and removals associated with the products under assessment.

Note 1 *While the system boundary is defined by the requirements in **6.4.2** to **6.4.10**, not all products will have processes or emissions arising from each of the categories.*

Note 2 *Product systems are typically described as a series of interconnected life cycle stages: raw materials; manufacture; distribution/retail; use; and final disposal/recycling, with processes or emissions assigned at each stage. Describing the life cycle of services can be more difficult as not all stages may be relevant. For example, the raw materials, production and use stages may be combined into the service delivery stage. Definition of life cycle stages can also be influenced by the perspective of the organization implementing this PAS, and its position in the supply chain. Transparency is therefore important when defining boundaries and assigning the processes and emissions that are included at each stage. Examples of system boundaries are further described in the* Guide to PAS 2050.

6.4.2 Production materials

The GHG emissions and removals arising from all processes used in the formation, extraction or transformation of materials used in production (including farming, horticulture, fishing and forestry) shall be included in the assessment, including all sources of energy consumption or direct GHG emissions associated with that formation, extraction or transformation.

The GHG emissions and removals arising from materials used in production shall include, for example, those from:

- development of material sources (e.g. surveying, prospecting);
- mining or extracting raw materials (solids, liquids and gases, such as iron, oil and natural gas), including emissions from any machinery used;
- consumables used in sourcing production materials;
- waste generated at each stage of the extraction and pre-processing of production materials;
- fertilizers (e.g. N_2O emissions arising from the application of nitrogen fertilizer and emissions arising from the production of the fertilizer);
- direct land use change (e.g. draining of peatland or removal of a forest);
- energy-intensive atmospheric growing conditions (e.g. heated greenhouse);
- emissions from crop production (e.g. methane from rice cultivation) and livestock (e.g. methane from cattle).

6.4.3 Energy

The GHG emissions and removals associated with the provision and use of energy in the life cycle of the product shall be included in the emissions arising from the energy supply system.

Note *Emissions from energy include the emissions arising from the life cycle of the energy. This includes emissions at the point of consumption of the energy (e.g. emissions from the burning of coal and gas) and emissions arising from the provision of the energy, including the generation of electricity and heat, and emissions from transmission losses, transport fuels; upstream emissions (e.g. the mining and transport of fuel to the electricity generator or other combustion plant); downstream emissions (e.g. the treatment of waste arising from the operation of nuclear electricity generators); and the growing and processing of biomass for use as a fuel.*

6.4.4 Capital goods

The GHG emissions and removals arising from the production of capital goods used in the life cycle of the product shall be excluded from the assessment unless provided for in supplementary requirements in accordance with the principles set out in **4.3**.

Where such supplementary requirements relating to the treatment of capital goods have been developed for the product being assessed, they should be used.

Note *An assessment of the materiality of capital goods in relation to a particular product or product sector (including reference to existing studies) can be conducted as part of the supplementary requirement development process. Where capital goods are found to make a significant contribution to the level of GHG emissions from those products, requirements and guidance on how to include capital goods in the assessment should be included as part of the supplementary requirements*

6.4.5 Manufacturing and service provision

The GHG emissions and removals arising from manufacturing and service provision that occur as part of the life cycle of the product, including emissions associated with the use of consumables, shall be included in the assessment of the GHG emissions of the life cycle of the product.

Where a process is used for prototyping a new product, the emissions associated with the prototyping activities shall be allocated to the resulting product(s) and co-product(s) of the process.

6.4.6 Operation of premises

The GHG emissions and removals arising from the operation of premises, including those from factories, warehouses, central supply centres, offices, retail outlets, etc., shall be included in the assessment of the GHG emissions of the life cycle of the product.

Note *Operation includes the lighting, heating, cooling, ventilation, humidity control and other environmental controls over the premises. An appropriate approach for the division of emissions arising from the operation of, for example, warehouses would be to use the residence time and volume of space occupied by the product as a basis for the division.*

6.4.7 Transport

The GHG emissions and removals arising from road, air, water, rail or other transport methods that form part of the life cycle of the product shall be included in the assessment of the GHG emissions of the life cycle of the product taking account of the requirements in **8.6.**

Where supplementary requirements relating to transport have been developed for the product being assessed in accordance with the principles set out in **4.3**, they should be used.

Note 1 *Emissions associated with environmental control requirements throughout the life cycle are included in **6.4.8**. Care is necessary to avoid double counting (e.g. for refrigerated transport).*

Note 2 *GHG emissions from transport include the emissions associated with transporting fuels (e.g. emissions arising from the operation of pipelines, transmission networks and other fuel transport activities).*

Note 3 *GHG emissions from transport include the emissions arising from transport associated with individual processes, such as the movement of inputs, products and co-products within a factory (e.g. by conveyor belt or other localized transport methods).*

Note 4 *Where products are distributed to different points of sale (i.e. different locations within a country), emissions associated with transport will vary from location to location due to different transport requirements. Where this occurs, organizations should calculate the average release of GHGs associated with transporting the product based on the average distribution of the product within each country, unless more specific data are available. Where the same product is sold in identical form in multiple countries, country-specific data could be used, or the average could be weighted by the amount of product sold in each country.*

6.4.8 Storage of products

The GHG emissions and removals arising from storage shall be included in the assessment of the life cycle GHG emissions of the product, including:

a) storage of inputs, including raw materials, at any point in the product life cycle;

b) environmental controls (e.g. cooling, heating, humidity control and other controls) related to a product at any point in the product life cycle (**6.4.6)** for the operation, including environmental control, of factories in which products may be stored;

c) storage of products in the use phase ;

d) storage prior to reuse, recycling or disposal activities.

Note *GHG emissions identified under* ***6.4.8*** *relate to storage activities not already covered by* ***6.4.6****.*

Where supplementary requirements relating to the storage of products have been developed for the product being assessed in accordance with the principles set out in **4.3**, they should be used.

6.4.9 Use phase

6.4.9.1 General principle

The GHG emissions and removals arising from the use of products shall be included in the assessment of the life cycle GHG emissions of products, subject to the provisions of **6.2** for cradle-to-gate assessments. The emission factor associated with energy used in the use phase of products shall be determined in accordance with **6.4.3**.

