PUBLICLY AVAILABLE SPECIFICATION

PAS 2050 – Specification for the assessment of the life cycle greenhouse gas emissions of goods and services

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Foreword

This Publicly Available Specification (PAS) has been prepared by BSI to specify requirements for assessing the life cycle greenhouse gas emissions (GHG) of goods and services. The development of this PAS was co-sponsored by the Carbon Trust and the Department for Environment, Food and Rural Affairs (Defra).

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.

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

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This Publicly Available Specification 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is put forward to form the basis of a full British Standard, European Standard or International Standard, it will be withdrawn.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 is presented in smaller 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.

Summary of pages

This document comprises a front cover, an inside front cover, pages 1 to 47, and inside back cover and a back cover. The BSI copyright notice displayed in this document indicates when the document was last issued.

Introduction

Climate change has been identified as one of the greatest challenges facing nations, governments, business and citizens over future decades (IPCC 2007). Current actions, including the release of CO_2 and other greenhouse gases through human activities, including the burning of fossil fuels, emissions from chemical processes, and other sources of anthropogenic greenhouse gasses, 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 life cycle GHG emissions associated with goods and services reflect the impact of process, materials and decisions occurring throughout the life cycle of goods and services.

PAS 2050 has been 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, disposing of and/or recycling of goods and services. PAS 2050 recognizes the potential for organizations to use this method to provide improved understanding of the GHG emissions arising from their supply chains, and to provide a common basis for the comparison and communication of results arising from the use of PAS 2050. There is, however, no requirement for communication, or standardization of communication techniques, included in this specification.

PAS 2050 benefits organizations, businesses and other stakeholders by providing clarity and consistency for quantifying the life cycle GHG emissions associated with goods and services. Specifically, PAS 2050 provides the following benefits:

(a) For organizations that supply goods and services:

- allows internal assessment of the existing life cycle 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 services;
- provides a benchmark for ongoing programmes aimed at reducing GHG emissions; and
- allows for a comparison of goods or services using a common, recognized and standardized approach to life cycle emissions assessment.

(b) For customers of goods and services:

- provides a common basis from which the results of life cycle GHG emissions assessments can be reported and communicated; and
- provides an opportunity for greater customer understanding 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 greenhouse gas (GHG) emissions associated with the life cycle of goods and services. This PAS is applicable to organizations assessing the life cycle GHG emissions of goods and services across their life cycle.

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

This PAS does not assess other potential social, economic and environmental impacts arising from the provision of goods and services, such as non-greenhouse gas emissions, acidification, eutrophication, toxicity, biodiversity, labour standards or other social, economic and environmental impacts. The life cycle GHG emissions of goods and services calculated using this PAS do not provide an indicator of the overall environmental impact of these good or services, such as may result from other types of life cycle assessment.

This PAS does not include category provisions for goods and services; however, it is intended that category specific provisions for goods and services, developed in accordance with ISO14025:2006, will be adopted where available, as specified in this PAS.

It is one of the intentions of this PAS to allow for the comparison of GHG emissions between goods or services, and to enable the communication of this information. However, this PAS does not specify requirements for communication.

2 Normative references

The following referenced documents are indispensable for the application of this PAS. 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 14040:2006, *Environmental management — Life cycle assessment — Principles and framework*

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

BS EN ISO/IEC 17000:2004*, Conformity assessment — Vocabulary and general principles*

BS EN ISO/IEC 17021:2006, *Conformity assessment — Requirements for bodies providing audit and certification of management systems*

BS EN ISO/IEC 17050-1:2004, *Conformity assessment — Supplier's declaration of conformity — Part 1: General requirements*

BS ISO 14064-1:2006, *Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals*

ISO 14025:2006, *Environmental labels and declarations - Type III environmental declarations - Principles and procedures*

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

IPCC (2007), *Climate Change: the physical science basis. Chapter 2: Changes in atmospheric constituents and in radiative forcing*, Intergovernmental Panel on Climate Change

Office of the Renewable Fuels Agency (2008), *Carbon and sustainability reporting with the Renewable Transport Fuels Obligation – Technical Guidance (Part 2),* Department for Transport, London

3 Terms and definitions

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

3.1 activity-based assessment

quantification of processes that combine to deliver a service (see also **3.28**)

NOTE The activity-based assessment differs from that of the mass balance as emissions may be associated with processes that provide a service with no physical output. An example would be the emissions associated with operating a web-based service such as internet banking.

3.2 anticipated life cycle greenhouse gas emissions

initial estimate of greenhouse gas (see **3.21** for a definition of greenhouse gases) emissions for a product (see **3.33** for a definition of product) that is calculated using secondary data (see **3.40** for a definition of secondary data), or a combination of primary (see **3.32** for a definition of primary activity data) and secondary data, for the processes used to produce the product

3.3 biogenic carbon

carbon derived from biomass, excluding fossil carbon (see **3.18** for a definition of fossil carbon)

3.4 biomass

biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste (Directive 2001/77/EC)

3.5 capital goods

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

NOTE Capital goods do not include raw materials, fuel or energy, or other inputs to the life cycle of products.

3.6 carbon dioxide equivalent (CO_2e)

unit for comparing the radiative forcing of a greenhouse gas measure of the amount of global warming arising from different greenhouse gasses, expressed in terms of the amount of carbon dioxide that would have an equivalent global warming potential (see **3.20** for a definition of global warming potential)

NOTE Greenhouse gasses, other than CO_2, are converted to their carbon equivalent value on the basis of their contribution to radiative forcing using 100-year global warming potentials defined by the Intergovernmental Panel on Climate Change (IPCC).

3.7 combined heat and power (CHP)

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

3.8 competent person

person with sufficient training and experience or knowledge and other qualities, and with access to the requisite tools, equipment and information to enable them to carry out a defined task

3.9 consumable

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

NOTE Consumables include lubrication oil, tools and other rapidly wearing inputs to a process. 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. Fuel and energy inputs are not considered consumables.

3.10 co-product

any of two or more products from the same unit process that are produced at the same time (BS EN ISO14044:2006)

NOTE Where two or more products can be produced from a unit process, they are considered co-products only where they arise at the same time (i.e. one cannot be produced without the other being produced).

3.11 customer

purchaser of goods or services

3.12 economic value

market value of a product, co-product or waste at the point of production

3.13 emission factor

rate of emission of greenhouse gasses, relative to a unit of activity

NOTE For example, kgCO_2e per unit input.

3.14 energy carrier

system or substance that moves energy in a useable form from one location to another, rather than being a primary source of energy itself

NOTE Electricity and hydrogen are examples of energy carriers, as they allow energy to be moved from one location to another.