Note *The calculation of GHG emissions from energy use is based on country-specific annual average emission factors for energy, unless it can be demonstrated that a different emission factor is more representative of the energy use characteristics of the product. For example, where the use phase includes the consumption of electricity by the consumer in relation to the product being assessed, the country-specific annual average emission factor of the electricity would be used; where an identical product is supplied to multiple international markets, the emission factor for the energy used by the product in the use phase would be the average emission factor of the countries where the product is supplied, weighted by the proportion of the product supplied in the different countries.*

6.4.9.2 Basis of the use profile

Determination of the use profile for the use phase of products shall be based on a hierarchy of boundary definitions in the following order of preference:

1) supplementary requirements in accordance with the principles set out in **4.3**, which include a use phase for the product being assessed;

2) published international standards that specify a use phase for the product being assessed;

3) published national guidelines that specify a use phase for the product being assessed;

4) published industry guidelines that specify a use phase for the product being assessed.

Where no method for determining the use phase of products has been established in accordance with points 1–4 of this clause, the approach taken in determining the use phase of products shall be established by the organization carrying out the assessment of GHG emissions for the product and recorded.

Where emissions arise from energy use in the use phase, the use profile shall record the emission factor of each energy type used by the product and the source of the emission factor. Where the emission factor is not an annual average emission factor for a single country, the determination of the emission factor shall be included in the recording of the use phase profile and retained (**4.4**).

Note *The manufacturer's recommended method for achieving the functional unit (e.g. cooking by oven at a specified temperature for a specified time) may provide a basis for determining the use phase of a product. However, actual usage patterns may differ from those recommended, and the use profile should seek to represent the actual usage pattern.*

6.4.9.3 Time period for use-phase GHG assessment

6.4.9.3.1 The emissions and removals specified in **5.1** arising during the use phase of the product during the 100-year assessment period shall be included. Where the use phase of a product results in the release of GHG emissions over time, the total emissions projected to occur over the 100-year assessment period shall be included in the assessment of GHG emissions of that product as if occurring at the start of the 100-year assessment period.

6.4.9.3.2 Organizations wishing to identify the effect of emissions released over time during the use phase shall do this separately from the single-release assessment specified in **6.4.9.3.1** provided that both outcomes are recorded together in parallel. The method used for calculating the weighted average impact of delayed emissions arising from the use phase of the product over a period of more than one year shall be that provided in **Annex E.**

6.4.9.4 Recording the basis of use-phase calculations for products

Where use-phase emissions and removals form part of an assessment carried out under this PAS, the detail of the basis on which the use phase for the product is assessed shall be recorded and retained (**4.4** and **Annex B**).

6.4.9.5 Impact of the product on the use phase of other products

Where the operation or application of a product causes a change (either increase or decrease) in the GHG emissions arising from the use phase of another product, this change shall be excluded from the assessment of the life cycle GHG emissions of the product being assessed.

6.4.10 GHG emissions from final disposal

The GHG emissions arising from final disposal (e.g. waste disposed of through landfill, incineration, burial and wastewater) shall be included in the assessment of the life cycle GHG emissions of the product, subject to the provisions of **6.2** for cradle-to-gate assessments and **8.2** emissions from waste.

Determination of the waste disposal profile shall follow the data quality rules (**7.2**) and be based on a hierarchy of boundary definitions in the following order of preference:

1) supplementary requirements in accordance with the principles set out in **4.3**, which include a waste disposal profile for the product being assessed;
2) published international standards that specify a waste disposal profile for the product being assessed;
3) published national guidelines that specify a waste disposal profile for the product being assessed;
4) published industry guidelines that specify a waste disposal profile for the product being assessed.

Where no method for determining the waste disposal profile of the product has been established in accordance with points 1–4 of this clause, the approach taken in determining the waste disposal profile shall be established by the organization carrying out the assessment of GHG emissions for the product.

Where emissions arise from energy use in waste disposal, the profile shall record the emission factor of each energy type used during disposal of the product and the source of the emission factor. Where the emission factor is not an annual average emission factor for a single country, the determination of the emission factor shall be included in the recording of the waste disposal profile and retained (**4.4**).

Note *Where waste arises from recyclable material, the emissions associated with that waste are included in the assessment of emissions from recycled material (see Annex D).*

6.4.10.1 Time period for GHG emissions from final disposal

The GHG emissions specified in **5.1** arising from final disposal during the 100-year assessment period shall be included. Where the final disposal of materials or products results in the release of GHG emissions over time (e.g. decomposition of food waste sent to landfill), the total emissions projected to occur over the 100-year assessment period shall be included in the assessment of GHG emissions of the product giving rise to the disposal, as if occurring at the start of the 100-year assessment period.

6.4.10.2 Effect of emissions released over time during final disposal

Entities wishing to identify the effect of emissions released over time during the disposal phase may do this separately from the single-release assessment specified in **6.4.10.1** provided that both outcomes are recorded together in parallel. The method used for calculating the weighted average impact of delayed emissions arising from the use phase of the product over a period of more than one year shall be that provided in **Annex E.**

6.4.10.3 Activities following final disposal

Where the emissions from final disposal are diverted to another system (e.g. combustion of methane arising from landfill, combustion of waste timber fibre), the assessment of GHG emissions from the products giving rise to the emissions shall reflect the emissions arising from this diversion, as described in **8.2**.

6.5 System boundary exclusions

The system boundary of the product life cycle shall exclude the GHG emissions associated with:

a) human energy inputs to processes and/or pre-processing (e.g. if fruit is picked by hand rather than by machinery);
b) transport of consumers to and from the point of retail purchase;
c) transport of employees to and from their normal place of work;
d) animals providing transport services.

7 Data

7.1 General

The data recorded in relation to a product shall include all GHG emissions and removals occurring within the system boundary of that product.

7.2 Data quality rules

When identifying primary activity data and secondary data for use in GHG emissions and removals assessment, the following preferences shall be applied.

a) For time-related coverage (e.g. age of data and the minimum length of time over which the data are collected); data that are time-specific to the product being assessed shall be preferred.

b) For geographical specificity (e.g. geographical area from which data are collected such as district, country, region); data that are geographically-specific to the product being assessed shall be preferred.

c) For technology coverage (e.g. whether the data relate to a specific technology or a mix of technologies); data that are technology-specific to the product being assessed shall be preferred.

d) For accuracy of the information (e.g. data, models and assumptions); data that are most accurate shall be preferred;

e) For precision: measure of the variability of the data values for each data expressed (e.g. variance); data that are more precise (i.e. have the lowest statistical variance) shall be preferred.

In addition, the following shall be documented:

1) Completeness: (the percentage of data that are measured, and the degree to which the data represents the population of interest; is the sample size large enough, is the periodicity of measurement sufficient, etc.).