3.15 environmental input–output life cycle assessment (EIOA)

method of estimating the greenhouse gas emissions (and other environmental impacts) arising from sectors within an economy through the analysis of economic flows

NOTE Alternative terms, such as economic input-output life cycle assessment (EIO-LCA), input output based life cycle analysis (IOLCA) and hybrid life cycle assessment (HLCA) refer to different approaches to implementing EIOA.

3.16 European Reference Life Cycle Data System (ELCD)

life cycle assessment dataset compiled by the European Platform on Life Cycle Assessment which contains secondary emission factors for selected materials and processes

3.17 forest product

any commercial roundwood product (boards, dimension lumber, pulp and paper products) except fuelwood

3.18 fossil carbon

carbon derived from fossil fuel or another fossil source, including peat (IPCC 2006)

3.19 functional unit

quantified performance of a product for use as a reference unit (BS EN ISO 14044:2006)

3.20 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 carbon dioxide over a given period of time (BS ISO 14064-1:2006)

NOTE Carbon dioxide from fossil carbon sources is assigned a GWP of 1, while carbon dioxide from biogenic sources is assigned a GWP of zero. The GWP of other gases is expressed relative to the GWP of carbon dioxide from fossil carbon sources. ***Annex A*** *contains global warming potentials for a 100 year time period produced by the Intergovernmental Panel on Climate Change.*

3.21 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 GHGs are specified in ***Annex A****, and include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) (BS ISO 14064-1:2006).*

3.22 input

product, material or energy flow that enters the life cycle of a product

3.23 input-output life cycle analysis (IOLCA)

top-down method for analysing the environmental interventions of a product (functional unit) from cradle-to-gate based on environmental input-output analysis

3.24 intermediate product

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

3.25 life cycle

consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to final disposal (BS EN ISO 14040:2006)

3.26 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)

3.27 life cycle GHG emissions

sum of all greenhouse gas emissions occurring at each stage of the product life cycle and within the specified system boundaries of the product

NOTE This includes all emissions that are released as part of all processes involved in obtaining, creating, modifying, transporting, storing, use and end of life disposal of the product.

3.28 mass balance

quantification of total materials into and out of a process

3.29 material contribution

contribution of any one source of GHG emissions to a product of more than 1% of the anticipated life cycle GHG emissions associated with the product

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.

3.30 offsetting

net reduction in emissions associated with a process or product through causing the removal of, or preventing the release of, GHG emissions in an unrelated process

NOTE An example is the purchase of voluntary carbon offsets.

3.31 output

products, material or energy that leaves a unit process (BS EN ISO14044:2006)

NOTE Material may include raw materials, intermediate products, co-products, products, and releases.

3.32 primary activity data

quantitative measurement of activity from a product's supply chain that, when multiplied by an emission factor, determines the GHG emissions arising from a process

NOTE 1 Examples of GHG activity data include the amount of energy, fuels or electricity consumed, 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 does not include emission factors.

3.33 product(s)

goods or services resulting from a supply chain

NOTE Services have tangible and intangible elements. Provision of a service can involve, for example, the following:

- *an activity performed on a customer-supplied tangible product (e.g. automobile to be repaired);*
- *an activity performed on a customer-supplied intangible product (e.g. the income statement needed to prepare a tax return);*
- *the delivery of an intangible product (e.g. the delivery of information in the context of knowledge transmission);*
- *the creation of ambience for the customer (e.g. in hotels and restaurants)*
- *software consists of information and is generally intangible and can be in the form of approaches, transactions or procedures.*

3.34 product category

group of products that can fulfil equivalent functions (ISO14025:2006)

3.35 product category rules (PCRs)

set of specific rules, requirements and guidelines for developing Type III environmental declarations (ISO 14025:2006) for one or more product categories

3.36 raw material

primary or secondary material used to produce a product

NOTE Secondary material includes recycled material (BS EN ISO 14044:2005).

3.37 releases

emissions to air and discharges to water and soil that result in GHGs entering the atmosphere

3.38 renewable energy

energy from non-fossil energy sources: wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases (Directive 2001/77/EC)

3.39 reporting units

units in which the results of the assessment of GHGs are reported

3.40 secondary data

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

NOTE Secondary data is used when primary data is not available or it is impractical to obtain primary data.

3.41 sustainable forest management

stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems

3.42 system boundary

set of criteria specifying which unit processes are part of a product system (BS EN ISO ISO14044:2005)

3.43 unit process

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

3.44 upstream emissions

in relation to the provision of fuels, electricity or heat, these are the emissions associated with the life cycle of the fuel

3.45 use phase

that part of the life cycle of a product that occurs between the first arrival of the product and the end of life of the product

NOTE For services, the use phase includes the provision of the service.

3.46 use profile

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

3.47 useful energy

energy that meets a demand by displacing an alternative source of energy

3.48 waste

materials, co-products, products or releases which the holder intends or is required to dispose of

NOTE Materials, co-products, products or releases which have zero or negative economic value to the owner of wastes.

4 Assessment, principles and implementation

4.1 Assessment

The assessment of GHG releases shall be carried out in accordance with the requirements of this PAS and shall be in conformance with the life-cycle assessment techniques specified in BS EN ISO 14040:2006 and BS EN ISO 14044:2006.

4.2 Principles

The application of principles is fundamental to ensure a true and fair account of the GHG emissions arising from the life cycle of products. The principles are the basis for, and shall guide the application of, the requirements in this PAS.

4.2.1 Completeness

All relevant GHG emissions and removals, and all relevant information to support the assessment of GHG emissions and removals arising from products, shall be included in the assessment of GHG releases.

4.2.2 Consistency

Meaningful comparisons in GHG-related information shall be enabled.

4.2.3 Data quality

Organizations undertaking GHG emissions assessment in accordance with this PAS shall endeavour to reduce uncertainty as much as practicable by using the best quality data achievable. When selecting data, consideration shall be given to:

- temporal specificity – age of the data and the length of time over which it is collected;
- geographical specificity – area from which data is collected (e.g. district, country, region);
- technological specificity – whether the data is associated with one technology or a mixture;
- reliability – the extent to which the data can be trusted, based on an assessment of the sources of data, the methods used to collect the data and the verification procedures used;
- completeness – degree to which the set of data represents the population of interest (is the sample size large enough, is the periodicity of measurement sufficient, etc.).

4.2.4 Transparency

Where the GHG results calculated in accordance with this PAS are communicated to a third party, the organization communicating the GHG assessment shall disclose sufficient and appropriate GHG-related information to allow intended third party users to make decisions with reasonable confidence.

4.2.5 Conservativeness

Conservative assumptions, values and procedures shall be used to ensure that GHG emissions are not underestimated.

NOTE It is not the intention of this PAS that the requirements for calculating GHG emissions be interpreted narrowly or in a manner that artificially reduces the calculated GHG emissions associated with products.

4.3 Implementation, validation and supporting data

This PAS shall be implemented by a competent person or persons. Data supporting calculations submitted as part of a claim of conformity with this PAS, including but not limited to product and process boundaries, materials, emissions and carbon intensity, shall be recorded in sufficient detail and presented in a format suitable for analysis and validation.

*NOTE It is necessary that the data referred to in **4.3** be available to support claims of conformance no matter what form of validation is chosen. The basis of support for self validation of conformance is no different from that required for other party validation or independent third party certification (see Clause **10**).*

5 Emission sources, offsetting and unit of analysis

5.1 Scope of GHG emissions

The assessment of GHG emissions in this PAS shall include emissions arising from (BS ISO 14064-1:2006):

- carbon dioxide (CO_2);
- methane (CH_4);
- nitrous oxide (N_2O);
- hydrofluorocarbons (HFCs);
- perfluorocarbons (PFCs);
- sulfur hexafluoride (SF_6).

*NOTE See **Annex A** for values of global warming potentials for GHGs.*

5.2 Sources of GHG releases

The estimate of GHG emissions shall include emissions throughout the life cycle of the product (see Clause **6** for a description of system boundary) arising from processes, inputs and outputs in the life cycle of a product, such as, but not limited to:

- consumption of energy that results in releases of GHGs associated with it;

- consumption of energy carriers that were themselves created using processes that have GHG emissions associated with them, e.g. electricity;
- chemical reactions, refrigerant loss and other fugitive releases;
- releases resulting from land use change;
- releases arising from livestock and other agricultural processes;
- releases arising from waste.

NOTE See Clause ***7*** *for data sources.*

5.3 Carbon dioxide originating from fossil and biogenic carbon sources

CO_2 releases arising from fossil carbon sources shall be included in the calculation of GHG releases from the life cycle of products.

CO_2 releases arising from biogenic carbon sources shall be excluded from the calculation of GHG releases from the life cycle of products, except where the CO_2 arises from land use change (see **5.6**).

5.4 Carbon sequestration

Where the permanent removal (i.e. net removal remaining over a 100 year time period following the creation of the product) of GHGs from the atmosphere occurs as part of the life cycle of timber fibre, cement or lime, the removal of GHGs shall be included in the assessment of the life cycle emissions of the product.

5.4.1 Wood fibre

For products incorporating wood fibre, reductions in GHG emissions shall only be included in the assessment of the life cycle emissions of the product if the fibre is obtained from:

- a recycling or re-use source; or
- a source that has demonstrated compliance with sustainable forest management.

Only that proportion of carbon retained in the product after 100 years shall be treated as sequestered during the life cycle of the product (see **8.2** for the treatment of emissions from waste for that portion of the product not sequestered).

NOTE 1 Sequestration of carbon in wood fibre will vary depending on the type of product. For example, some dimensional timber products may have a life span of more than 100 years, while others, that have a life span of less than 100 years, may retain some carbon in landfill. For paper tissue products, it is anticipated that the product life is less than 100 years; however, some products may result in some carbon being retained in landfill for 100 years or more.

NOTE 2 While sustainable forest management activities may result in additional carbon sequestration in managed forests through the retention of forest biomass (e.g. trees not harvested), the methods and data requirements for calculating this sequestration are not fully developed. This potential source of sequestration is not included in the scope of this PAS.

5.4.2 Cement and lime

For products incorporating cement and lime, reductions in GHG emissions shall equal the amount of CO_2 reabsorbed in the 100 years following manufacture of the cement and lime.

Only that amount of carbon reabsorbed by the cement and lime after 100 years shall be treated as sequestered during the life cycle of the product.

5.4.3 Basis of the sequestration assessment

Determination of the amount of sequestration occurring in products shall be based on a hierarchy of sequestration data sources. The order of preference for the basis of the sequestration assessment shall be:

1. Product Category Rules (PCRs) that specify a 100 year sequestration rate for the product being assessed;
2. published international standards that specify a 100 year sequestration rate for the product being assessed;
3. published industry guidelines that specify a 100 year sequestration rate for the product being assessed;
4. published national guidelines that specify a 100 year sequestration rate for the product being assessed.

Where no sequestration rate is established in accordance with points 1-4 above, a description of the assumptions leading to the determination of the 100 year sequestration rate shall be recorded.

5.4.4 Recording of the basis of the sequestration assessment

Where the assessment of the life cycle GHG emissions of a product includes an amount of carbon sequestered, the data source from which the amount of sequestration was calculated shall be recorded.

5.5 Soil carbon

Changes to soil carbon (either releases or sequestration) for agricultural systems established prior to 1 January 2008 shall be excluded from the assessment of GHG emissions under this PAS.

5.6 Treatment of land use change

The GHG releases arising from direct land use change that is associated with inputs to the life cycle of a product shall be included in the assessment of GHG emissions of the product.

The GHG releases occurring as a result of direct land use change shall be assessed in accordance with the IPCC Guidelines for National Greenhouse Gas Inventories. The assessment of the impact of land use change shall include all direct land use change occurring on or after 1 January 2008, and shall be amortized over the 20 years following the change in land use.

NOTE While GHG emissions also arise from indirect land use change, the methods and data requirements for calculating these emissions are not fully developed. The inclusion of indirect land use change GHG emissions when implementing this PAS is therefore optional.

5.6.1 Limited traceability of agricultural products

The following hierarchy shall apply when determining the GHG emissions arising from land use change:

1. Where the country of origin is known and the previous land use is known, the GHG emissions arising from land use change shall represent the emissions resulting from the change in land use from the previous land use to the current land use in that country;
2. Where the country of origin is known, but the former land use is not known, the GHG emissions arising from land use change shall be the worst case outcome for the current land use in that country;
3. Where the country of origin is not known, the GHG emissions arising from land use change shall be the worst case outcome for all countries (i.e. it shall be assumed that GHG emissions associated with land use change equivalent to that arising from the conversion of forest land to annual cropland in Malaysia).

The GHG emissions from land use change for selected countries, by previous and current land use, shall be as shown in **Annex B**.

5.6.2 Limited knowledge of the timing of land use change

Where the timing of land use change cannot be demonstrated to be prior to 1 January 2008, it shall be assumed that the land use change occurred on 1 January of the year in which the assessment of GHG emissions is being carried out.

5.7 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 life cycle of the product in order to claim reduction in the emissions associated with 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 reduced GHG releases to the atmosphere and therefore achieves a lower emission factor, e.g. renewable electricity, is not a form of offsetting (see **8.3.2**).*

5.8 Unit of analysis

5.8.1 Functional unit

Calculations of the GHG emissions for the use phase of products shall be carried out and reported per functional unit, and shall be determined in terms of the mass of CO_2e per functional unit.