2) Consistency: (qualitative assessment of whether the selection of data is carried out uniformly in the various components of the analysis).

3) Reproducibility: (qualitative assessment of the extent to which information about the method and data values would allow an independent practitioner to reproduce the results reported in the study).

4) Data sources: (with reference to the primary or secondary nature of the data).

Note 1 *Adapted from BS EN ISO 14044:2006, 4.2.3.4.3.*

Note 2 *Assessment of GHG emissions should use data that will reduce bias and uncertainty as far as practicable by using the best quality data achievable. Determination of the best quality data could be supported by a data-scoring framework that allows the different attributes of data quality to be combined.*

7.3 Primary activity data

Primary activity data shall be collected from those processes owned, operated or controlled by the organization implementing this PAS. The primary activity data requirement shall not apply to downstream emission sources.

Where the organization implementing this PAS does not contribute 10% or more to the upstream GHG emissions of the product or input prior to its provision to another organization or to the end user, the collection of primary activity data shall apply to the emissions arising from those processes owned, operated or controlled by the organization and any upstream supplier(s) that cumulatively contribute 10% or more to the upstream GHG emissions of the product or input. The 10% contribution figure shall be based on the net emissions excluding any stored carbon that may be released over the 100-year assessment period.

Primary activity data shall be collected for individual processes or for premises where processes are occurring and shall be representative of the process for which it is collected. Allocation between co-products, where required, shall be carried out in accordance with **8.1.1**.

The requirement to obtain primary activity data shall not apply where implementing the requirement would necessitate the physical measurement of the GHG emissions (e.g. measuring CH_4 emissions from livestock or N_2O emissions from fertilizer application).

Note 1 *Obtaining primary data for operations that are not under the control of the organization implementing the PAS (i.e. upstream emissions) enhances the ability of the organization to differentiate the GHG assessment of its products from other products.*

Note 2 *Where an organization imposes conditions on the supply of products to it, such as a retailer specifying the quality of the product supplied to it or the manner of its packaging, this is evidence of control over the processes upstream of the organization implementing the PAS. In this situation, the requirement for primary activity data applies to the processes upstream of the organization implementing this PAS.*

Note 3 *Examples of primary activity data would be the measurement of energy use or material use in a process, or fuel use in transport.*

Note 4 *To be representative, primary activity data should reflect the conditions normally encountered in the process that are specific to the product being assessed. For example, if refrigerated storage of a product is required, the primary activity data associated with this refrigeration (e.g. quantity of energy used and quantity of refrigerant escaped) should reflect the long-term operation of the refrigeration and not those associated with a period of typically higher (e.g. August) or lower (e.g. January) energy consumption or refrigerant escape.*

Note 5 *Emissions from livestock, their manure and soils are treated as secondary data (see **7.4**).*

Note 6 *Material input volumes are treated as primary data, provided these inputs undergo a transformation process (i.e. volume of goods handled through retail, wholesale, import/export or repackaging does not qualify as primary activity data for the purposes of the requirement in this clause).*

Note 7 *Where cradle-to-gate emissions assessment information is used for a specific input material and has been included in certification to PAS 2050, It may be assumed that this contains a minimum of 10% primary data for the purpose of this clause. Where the exact proportion of primary data has been communicated, that figure may be used in the assessment.*

7.4 Secondary data

7.4.1 General

Secondary data shall be used for inputs where primary activity data have not been obtained.

7.4.2 Use of PAS 2050 GHG assessment information as secondary data

Where data conforming to the requirements of this PAS (e.g. cradle-to-gate information from a supplier) is available for inputs to the life cycle of the product being assessed, preference shall be given to the use of this data over other secondary data.

7.4.3 Other secondary data

Where secondary data in accordance with **7.4.1** is not available, the data quality rules (**7.2**) shall be used to select the most relevant source of secondary data. Determination of the source of the secondary data (see **7.2i)** shall recognize that secondary data arising from competent sources (e.g. national government, official United Nations publications and publications by United Nations-supported organizations, and peer review publications) are preferred over secondary data from other sources.

Note *Reference to the the International Reference Life Cycle Data System (ILCD)[2] as a source of secondary data remains under consideration for inclusion in a future revision of this PAS.*

7.5 Changes in the life cycle of a product

7.5.1 Temporary unplanned change

Where an unplanned change to the life cycle of a product results in an increase in the assessment of GHG emissions of more than 10% and is experienced for more than three months, a reassessment of the life cycle GHG emissions associated with the product shall be carried out.

7.5.2 Planned change

Where a planned change to the life cycle GHG emissions or removals of a product leads to an increase in the assessment result of 5% or greater for a period exceeding three months, a reassessment of the life

cycle GHG emissions and removals associated with the product shall be carried out.

7.6 Variability in emissions and removals associated with the product life cycle

Where the GHG emissions or removals associated with the life cycle of a product vary over time, data shall be collected over a period of time sufficient to establish the average GHG emissions and removals associated with the life cycle of the product.

Where a product is made available on a continuing basis, the assessment of GHG emissions and removals shall be carried out over a period that is characteristic of the long-term production of that product (typically 1 year). Where a product is new (i.e. has been in production for less than 1 year) or where a product is differentiated by time (e.g. seasonal products), the assessment of GHG emissions and removals shall cover the particular period associated with the production of the product under assessment (see **7.2** and **7.5**).

Note 1 *The average result should be informed by historic data, where available.*

Note 2 *The life cycle GHG emissions of sources of energy, particularly electricity, can vary over time. Where this occurs, data representing the most recent estimate of GHG emissions associated with the energy source should be used.*

7.7 Data sampling

Where an input to a process arises from multiple sources and emissions and removals data are collected from a representative sample of the sources used in the assessment of GHG emissions and removals for a product, the use of sampling shall conform to the requirements for data quality under **7.2**.

Note *Examples of where data sampling might be appropriate include:*

a) a bank may include data from a representative sample of its branches, rather than from all branches;

b) a flour mill may include data from a representative sample of grain sources, rather than from all farms that provide it with grain;

c) where a factory has a number of production lines that produce the same product, it may include data from a representative sample of the production lines.

7.8 Non-CO_2 emissions data for livestock and soils

The estimation of the non-CO_2 GHG emissions arising from livestock, their manure or soils shall use whichever of the two approaches yields the highest assessment with reference to the data quality rules specified in **7.2**:

a) the highest tier approach set out in the *IPCC Guidelines for National Greenhouse Gas Inventories*, Clause 2; or

b) the highest tier approach employed by the country in which the emissions were produced.