NOTE For services, or for goods delivering a service (e.g. a light bulb delivering the service of supplying light), the functional unit would present the mass of CO_2e per unit of service provided.

5.8.2 Reporting units

The reporting units shall be consistent with the unit basis on which the product is provided. 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 a product sold, or per month or year of a service provided).

NOTE 1 For services the appropriate reporting unit may be established on a time (e.g. annual emissions associated with an internet service) or event basis (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 for a product provided to customers.

6 System boundary

6.1 Establishing the system boundary

Where a Product Category Rule (PCR) developed in accordance with ISO14025:2006 exists for the product being considered, the boundary conditions established in the PCR shall form the system boundary for the product.

Where a PCR developed in accordance with ISO14025:2006 does not exist for the product being considered, the system boundary shall be clearly defined for each product, and its underlying processes, in accordance with **6.2**.

*NOTE 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 **6.1.1**).*

6.1.1 Material contribution

Calculations carried out in accordance with this PAS shall include all emissions within the system boundary that are likely to make a material contribution to the life cycle GHG emissions of the product.

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 IOLCA approach. This preliminary assessment could provide an overview of the key sources of GHG emissions within the lifecycle of the product, and identify minor contributors to the GHG emissions assessment.

6.1.2 Threshold for inclusion in the assessment of GHG emissions

For GHG emissions arising from the life cycle of a product, except those from the use phase, the assessment of GHG emissions shall include:

- all sources of emissions anticipated to make a material contribution (more than 1%) to the life cycle GHG emissions of the functional unit;
- at least 95% of the anticipated life cycle GHG emissions of the functional unit; and

- Where a single source of GHG emissions accounts for more than 50% of the likely life cycle GHG emissions of a product, the 95% threshold rule shall apply to the remaining GHG emissions associated with the anticipated life cycle GHG emissions the product.

For GHG emissions arising from the use phase of a product, the assessment of GHG emissions shall include:

- all sources of emissions likely to make a material contribution (more than 1%) to the emissions of the use phase;

- at least 95% of the likely life cycle emissions of the use phase.

Where less than 100% of the anticipated life cycle GHG emissions have been determined, the assessed emissions shall be scaled up to represent 100% of the GHG emissions associated with the functional unit in accordance with **8.4**.

6.2 Definition of the system boundary

The following rules shall define the cradle to grave system boundary for the life cycle of a product.

6.2.1 Raw materials

The GHG emissions resulting from the processes used in the transformation of the raw material from its natural state shall be included in the calculation, including all sources of energy consumption or direct GHG emissions.

NOTE 1 GHG emissions from raw materials include: GHG emissions from mining or extracting raw materials, including releases from machinery and consumables; GHG emissions from farming, fishing and forestry, including the use of fertilizers and other inputs as well as releases from land use change and energy intensive atmospheric growing conditions (e.g. heated greenhouse); waste generated at each stage of the extraction and pre-processing of raw materials (see also ***6.2.3****).*

NOTE 2 Agricultural emissions include at a minimum releases from crops (e.g. methane from rice cultivation) and livestock (e.g. methane from cattle), releases from fertilizers (e.g. N_2O *emissions arising from the application of fertilizer and releases arising from the production and transport of the fertilizer), and releases due to land use change.*

NOTE 3 Raw materials have zero GHG emissions associated with them when they have not been through any external process transformation, e.g. iron ore before it has been extracted.

6.2.2 Energy

The GHG emissions associated with the provision and use of energy, including the generation of electricity and heat and emissions from transport fuels, shall include the GHG emissions falling within the system boundary of the energy supply system. Upstream emissions (e.g. the mining and transport of fuel to the electricity generator; the growing and processing of biomass for use as a fuel) shall be included in the system boundary of the energy supply system.

NOTE Emissions from energy include the releases arising from the life cycle of the energy. This includes releases at the point of consumption of the energy (e.g. emissions from the burning of coal and gas), and *releases arising from the provision of the energy (e.g. emissions arising from the generation of electricity, the provision of biomass).*

6.2.3 Capital goods

The GHG emissions that arose from the production of capital goods that form part of the life cycle of the product shall be allocated to the life cycle of the product (see Clause **8**).

NOTE It is anticipated that the impact of emissions arising from capital goods will in most instances not make a material contribution to the life cycle emissions of the product, and therefore will be excluded under ***6.1.1****.*

6.2.4 Manufacturing and service delivery

The GHG emissions arising from manufacturing and service delivery within the system boundary shall be included in the assessment of the GHG emissions across the life cycle of the product, including releases associated with the use of consumables.

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

6.2.5 Lighting, heating, cooling and ventilation of premises

GHG emissions arising from the operation of factories, warehouses, central supply centres and retail outlets shall be included in the calculation.

NOTE Operation includes the lighting, heating, cooling, ventilation and humidity control of the premises. An appropriate approach for the allocation 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 allocating emissions.

6.2.6 Transport

The GHG emissions associated with road, air, water, rail or other transport (including heating and cooling) shall be included for the transport of:

- inputs that form part of the life cycle of a product;
- products and materials from the point at which they become waste to the point of disposal or reprocessing.

NOTE 1 Emissions associated with storage requirements during transport (e.g. refrigerated transport) are included in ***6.2.7****.*

NOTE 2 GHG releases 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 localised transport methods).

NOTE 3 Where products are distributed to different points of sale (i.e. different stores), emissions associated with transport will vary from store to store due to different transport requirements. Where this occurs, organizations should calculate the average release of GHG's associated with transporting the product based on the average distribution of the product.

6.2.7 Storage

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

- storage of inputs, including raw materials, at any point in the product life cycle;
- cooling or heating of a product at any point in the product life cycle (see **6.2.5** for the heating or cooling of factories in which products may be stored);
- storage prior to re-use or recycling activities (see **6.2.9**).

*NOTE GHG emissions identified under **6.2.7** are in addition to those already identified in **6.2.5**.*

6.2.8 Use phase

The GHG emissions arising from the use of goods or the provision of services shall be included in the assessment of life cycle GHG emissions of products, subject to **6.3**. The emission factor associated with energy consumed in the use phase of products shall be determined in accordance with **6.2.2.**

NOTE When assessing the use phase of products, the calculation of energy consumption in the use phase shall be on the basis of country specific annual average emission factor for energy. 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 shall be used.

6.2.8.1 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. The order of preference for the basis of the use profile shall be:

1. Product Category Rules (PCRs) that specify a use phase for the product being assessed;
2. published international standards that specify a use phase for the product being assessed;
3. published industry guidelines that specify a use phase for the product being assessed;
4. published national guidelines that specify a use phase for the product being assessed.

Where no use profile is established in accordance with points 1-4 above, a description of the use profile for the use phase shall be recorded.

NOTE The manufacturer's recommended method for achieving the functional unit (e.g. cooking by oven at a specified temperature for a specified time) can be used as a basis for determining the use phase of a product.

6.2.8.2 Recording of the basis of use phase calculations for products

The basis on which the use phase for products is assessed shall be recorded. Where there is no established method for determining the use phase of products, the rules used to determine the use phase shall be recorded.

NOTE It is anticipated that, over time, PCRs and other published material will increasingly form the basis of use phase emissions assessments.

6.2.9 Recycling and reuse

The GHG emissions arising from the recycling or re-use of a product or material shall be associated with the life cycle of the product for which the recycled or re-used product or material forms an input. GHG emissions associated with the following sources shall be included in the calculation:

- processes required to recycle a product to a state where it is an input to the life cycle of the product being assessed;
- transport of the recycled material from the place of reprocessing to the place where it forms an input to the life cycle of the product being assessed.

6.2.10 Final disposal

The GHG emissions arising from materials or products that are disposed of permanently (e.g. through landfill, incineration, burial, wastewater) shall be associated with the life cycle from which the product or material arose and shall be incorporated into the calculation.

Where a process is used for prototyping a new product, wastes arising from the prototyping shall be allocated to the usual product(s) and co-product(s) of the process.

6.2.10.1 Time period for releases of GHGs

The final disposal of materials or products may result in the release of GHG over time. Where this occurs (e.g. decomposition of food waste sent to landfill), releases projected to occur over a 100 year time period shall be included in the assessment of GHG emissions of the product that gave rise to the material or product that was disposed of.

6.2.10.2 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 releases from the products giving rise to the emissions shall reflect the releases arising from this diversion, as described in **8.2**.

6.3 System boundary exclusions

The system boundary of the product life cycle shall exclude the GHG releases in the following situations:

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

Where a product is used as an input to another process, such as in business-to-business transactions, the system boundary shall include all emissions that have occurred up to the point where the business-to-business transaction occurred.

NOTE For example, the calculation of life cycle GHG emissions associated with the production of aluminium that is subsequently supplied to a can manufacturer would not include emissions arising from subsequent processes where the aluminium was provided to a subsequent business; however, a can of drink being supplied to consumers would include the complete life cycle GHG emissions of the product.

6.4 Limits

GHG emissions from outputs shall be included up to the point where:

- The product or co-product displaces an input in another products' life cycle, e.g. when the product has been made available for recycling or when a co-product is used in the production of another product;

- The product or waste reaches a state where no further GHG emissions are associated with it. However, the GHG emissions of any waste (non-useful co-product) produced in the manufacture of the product shall be attributed to it, e.g. GHG emissions from transporting waste to landfill and GHG emissions from the waste whilst in the landfill site shall be attributed to the product.

7 Data

7.1 General

The GHG emissions of a product shall be determined and recorded so that the emissions which occur within the system boundary are included. Assessment of GHG emissions shall use data that will maximize certainty in the assessment of life cycle GHG emissions of the product, and yield accurate and reproducible results. Data shall reflect the temporal and geographical features of the life cycle of the product being assessed.

7.2 Emissions contribution

The contribution of a GHG emission source to the life cycle of a product shall be calculated by multiplying activity data (e.g. MJ of electricity consumed) by an emission factor (e.g. kg of CO_2e per MJ of electricity).

7.3 Primary activity data

Primary data shall be used for all processes owned or operated by the organization implementing this PAS. For each of these processes, 60% of the GHG emissions shall be calculated from emission factors which have themselves been derived by obtaining primary activity data for the previous process in the supply chain. This process of obtaining primary activity data for previous processes shall continue until limited by:

- an input being sourced through a homogenous market (e.g. vegetable oils); or

- the requirement to physically measure GHG emissions themselves (e.g. measuring methane emissions from livestock).

The primary activity data requirement shall only apply to those processes owned or operated by the organization implementing this PAS, or inputs into those processes. The primary activity data requirement shall not apply to downstream sources of GHG emissions.

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**.

NOTE 1 Examples of primary activity data would be the measurement of energy use or material use in a process, or fuel consumption in transport.

NOTE 2 To be representative, primary 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 data associated with this refrigeration (e.g. quantity of energy consumed, 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 release.

*NOTE 3 Emissions from livestock, their manure and soils are treated as secondary data (see **7.5**).*

7.4 Secondary data

Secondary data shall be used where primary data is not available. Secondary data shall be selected from the following hierarchy of sources:

1. GHG emissions calculated in accordance with this PAS;
2. emission factors reported in the ELCD;
3. emission factors reported in ELCD-compliant databases;
4. emission factors reported in national (Government-produced) publications;
5. emission factors reported in published national and international industry guidelines;
6. emission factors reported in peer-review research.

7.5 Non-carbon dioxide emissions data for livestock and soils

Non-CO_2 GHG emissions from livestock, their manure or soils, shall be calculated using approaches approved for use within the IPCC Guidelines for National Greenhouse Gas Inventories. Estimation of the GHG emissions arising from livestock, their manure or soils shall use the most accurate approach available, which shall be one of:

- the highest tier approach set out in the latest IPCC Guidelines; or
- the highest tier approach employed by the country in which the emissions were produced.

NOTE Secondary data sources do not routinely include the impact of land use change when assessing the GHG emissions arising from agricultural products.

7.6 Emissions data for fuel, electricity and heat

Fuel and energy data shall include:

- the amount of energy used; and
- the average emission factor of the energy input (e.g. kgCO_2/kg fuel, kgCO_2/MJ electricity or heat) based on the source of energy used.

The emissions associated with fuel and energy consumed in the life cycle of a product shall be determined in accordance with **6.2.2**.

NOTE For electricity, the average emission factor would be based on the annual emission factor for the electricity unless it could be demonstrated that the emission factor should be based on an alternative basis.

7.6.1 Onsite generation of electricity and heat

Where electricity and/or heat are generated and consumed 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.

7.6.2 Offsite generation of electricity and heat

Where electricity and/or heat are not generated onsite, the emission factor used shall be either:

- the emission factor provided by the supplier of the energy input (e.g. for purchases of electricity, the emission factor provided by the electricity supplier; for purchases of heat from CHP, the emission factor calculated in accordance with **8.3.1**); or
- other secondary data source 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).