Where the anticipated emissions from such an input does not make a material difference then a tier 1 approach, or results derived from national inventories of the country in which the emissions were produced, shall be used.

Note *Where organizations implementing this PAS rely on secondary data sources when assessing the GHG emissions arising from livestock, their manure or soils, they should confirm whether the secondary data source includes emissions arising from direct land use change or whether this needs to be calculated separately.*

7.9 Emissions data for fuel, electricity and heat

7.9.1 General

Fuel and energy data shall include:

a) the amount of energy used; and

b) the average emission factor of the energy input (e.g. $kgCO_2e$/kg fuel, $kgCO_2e$/MJ electricity or heat) based on the source of energy used.

The emissions associated with fuel and energy used in the life cycle of a product shall be determined using an emission factor calculated by a method consistent with this PAS and including emissions from fuel inputs and other upstream emissions.

7.9.2 Onsite generation of electricity and heat

Where electricity and/or heat are generated and used onsite, the emission factor for the electricity and/or heat shall be calculated using the method described in this PAS, including emissions from fuel input and upstream emissions.

7.9.3 Offsite generation of electricity and heat

Where electricity and/or heat are generated offsite, the emission factor used shall be either:

a) for electricity and heat delivered by a stand-alone source (i.e. not part of a larger energy transmission system), the emission factor relevant to that source (e.g. for purchases of heat from third-party CHP), the emission factor calculated in accordance with **8.1** and **8.5**); or

b) for electricity and heat delivered via a larger energy transmission system, secondary data that is as specific to the product system as possible (e.g. average electricity supply emission factor for the country in which the electricity is used).

7.9.4 GHG emissions associated with renewable electricity generation

7.9.4.1 Eligibility of renewable energy-specific emission factors

A renewable energy-specific emission factor shall be applied to a process using renewable energy only where both of the following can be demonstrated.

a) The process used the energy (i.e. use of renewable energy generated onsite) or used an equivalent amount of energy of the same type to that generated (i.e. use of renewable energy delivered via an energy transmission network that combines different types of energy generation), and another process did not use the energy generated whilst claiming it as renewable.

b) The generation of this renewable energy does not influence the emission factor of any other process or organization using the same type of energy (e.g. renewable electricity) and is excluded from the national average emission factor.

Where conditions a) or b) are not met, national average energy emission factors shall be used.

Note 1 *Demonstration that the energy is from a renewable source should be carried out independent of other verification or trading schemes.*

Note 2 *In many situations, the emission factor for renewable energy generation is automatically incorporated into the national average energy emission factor. For example, renewable electricity is typically assumed to be a source of zero-emissions electricity in national reporting of electricity emission factors; were a company to claim a low emission factor for the purchase of renewable electricity (e.g. through the purchase of a "green tariff") that was also included in national reporting, double-counting of the low emissions benefit of the electricity would occur. In many countries, methods for reporting the impact of renewable electricity generation on the national emissions factor for electricity are not sufficiently developed to separately account for grid-average and tariff-specific electricity supplies.*

Note 3 *In countries where the flow of renewable electricity is accurately accounted for, the requirement* ***7.9.4.2*** *allows companies using renewable electricity, or purchasing renewable electricity through a dedicated tariff, to use the GHG emission of the renewable electricity (rather than grid-average carbon intensity) when calculating the emissions arising from their processes.*

7.9.4.2 Emissions from renewable electricity

The assessment of emissions and removals from renewable electricity generation shall include those emissions and removals arising within the system boundary specified in **6.4.3** (e.g. where renewable electricity is generated from biomass, the emissions associated with the electricity generation shall include emissions and removals associated with the direct land use change, growing, harvesting, processing, transporting, etc., of the biomass as applicable).

7.9.5 Emissions from biomass and biofuels

Emissions and removals arising from the use of biomass (e.g. co-firing of biomass, biodiesel, and bioethanol) shall include the GHG emissions and removals arising from both the production of the fuel and the combustion of the fuel (**8.2.1).**

Note 1 *Where biofuel is produced from waste (e.g. cooking oil after it has been used in a cooking process), the GHG emissions and removals arising from the production of the fuel are those arising from the conversion of the waste to fuel.*

Note 2 *Where the biofuel is not produced from waste (e.g. biodiesel produced from oilseed rape or palm oil, ethanol produced from wheat, sugar beet, sugarcane or corn), the GHG emissions and removals associated with the use of the biofuel include all upstream emissions (see* ***6.4.3****), including where appropriate direct land use change emissions (see* ***5.6****) and other emissions and removals.*

7.10 Validity of analysis

Results obtained from the implementation of this PAS shall be valid for a maximum period of two years, unless there is a change in the life cycle of the product whose GHG emissions are being assessed (see **7.5**), in which situation the validity ceases.

Note *Within the permitted two-year period, the length of time that an analysis is valid varies depending on the characteristics of the life cycle of the product.*

8 Allocation of emissions

8.1 General requirements

8.1.1 Allocation to co-products

The preferred approach to allocation of emissions and removals to co-products shall be, in order of preference:

a) dividing the unit processes to be allocated into two or more subprocesses and collecting the input and output data related to these subprocesses; or

b) expanding the product system to include additional functions related to the co-products where:

   1) a product that is displaced by one or more of the co-products of the process being considered can be identified; and

   2) the avoided GHG emissions associated with the displaced product represent the average emissions arising from the provision of the avoided product.

Note 1 *As an example of 2), where a process results in the co-production of electricity that is exported to a larger electricity transmission system, the avoided emissions resulting from this co-production of electricity would be based on the average GHG emissions intensity of grid electricity.*

Note 2 *See BS EN ISO 14044:2006, 4.3.4.2(a).*

Where neither of these approaches is practicable and where supplementary requirements in accordance with the principles set out in **4.3** have been developed to deal with allocation (e.g. on the basis of physical allocation or mass) in connection with the product being assessed, they should be used. When used, the method should be uniformly applied.

Where the approaches in a) and b) are not practicable and applicable supplementary requirements are not available, the GHG emissions and removals arising from the process shall be allocated between the co-products in proportion to their economic value.

8.1.2 Recording allocation assumptions

The applied approach to the allocation of emissions to co-product shall be recorded by the organization implementing this PAS. Where the allocation to co-products is carried out by expanding the product system **(8.1.1b))**, the organization implementing this PAS shall record the assumptions made regarding the scope and emissions of the expanded product system.