Where the emission factor is provided by the energy supplier, the supplier shall guarantee the origin of the electricity and/or heat. The emission factor provided by the energy supplier shall be in accordance with **6.2.2.**

NOTE For example, in the UK a "green" or "renewable" electricity tariff is not considered to be a low GHG emissions source of energy unless the supplier of the tariff can provide a guarantee of origin of the renewable electricity, and this guarantee of origin is unique. An appropriate mechanism would be the acquisition of Renewable Energy Guarantee of Origin certificates for each unit of energy sold under a "renewable" tariff.

7.6.3 GHG releases associated with renewable electricity generation

Where renewable electricity generation results in GHG releases within the system boundaries established in this PAS, the renewable electricity shall be allocated an emission factor based on these GHG releases in accordance with **6.2.2** (e.g. where renewable electricity is generated from biomass, the emissions associated with the electricity generation shall include emissions associated with the growing, harvesting, processing, transporting, etc. of the biomass).

7.6.4 Emissions from biomass and biofuels

Releases arising from the use of biomass (e.g. co-firing of biomass, biodiesel, bioethanol) shall reflect the GHG emissions arising from the production of the fuel, and shall exclude the CO_2 emissions arising from the biogenic carbon component of the fuel.

NOTE 1 Where biofuel is produced from waste (e.g. cooking oil after it has been used in a cooking process), the GHG releases 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 palm oil, ethanol produced from corn or sugarcane), the GHG emissions associated with the use of the renewable transport fuel include the emission sources occurring within the boundaries of the life cycle of the biofuel.

7.7 Emissions data for the use phase

The determination of the use phase of products shall be based on a hierarchy of boundary definitions. The order of preference for the basis of the use phase shall be:

1. Product Category Rules (PCRs) that specify a use phase for the product being assessed;
2. published international standards that specify a use phase for the product being assessed;
3. published industry guidelines that specify a use phase for the product being assessed;
4. published national 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 above, 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.

7.8 Disclosure

7.8.1 Use phase analysis

Where use phase emissions for a product are communicated to a third party (e.g. consumers), a full description of the basis on which the use phase was calculated shall be made available.

The basis for the calculation of the use phase shall be made available at or prior to the communication of the use phase emissions to a third party.

7.8.2 Sequestration analysis

Where an assessment of the life cycle GHG emissions of a product that includes an assessment of sequestration is communicated to a third party (e.g. consumers), a full description of the basis on which the sequestration was calculated shall be made available.

The basis for the calculation of sequestration shall be made available at or prior to the communication of the assessment of the life cycle GHG emissions of such a product.

NOTE Disclosure of the basis of the use phase calculation or sequestration 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 sequestration assessment may be made available via a web site.

7.9 Global warming potential (GWP)

The CO_2e emissions included in the GHG emissions associated with products and processes shall be calculated by obtaining values for the following quantities:

- type of emissions (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6);
- mass of gas emitted per functional unit;
- the GWP of the gas (in accordance with **Annex A**) to allow conversion from kg gas to kg CO_2e.

All GHG emissions shall be measured by mass and shall be converted into CO_2e emissions using 100-year global warming potential (GWP) coefficients in accordance with **Annex A**. The mass of emissions shall be multiplied by the GWP coefficient before being added.

NOTE 1 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.

NOTE 2 Due to the uncertainty surrounding radiative forcing for aircraft emissions, a radiative forcing factor does not need to be applied to the GWP of emissions arising from aircraft.

7.10 Variable supply chain

Where an input or product is identifiable by source or time period (e.g. season), the assessment of GHG emissions shall reflect the inputs to the life cycle of the product that are specific to the source or time period. Where an input or product is not identifiable by source or time period, the assessment of GHG emissions shall reflect the weighted average emissions of inputs to the life cycle of the product.

NOTE 1 The intention is to deliver an assessment of GHG emissions that is relevant to the product being assessed. For example:

1. *Where a computer assembler uses memory components from different manufacturers, the assessment of GHG emissions of the computer could be based on the average GHG emissions associated with the memory components from the different manufacturers. However, where the memory components are being sold independently, the life cycle of the memory chips would be specific to the manufacturer, and the assessment of GHG emissions would be specific to the different manufacturers.*
2. *Where a carton of orange juice uses oranges sources from different locations, the assessment of GHG emissions of the orange juice could be based on the average GHG emissions associated with the oranges from the different locations. However, where the oranges are sold independently, the life cycle of the oranges would be specific to their location, and the assessment of GHG emissions would be specific to the different manufacturers.*

*NOTE 2 See **7.11** for variable GHG emissions associated with energy.*

7.11 Averaging of energy data

The life cycle GHG emissions of sources of energy, particularly electricity, may vary over time. Where this occurs, data representing the most recent estimate of average annual GHG emissions associated with the energy source shall be used.

7.12 Data sources and record keeping

The sources of data used in the assessment of life cycle GHG emissions of products shall be recorded by the organization carrying out the assessment.

7.13 Validity of analysis

Results obtained from the implementation of this PAS shall be valid for a period of two years, unless there is a material change in the life cycle of the product whose GHG emissions are being assessed.

Results obtained by implementing this PAS shall be valid throughout the temporal period (see **7.10**) for which the assessment of GHG emissions was performed.

NOTE The length of time that an analysis is valid will vary depending on the characteristics of the life cycle of the product.

8 Allocation and implementation

8.1 Allocation of emissions from co-products

Unless specified elsewhere in this PAS, where a process results in co-products, the GHG emissions up to that point in the life cycle, together with the emissions associated with that process, shall be allocated between co-products in proportion to the economic value of the co-products (i.e. economic allocation).

8.2 Allocation of emissions from waste

Where waste results in GHG releases (e.g. organic matter disposed of in a landfill), allocation of emissions from the waste shall be treated as follows:

8.2.1 Carbon dioxide emissions from waste

No GHG emissions shall be incurred where CO_2 arises from the biogenic carbon fraction of the waste;

Where CO_2 arises from the fossil carbon fraction of the waste, the GHG emissions incurred shall be allocated to the life cycle of the product that gave rise to the waste.

8.2.2 Non-carbon dioxide emissions from waste

Releases of GHGs, other than CO_2 arising from the biogenic and fossil carbon fraction of the waste, shall be allocated to the life cycle of the product that gave rise to the waste.

8.2.3 Combustion of methane emissions from waste

Where methane from waste is combusted to generate useful energy:

1. No GHG emissions shall be incurred where the methane being combusted is derived from the biogenic component of the waste;

2. GHG emissions shall be allocated to the useful energy produced where the methane being combusted is derived from the fossil component of the waste.

*NOTE See **8.3.1** for the allocation of emissions from CHP.*

Where methane is combusted without the generation of useful energy (i.e. flaring):

1. No GHG emissions shall be incurred where the methane being combusted is derived from the biogenic component of the waste;

2. GHG emissions shall be allocated to the life cycle of the product that gave rise to the waste when the methane being combusted is derived from the fossil component of the waste.