8.2 Emissions from waste

8.2.1 General allocation principle

Where waste results in GHG emissions (e.g. organic matter disposed of in a landfill), those emissions (CO_2 and non-CO_2) shall be allocated to the product system that gave rise to the waste. This allocation also applies to methane combusted without the generation of useful energy (i.e. flaring).

8.2.2 Waste combustion with energy recovery

Where waste or fuel derived from waste is combusted to generate useful electricity and/or heat, GHG emissions shall be allocated to the generation of the energy. GHG removals shall also be allocated to the energy generation system.

8.3 Use of recycled material and recycling

The method for assessing emissions arising from recycled or recyclable material shall be as specified in **Annex D**.

8.4 Treatment of emissions associated with reuse

Where a product is reused, the GHG emissions per instance of use or reuse shall be assessed on the basis of:

$$\text{GHG emissions} = \frac{a + f}{b} + c + d + e$$

where:

a is the total life cycle GHG emissions of the product, excluding use-phase emissions;

b is the anticipated number of reuse instances for a given product;

c is emissions arising from an instance of refurbishment of the product to make it suitable for reuse (e.g. recovering and sterilising a glass bottle);

d is emissions arising from the use phase;

e is emissions arising from transport returning the product for reuse;

f is emissions arising from disposal.

Note *This is a simplified treatment of reuse assuming a steady state and more sophisticated modelling should be used where data is available to take account of changing demand patterns and losses in the system.*

8.5 Emissions from energy production using CHP

Where energy production from CHP is exported to a larger system (e.g. export of electricity to a national electricity network), the avoided GHG emissions arising from the exported energy shall be allocated in accordance with **8.1.1** (i.e. the avoided emissions resulting from the co-production of electricity would be based on the average GHG emissions intensity of grid electricity).

Where some or all of the heat and electricity production from CHP is used by more than one process, the emissions arising from CHP, less any avoided burden calculated in **8.1.1**, shall be allocated between the heat and electricity used. The allocation shall be carried out in proportion to the amount of useful energy delivered in each form, multiplied by the intensity of GHG emissions associated with each unit of useful energy delivered as heat and electricity. The intensity of GHG emissions shall be:

a) for boiler-based CHP systems (e.g. coal, wood, solid fuel) – emissions per MJ electricity:emissions per MJ heat in the ratio of 2.5:1;

b) for turbine-based CHP systems (e.g. natural gas, landfill gas) – emissions per MJ electricity:emissions per MJ heat in the ratio of 2.0:1.

Where other forms of CHP are used, the organization implementing this PAS shall identify the emissions ratios for the various types of energy from the particular system under assessment.

***Note** The allocation of emissions to heat and electricity arising from CHP relies on the process-specific ratio of heat to electricity arising from each CHP system. For example, where a boiler-based CHP system delivers useful energy in the electricity:heat ratio of 1:6, 2.5 units of emissions would be allocated to each unit of electricity, and 1 unit of emission would be allocated to each unit of heat delivered by the CHP system. In this example, while the CHP system had a useful electricity:heat ratio of 1:6, the corresponding GHG emissions ratio was 2.5:6. These results will change with different electricity:heat characteristics of the CHP system.*

8.6 Emissions from transport

Where more than one product is being transported by a transport system (e.g. truck, ship, aircraft, train), the emissions arising from the transport system shall be divided amongst the products on the basis of:

a) where mass is the limiting factor for the transport system, the relative mass of the different products being transported; or

b) where volume is the limiting factor for the transport system, the relative volume of the different products being transported.

Transport emissions shall include the emissions associated with the entire delivery journey from source to delivery point and back, including those arising from any portion of the journey that products were not being transported (e.g. as in a delivery by road in which the delivery vehicle makes the return trip empty). Where return journeys are used to transport other products, the emissions from those journeys shall be allocated to the products transported on the return journey.

9 Calculation of the GHG emissions of products

This PAS requires that both emissions to the atmosphere and removals from the atmosphere be taken into account in calculating the total GHG emissions of a product over its lifecycle. The following method shall be used to calculate the GHG emissions per functional unit of the product under assessment.

1) Determine the emissions and removals for each activity within the system boundary as primary activity data or secondary data, with emissions included as positive values and removals included as negative values.
2) Convert the primary activity data and secondary data to GHG emissions and removals per functional unit of the product under assessment by multiplying the data by the emission factor for each activity.
3) Convert the GHG emissions and removals data into units of CO_2e by multiplying the individual GHG emissions or removals figures by the relevant GWP.
4) Calculate the overall impact of carbon storage associated with the product in accordance with **5.5.1** expressed as CO_2e (**5.3**) and recorded in accordance with **5.5.2**.
5) Sum the CO_2e emissions and removals occurring in the life cycle of the product under assessment (taking account of the impact of carbon storage), to determine the net CO_2e emissions (negative or positive) per functional unit. The result shall be unambiguously expressed as cradle-to-gate or cradle-to-grave.

10 Claims of conformity

10.1 General

While this PAS does not require external disclosure or public communication of the assessment, where claims of conformity to PAS 2050 are made the provisions in **10.2** and **10.3** shall apply. These provisions include identification of the type of certification/verification undertaken (**10.2**) and requirements for how the claim shall be expressed (**10.3**).

Note *Organizations seeking to make a claim should ensure the overall representation of the claim is accurate, clear and not misleading, to comply with international and national regulations on consumer protection. Further international guidance, standards and regulations on communication of environmental claims are available to assist organizations in this area and include:*

- *The international standard on self-declared environmental claims, BS EN ISO/IEC 14021;*
- The European Commission Guidance for Making and Assessing Environmental Claims*; and*
- Guidelines on the EU Unfair Commercial Practices Directive.

National government guidelines are also available in some countries e.g.:

- UK Department of Environment Food and Rural Affairs Green Claims Guidance (http://www.defra.gov.uk/environment/economy/products-consumers/green-claims-labels);
- The UK Code of Non-Broadcast Advertising, Sales Promotion and Direct Marketing (CAP code) and Code of Broadcast Advertising (BCAP);
- US Federal Trade Commission Green Guides (http://www.ftc.gov/opa/reporter/greengds.shtm
- Canadian Competition Bureau: Environmental Claims – a guide for industry and advertisers (http://www.competitionbureau.gc.ca/eic/site/cb-bc.nsf/eng/02701.html)
- Green Marketing and Australian Consumer Law (http://www.accc.gov.au/content/index.phtml/itemId/815763)
- NZ Commerce Commission guidelines on green marketing and carbon claims: (http://www.comcom.govt.nz/green-marketing-and-carbon-claims /)

10.2 Basis of claim

10.2.1 General

The claim shall identify the type of conformity assessment undertaken as one of the following:

a) independent third-party certification in accordance with **10.2.2**;

b) other-party verification in accordance with **10.2.3**; or

c) self-verification in accordance with **10.2.4**.