8.3 Allocation of emissions from energy

8.3.1 Allocation of emissions from CHP

The emissions arising from CHP shall be allocated between heat and electricity in proportion to the amount 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:

- 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;

- 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.

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 emissions 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 heat:electricity characteristics of the CHP system.

8.3.2 Allocation of emissions from renewable energy

The emissions associated with renewable energy shall be allocated to a process only where it can be demonstrated that the process:

- consumed the energy; or

- consumed an equivalent amount of energy of the same type to that generated (i.e. an equivalent amount of electricity to that generated, or an equivalent amount of heat to that generated), and it can be demonstrated that another process did not consume the energy generated whilst claiming it as renewable.

8.3.3 Demonstrating that renewable energy was used

Process shall claim the use of renewable energy only where it can demonstrate that the renewable energy was not consumed by another process, by either:

- using renewable energy in a process that is not connected to a larger energy transmission network; or

- where a certification system is in operation that provides a guarantee of origin of the renewable electricity, having sufficient guarantee of origin certificates to equal the amount of renewable energy claimed to have been used.

Demonstrating the renewable origin of energy shall be carried out independently of other verification schemes, and shall not take into account government policies such as national targets or mechanisms for subsidy allocation.

NOTE The European Union Directive on the Promotion of Electricity from Renewable Energy Sources in the Internal Electricity Market (Directive 2001/77/EC Article 5) requires that a guarantee of origin be issued by Member States for complying renewable electricity; this has been implemented in the UK through the Renewable Energy Guarantee of Origin (REGO).

8.4 Allocation of emissions from transport

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

- where mass is the limiting factor for the transport system: the relative mass of the different products being transported; or

- where volume is the limiting factor for the transport system: the relative volume of the different products being transported.

Transport emissions shall include the releases associated with the return journey of a vehicle where the vehicle does not transport products on its return.

8.5 Allocation of emissions from recycling and reuse

The emissions associated with recycling and reuse shall be allocated to the life cycle of the product using the recycled material or product as an input, and not to the life cycle that led to the creation of the material or product to be recycled.

NOTE The recycling or reuse rate (i.e. the proportion of the material that is recycled or reused) can be taken from national statistics on recycling rates.

9 Calculation of the GHG emissions of products

The following method shall be used to calculate the GHG emissions for a functional unit:

1. Primary activity data and secondary data shall be converted to GHG emissions by multiplying the activity data by the emission factor for the activity. This shall be recorded as GHG emissions per functional unit of product.

2. GHG emissions data shall be converted into CO_2e emissions by multiplying the individual GHG emissions figures by the relevant GWP.

3. Any carbon sequestered as part of the life cycle of the product in accordance with **5.4** shall be expressed as CO_2e and deducted from the total calculated at step 2 above.

4. The results shall be added together to obtain GHG emissions in terms of CO_2e emissions per functional unit. When the result is calculated, the result shall be:

   - for business to customer transactions: the complete product life cycle GHG emissions arising from the product (including the use phase), and separately the use phase GHG emissions arising from the product; or

   - for business to business transactions: the GHG emissions occurring up to that point where the business to business transaction occurred.

5. The GHG emissions shall then be scaled to account for the minor raw materials or activities that were excluded from the analysis by dividing the estimated emissions by the proportion of emissions calculated for the anticipated life cycle GHG emissions.

10 Claims of conformity

10.1 General

Claims of conformance with this PAS shall be made in the principal documentation or on the packaging, provided for the product or service for which the claim is being made, in accordance with BS EN ISO/IEC 17050 and in the form relevant to that particular claim as provided for in **10.3**. This statement shall include unambiguous identification of the organization claiming conformance.

NOTE In accordance with the relevant definitions given in BS EN ISO/IEC 17000, the term "certified" is used in this PAS to describe the issuing of an attestation document by an independent third party certification body. The term "declared", appropriately qualified, is used to identify the other options accepted in this PAS.

10.2 Scope of claim

In making a claim of conformance with this PAS, the organization shall address all of the provisions of the PAS.

10.3 Basis of claim

10.3.1 General

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

1. certification in accordance with **10.3.2**;

2. other party validation in accordance with **10.3.3**; or

3. self-validation in accordance with **10.3.4**.

*NOTE Attention is drawn to the fact that claims of conformity used to support communication of results calculated under this PAS to third parties, made in accordance with **10.3.2,** are most likely to gain customers' confidence.*

10.3.2 Certification

An organization seeking to demonstrate that their calculations of GHG emissions have been independently validated as being in accordance with this PAS, shall undergo assessment by an independent third party certification body that is able to demonstrate its compliance with BS EN ISO/IEC 17021 and which has certification to this PAS within its scope.

NOTE Organizations preparing such a claim should be aware that potential customers are likely to have the greatest confidence in claims certified by bodies accredited to BS EN ISO/IEC 17021.

10.3.3 Other-party validation

Organizations using an alternative method of validation involving parties other than those qualifying as independent third parties, shall satisfy themselves that any such scheme has been structured to conform to the relevant sections of BS EN ISO/IEC 17021, and that it provides for external validation.

NOTE Unless legislation requires otherwise, organizations may seek an alternative validation method that will engender a good level of confidence in customers without incurring the cost of certification. Various arrangements exist or can be envisaged within which bodies other than independent third party certification bodies could assess and declare conformity to this PAS.

10.3.4 Self-validation

In undertaking self-validation, organizations shall be able to demonstrate how they made the calculations and make available supporting documentation to any interested party. The appropriate method for self-validation and for presentation of the results shall be through the application of BS EN ISO/IEC 17050.

NOTE 1 Organizations, for whom neither certification nor other party validation is a realistic option, may rely on self-validation, but in so doing they should be aware that external validation could be required in the event of challenge and that potential customers could have less confidence in this option.

NOTE 2 Attention is drawn to the fact that customers may well have strong preference for demonstration of independent third party certification.

10.4 Identification of the basis of a claim

All claims of conformity with this PAS shall include identification of the basis of the claim, using the appropriate form of disclosure, as follows:

1. For claims of conformity based on certification in accordance with **10.3.2**:

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

2. For claims of conformity based on other party assessment in accordance with **10.3.3**:

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

3. For claims of conformity based on self-assessment in accordance with **10.3.4**:

   "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 A.1 Global warming potentials of GHGs

Comparison of 100-Year GWP Estimates from the IPCC's Third Assessment Report

GHG	2007 IPCC GWP
Carbon Dioxide	1
Methane	25
Nitrous Oxide	298
Hydrofluorocarbons (HFCs)	See Note.
Perfluorocarbons (PFCs)	See Note.
Sulfur Hexafluoride (SF_6)	22,800

NOTE Hydrofluorocarbons and perfluorocarbons are generic descriptions that include a large number of variant compounds. All variants specified in IPCC 2007 are included in the scope of the GHG emissions covered by this PAS.