10.2.2 Independent third-party certification

Organizations seeking to demonstrate that their calculations of GHG emissions have been independently verified as being in accordance with this PAS shall undergo assessment by an independent third-party certification body accredited to provide assessment and certification to this PAS.

10.2.3 Other-party verification

Organizations using an alternative method of verification involving parties other than those qualifying as accredited independent third-parties shall satisfy themselves that any such party is able to demonstrate compliance with recognized standards setting out requirements for certification bodies.

Note 1 *Other-party assessment bodies are those undertaking assessment services without having achieved accreditation from the authorized accreditation service (e.g. UKAS in the UK). Such bodies could include those which, although independent of the organization undertaking the assessment of GHG emissions and removals, cannot demonstrate complete independence, e.g. a trade body providing assessment services for its members or a consultant employed for such a purpose).*

Note 2 *Examples of such recognized standards include BS EN ISO/IEC 17021 and BS EN 45011.*

10.2.4 Self-verification

Organizations shall be able to demonstrate that the calculations have been made in accordance with this PAS, and make supporting documentation available on request. The appropriate method for self-verification and for presentation of the results shall be through the application of BS EN ISO 14021.

Note *Organizations for whom neither independent third-party certification nor other-party verification is a realistic option, may rely on self verification. In so doing, organizations should be aware that independent verification could be required in the event of challenge and that consumers could have less confidence in this option.*

10.3 Permitted forms of disclosure

Claims of conformity shall use the appropriate form of disclosure, as follows:

a) For claims of conformity based on independent third-party certification in accordance with **10.2.2**:

"Greenhouse gas emission calculated by ***[insert unambiguous identification of the claimant]*** in accordance with PAS 2050**,** ***[insert unambiguous identification of the certifying body]*** certified."

b) For claims of conformity based on other-party assessment in accordance with **10.2.3**:

"Greenhouse gas emission calculated by ***[insert unambiguous identification of the claimant]*** in accordance with PAS 2050, ***[insert unambiguous identification of the validating body]*** declared."

c) For claims of conformity based on self-verification in accordance with **10.2.4**:

"Greenhouse gas emission calculated by ***[insert unambiguous identification of the claimant]*** in accordance with PAS 2050, self-declared."

Annex A (normative)
Global warming potential

The values of global warming potentials for GHGs to be used in calculations shall be in accordance with Table A.1 (IPCC 2007, Table 2.14, see Clause 2).

Note *Attention is drawn to the requirement that the GWP actually used in calculations is the latest available from the IPCC (see 5.1.1). It is the responsibility of the organization undertaking GHG emissions assessment to confirm the currency of GWP values given in Table A.1 before use.*

Table A.1 Direct (except for CH_4) global warming potentials (GWP) relative to CO_2

Industrial designation or common name	Chemical formula	GWP for 100-year time horizon (at date of publication)
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298
Substances controlled by the Montreal Protocol		
CFC-11	CCl_3F	4,750
CFC-12	CCl_2F2	10,900
CFC-13	$CClF_3$	14,400
CFC-113	CCl_2FCClF_2	6,130
CFC-114	$CClF_2CClF_2$	10,000
CFC-115	$CClF_2CF_3$	7,370
Halon-1301	$CBrF_3$	7,140
Halon-1211	$CBrClF_2$	1,890
Halon-2402	$CBrF_2CBrF_2$	1,640
Carbon tetrachloride	CCl_4	1,400
Methyl bromide	CH_3Br	5
Methyl chloroform	CH_3CCl_3	146
HCFC-22	$CHClF_2$	1,810
HCFC-123	$CHCl_2CF_3$	77
HCFC-124	$CHClFCF_3$	609
HCFC-141b	CH_3CCl_2F	725
HCFC-142b	CH_3CClF_2	Rev2,310
HCFC-225ca	$CHCl_2CF_2CF_3$	122
HCFC-225cb	$CHClFCF_2CClF_2$	595
Hydrofluorocarbons		
HFC-23	CHF_3	14,800
HFC-32	CH_2F_2	675
HFC-125	CHF_2CF_3	3,500
HFC-134a	CH_2FCF_3	1,430

Industrial designation or common name	Chemical formula	GWP for 100-year time horizon (at date of publication)
HFC-143a	CH_3CF_3	4,470
HFC-152a	CH_3CHF_2	124
HFC-227ea	CF_3CHFCF_3	3,220
HFC-236fa	$CF_3CH_2CF_3$	9,810
HFC-245fa	$CHF_2CH_2CF_3$	1,030
HFC-365mfc	$CH_3CF_2CH_2CF_3$	794
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	1,640
Perfluorinated compounds		
Sulfur hexafluoride	SF_6	22,800
Nitrogen trifluoride	NF_3	17,200
PFC-14	CF_4	7,390
PFC-116	C_2F_6	12,200
PFC-218	C_3F_8	8,830
PFC-318	$c\text{-}C_4F_8$	10,300
PFC-3-1-10	C_4F_{10}	8,860
PFC-4-1-12	C_5F_{12}	9,160
PFC-5-1-14	C_6F_{14}	9,300
PFC-9-1-18	$C_{10}F_{18}$	>7,500
Trifluoromethyl sulfur pentafluoride	SF_5CF_3	17,700
Fluorinated ethers		
HFE-125	CHF_2OCF_3	14,900
HFE-134	CHF_2OCHF_2	6,320
HFE-143a	CH_3OCF_3	756
HCFE-235da2	$CHF_2OCHClCF_3$	350
HFE-245cb2	$CH_3OCF_2CHF_2$	708
HFE-245fa2	$CHF_2OCH_2CF_3$	659
HFE-254cb2	$CH_3OCF_2CHF_2$	359
HFE-347mcc3	$CH_3OCF_2CF_2CF_3$	575
HFE-347pcf2	$CHF_2CF_2OCH_2CF_3$	580
HFE-356pcc3	$CH_3OCF_2CF_2CHF_2$	110
HFE-449sl (HFE-7100)	$C_4F_9OCH_3$	297
HFE-569sf2 (HFE-7200)	$C_4F_9OC_2H_5$	59
HFE-43-10-pccc124 (H-Galden 1040x)	$CHF_2OCF_2OC_2F_4OCHF_2$	1,870
HFE-236ca12 (HG-10)	$CH_2OCF_2OCHF_2$	2,800
HFE-338pcc13 (HG-01)	$CHF_2OCF_2CF_2OCHF_2$	1,500
Perfluoropolyethers		
PFPMIE	$CF_3OCF(CF_3)CF_2OCF_2OCF_3$	10,300
Hydrocarbons and other compounds – direct effects		
Dimethylether	CH_3OCH_3	1
Methylene chloride	CH_2Cl_2	8.7
Methyl chloride	CH_3Cl	13

Annex B (normative)
Recording of supporting information

B.1 General

To provide for analysis and verification when required, information supporting greenhouse gas assessments to this PAS shall be recorded (**4.4**) and made available when requested.

Records shall be prepared in accordance with the principles set out in **4.2** and shall include:

- **System boundary:** description of the system boundary that has been used for the assessment of the GHG emissions of the product under assessment (**6.1**).
- **Carbon storage:** a full description of the basis on which the impact of any carbon storage was calculated including the emissions profile of the product.
- **Land use change:** data sources and identification of the options taken in the event of limited knowledge of sources and timing of land use change (**5.6**).
- **Exclusions on the basis of materiality:** where decision to exclude an emission source assessed as being below the 1% threshold has been made, the assessment details leading to that decision (**6.3**).
- **Production materials:** identification of all materials required to meet the specification of the product under assessment (**6.4.2**).

Note *Where the identification of particular materials is subject to confidentiality, evidence that they have been included in the assessment should still be provided.*

- **Energy sources:** all sources of energy contributing to the product under assessment together with related emissions factors where these are publicly available **(6.4.3)**.
- **Use phase analysis:** where use phase emissions form part of the assessment full description of the use profile used (**6.4.9**).
- **Allocation of emissions:** the basis on which allocations have been made including any assumptions that have contributed to those decisions (**8**).
- **Recycling:** the option selected for the treatment of recycled or recyclable material including any assumptions made about end-of-life treatment in cradle-to-gate assessments (**8.3** and **Annex D**).
- **Secondary data sources:** identification of the sources of the secondary data used and justification for their selection. (**7.2**).

B.2 Recording the use of supplementary requirements (SR)

Where supplementary requirements are used to determine the nature, extent and/or assessment method of one or more life-cycle elements, record shall be made of the supplementary requirements used and the justification for their selection.

Note 1 *This PAS does not include requirement for communication of the outcomes of GHG emissions and removals assessments although it is recognized that there may be situations where disclosure could be appropriate. Where communication of assessment outcomes is to be made, it is recommended that access to the supporting information is available at the same time.*

Note 2 *Disclosure of the basis of the use phase calculation or carbon storage assessment does not have to occur at the same location, or in the same form, as communication of the use phase emissions to a third-party occurs. For example, the basis of the use phase calculation or carbon storage assessment may be made available via a web site.*

Annex C (normative)
Default land use change values for selected countries

GHG emissions arising from specified changes in land use for a selection of countries shall be as given in Table C.1.

Note 1 *The information in Table.C.1 is derived from the Office of the Renewable Fuels Agency's technical guidance [5].*

Note 2 *Where habitat restoration occurs (e.g. re-forestation) the GHG emission rates provided in Table C.1 cannot be assumed to apply in reverse.*

Note 3 *See **5.6.2** for determining the GHG emissions associated with land use change where there is limited knowledge regarding the location or type of land use change.*

Note 4 *For emissions or removals from land use change in countries not listed in this Annex or for different types of land use change, refer to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, with particular reference to Volume 4, Chapter 5, Section 5.3 (and other chapters and sections as relevant) which provides details on how to apply the standard methodology to calculate the carbon lost when land is converted to cropland.*

Table C.1 Default land use change values for selected countries

Country	Current land use	Previous land use	GHG emissions (t CO_2e/ha/yr)
Argentina	Annual cropland	Forest land	17
		Grassland	2.2
	Perennial cropland	Forest land	15
		Grassland	1.9
Australia	Annual cropland	Forest land	23
		Grassland	2.2
	Perennial cropland	Forest land	21
		Grassland	1.9
Brazil	Annual cropland	Forest land	37
		Grassland	10.3
	Perennial cropland	Forest land	26
		Grassland	8.5
Canada	Annual cropland	Forest land	17
		Grassland	2.2
	Perennial cropland	Forest land	16
		Grassland	1.9
Finland	Annual cropland	Forest land	15
		Grassland	7.3
	Perennial cropland	Forest land	14
		Grassland	6.9
France	Annual cropland	Forest land	18
		Grassland	4.5
	Perennial cropland	Forest land	14
		Grassland	4.2
Germany	Annual cropland	Forest land	21
		Grassland	7.0
	Perennial cropland	Forest land	14
		Grassland	6.7

Country	Current land use	Previous land use	GHG emissions (t CO_2e/ha/yr)
Indonesia	Annual cropland	Forest land	33
		Grassland	19.5
	Perennial cropland	Forest land	31
		Grassland	17.7
Malaysia	Annual cropland	Forest land	37
		Grassland	10.3
	Perennial cropland	Forest land	26
		Grassland	8.5
Mozambique	Annual cropland	Forest land	24
		Grassland	3.6
	Perennial cropland	Forest land	22
		Grassland	3.2
Pakistan	Annual cropland	Forest land	16
		Grassland	3.6
	Perennial cropland	Forest land	15
		Grassland	3.2
Poland	Annual cropland	Forest land	21
		Grassland	7.0
	Perennial cropland	Forest land	14
		Grassland	6.7
South Africa	Annual cropland	Forest land	26
		Grassland	1.6
	Perennial cropland	Forest land	25
		Grassland	1.2
Ukraine	Annual cropland	Forest land	18
		Grassland	6.2
	Perennial cropland	Forest land	18
		Grassland	5.8
United Kingdom	Annual cropland	Forest land	27
		Grassland	7.0
	Perennial cropland	Forest land	20
		Grassland	6.7
United States	Annual cropland	Forest land	17
		Grassland	1.9
	Perennial cropland	Forest land	16
		Grassland	1.5

Annex D (normative)
Assessment of emissions arising from recycled or recyclable material inputs

D.1 General

Where a product uses recycled or recyclable material, the emissions associated with recycled and virgin material and with disposal of material after use shall be assessed in accordance with **D.2** to **D.6**.

D.2 Recycled content method

Note *This method is also called the cut-off method and the 100-0 method.*

If the recycled material does not maintain the same inherent properties as the virgin material input, the emissions and removals arising per unit (E) from that material shall reflect the product specific recycled content and/or recycling rate based on the following calculation:

$$E = (1 - R_1) E_V + R_1 E_R + (1-R_2) E_D$$

where

R_1 = proportion of recycled material input;

R_2 = proportion of material in the product that is recycled at end-of-life;

E_R = emissions and removals arising from recycled material input per unit of material;

E_V = emissions and removals arising from virgin material input per unit of material;

E_D = emissions and removals arising from disposal of waste material per unit of material.

D.3 Closed-loop approximation method

If the recycled material maintains the same inherent properties as the virgin material input, the emissions and removals arising per unit (E) from that material shall reflect the product specific recycling rate based on the calculation given in this clause (closed-loop approximation method).

Note 1 *If the product system includes many recycled material input and outputs, it can be difficult to correctly perform the closed loop approximation method even when the same inherent properties are maintained. In this case companies should use the recycled content method.*

Note 2 *This method is also called the end-of-life approach, recyclability substitution, and/or the 0-100 output method.*

$$E = (1-R_2)E_V + R_2 E_R + (1-R_2) E_D$$

where

R_2 = proportion of material in the product that is recycled at end-of-life;

E_V = emissions and removals arising from virgin material input, per unit of material;

E_D = emissions and removals arising from disposal of waste material, per unit of material;

E_R = emissions and removals arising from recycled material input, per unit of material.

D.4 Recycling data

D.4.1 Material input with system average recycle content and recycling rate

Where the life cycle of a product includes a material input that contains the system average proportion of recycled content and is recycled at the system average recycling rate for that product category, the calculation in **D.2** shall reflect the system average recycle content and recycle rate.

Note *It is assumed that materials are recycled in a steady state system. This might not be the case for some materials where the total stock of material in use is increasing or decreasing over time.*

D.4.2 Material input with a product specific recycle content and/or recycling rate

Where the life cycle of a product includes a material input with a specified proportion of recycled content and/or the material in the product has a recycle rate that is different from the average recycle rate for that product category, the emissions and removals arising from that material shall reflect the product specific recycle content and/or recycling rate.

D.4.3 Demonstration of product specific recycled content and/or recycling rate

Where emissions and removals associated with product specific recycled content and/or recycling rate are determined in accordance with D.2, the organization shall record the product specific recycle content and/or recycling rate.

D.5 Other types of recycling

Where the life cycle of a product includes a material input with recycled content other than that described in **D.2** and **D.3** supplementary requirements in accordance with the principles set out in **4.3** that are not in conflict with the requirements of this Annex shall be used to provide the calculation method. Where such supplementary requirements do not exist or are considered not to be appropriate, the emissions arising from the material shall be assessed using an approach consistent with BS EN ISO 14044:2006.

D.6 Recording the basis of the treatment of recycling

Where the assessment of the life cycle GHG emissions of a product includes emissions arising from the recycling of material, the approach adopted in assessing the GHG emissions associated with recycling shall be recorded and retained (**4.4**).

Note *Accurate recording of assumptions made in respect of emissions from end-of-life activities is particularly important where cradle-to-gate assessments are made. The actual end-of-life treatment for the product under assessment could be different from that assumed in the cradle-to-gate assessment. The availability of such information can help reduce the potential for double counting and/or omission.*

Annex E (normative)
Calculation of the weighted average impact of delayed emissions arising from the use and final disposal phases of products

E.1 General application

Where the impact of delayed emission is to be assessed, the emissions arising during the use phase or during final disposal, of the product over a period of more than one year, shall be taken into account using one of the methods provided in **E2** or **E3**.

Note 1 *The formulae presented in this Annex represent a simplification of the approach outlined in IPCC 2007, Table 2.14 (footnote (a)), Chapter 2 (see **Clause 2**). Full implementation of the IPCC approach give a more precise result.*

Note 2 *The approach presented in IPCC 2007 Table 2.14 (footnote (a)), Chapter 2 (see **Clause 2**) is applicable to CO_2 emissions only, while the approximation presented here is applied to GWP data assessed under this PAS. As a result, the approximation is less accurate where the overall CO_2e emissions of the product include a significant non-CO_2 component.*

E.2 Specific case: delayed single release

Where emissions from the use phase or the final disposal phase of a product occur as a single release within 25 years of the formation of the product, the weighting factor, FW, to be applied to the GHG emissions released at that time shall reflect the number of years of delay in the emissions being released (i.e. the number of years between formation of the product and the single release of the emissions) according to:

$$FW = \frac{100 - (0.76 \times t_o)}{100}$$

where

t_o = the number of years between formation of the product and the single release of the emissions.

E.3 General case: delayed release

The weighted average time the emissions are in the atmosphere shall be calculated according to:

$$FW = \frac{\sum_{i=1}^{100} x_i \cdot (100 - i)}{100}$$

where

i = each year in which emissions occur

x = the proportion of total emissions occurring in any year i.

Note *For example, if use phase emissions were to be delayed for 10 years following formation of the product, with total emissions being released evenly over the following 5 years, then the weighting factor that represents the weighted average time these emissions are present in the atmosphere would be:*

$$FW = \frac{(0.2 \times (100 - 11)) + (0.2 \times (100 - 12)) + (0.2 \times (100 - 13)) + (0.2 \times (100 - 14)) + (0.2 \times (100 - 15))}{100}$$

$$= 0.87$$

In this example, the total amount of use phase emissions, expressed as CO_2e, released during the 100-year quantification period would be multiplied by a factor of 0.87 to reflect the weighted average time these emissions are present in the atmosphere during the 100-year quantification period.

E.4 Recording the basis of the carbon storage assessment

Where the assessment of the life cycle GHG emissions of a product is accompanied by assessment of the impact of delayed release of the stored carbon, the data sources from which the impact of stored carbon was calculated, together with the carbon storage profile of the product over the 100-year assessment period, shall be recorded and retained (see **4.4**).

Note *Entities wishing to make the effect of carbon storage known to other parties may do this in parallel with the identification of the impact without carbon storage.*

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