Annex B (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 B.1** (**Office of the Renewable Fuels Agency 2008**).

*NOTE See **5.6.1** for determining the GHG emissions associated with land use change where there is limited knowledge regarding the location or type of land use change.*

Table B.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
Indonesia	Annual cropland	Forest land	33
		Grassland	19.5

Country	**Current land use**	**Previous land use**	**GHG emissions (t CO_2e / ha/yr)**
	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 C (informative)
Mass balance and activity-based assessment

C.1 General

NOTE Any product that requires an external energy source may have some GHG emissions attributed to it. For example, a field of crops which has been treated with fertilizer should be attributed with GHG emissions based on the GHG intensity of the fertilizers used, and any direct GHG emissions arising from the application of the fertilizer (e.g. nitrogen emissions from fertiliser). Similarly, for services, emissions from different components of the service need to be attributed to the service. For example, where towels are provided as part of accommodation at a hotel, the emissions associated with the laundering of the towels would be attributed to the provision of the service (the hotel room).

C.2 Calculating the mass balance for goods

The calculation of the mass balance accounts for all mass in a process, including inputs, outputs and waste (for example see **Figure C.1**).

To construct the mass balance, the mass flow of all major input and output streams per accounting unit (e.g. kg sand / kg glass produced) should be used to enable emissions at each step to be assessed on a comparable basis.

All process steps which have more than one input or output would have a mass balance step constructed. Each mass balance step is considered to have its own system boundary.

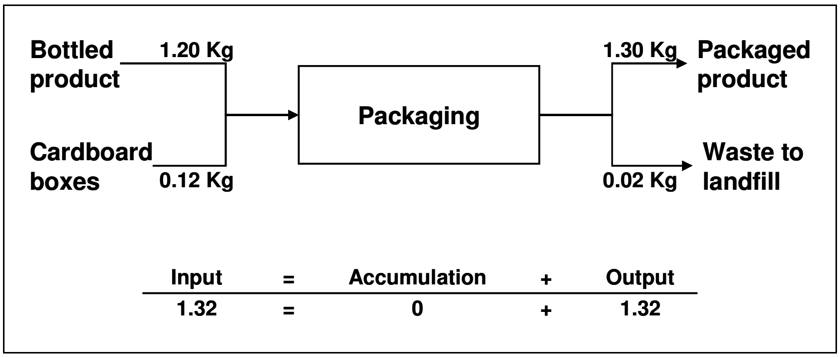
NOTE The mass balance tracks the flows of materials through the processes required to produce one functional unit.

*<MARGIN>COMMENTARY ON **C.2***

Once inside the system boundary, mass cannot be created or destroyed. In terms of mass: input = accumulation + output.

The mass balance step is repeated for the entire process map, so that the mass of each ultimate raw material is known per functional unit, and the mass of waste and/or by-product produced at each process step per functional unit is known.

Figure C.1 –Mass balance step



C.3 Calculating the activity-based assessment for services

The calculation of the activity-based assessment accounts for all activities that combine to deliver a service.

To construct the activity-based assessment, the contribution of all material activities per service unit should be recorded to enable emissions at each step to be assessed on a comparable basis.

*<MARGIN>COMMENTARY ON **C.3***

The activity-based assessment tracks the flow of activities through the processes required to produce one final service unit.

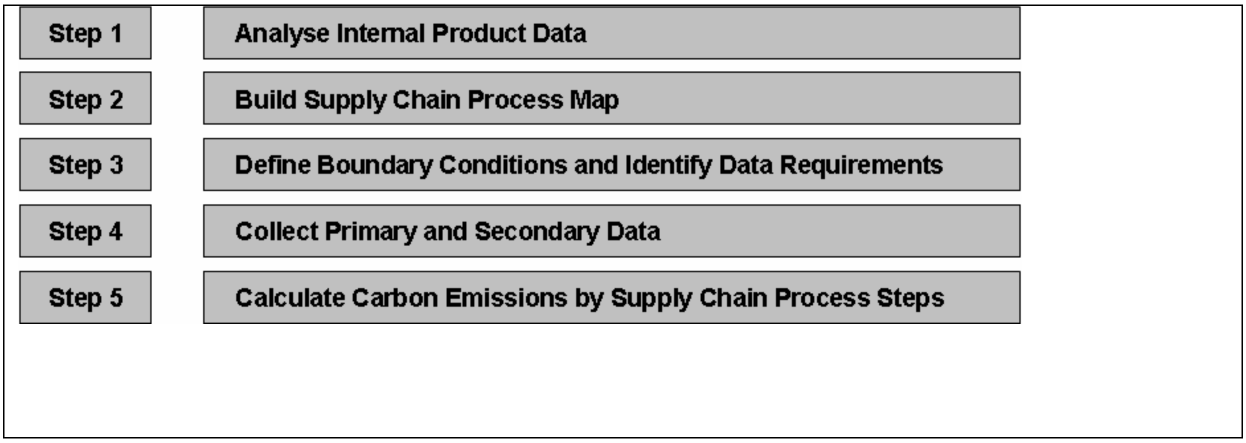
Activities that contribute to the provision of a service may themselves include the emissions associated with the provision of products.

Annex D (informative)
Example of method implementation

D.1 Structuring and process

It may be useful to consider the implementation of this PAS as a five-step process (see **Figure D.1**), where the steps would be completed in order (although some overlap is possible). Each step comprises several activities and builds on the previous step(s).

Figure D.1 – Method overview



D.2 Analyse internal product data

*<MARGIN>COMMENTARY ON **D.2***

The objective of this step is to develop deeper understanding of the product including raw materials required, production activities needed for converting the raw materials into the finished product, waste and co-products produced, and the storage and transportation required between each process step.

This requires input from internal sources to gain a preliminary overview of the product life cycle. Suitable internal sources for this may include the product technologist, production manager and head of logistics and distribution.

Internal data collection should start by obtaining a breakdown of the product by mass according to its constituent parts (e.g. ingredients, product specification, bill of materials). The constituent parts, along with individual packaging format, material and mass allows an initial prioritization of effort so that the most significant raw materials are analysed first.

Other key data points which are required to construct the process map and are often available internally include:

- details of manufacturing processes carried out internally;
- storage conditions at each stage in the product life cycle;
- transport of the final product.

For the raw material stage in the life cycle of the product there is often less internal data available. There is limited information on the manufacturing process steps needed to produce the raw materials and the distribution of raw materials to the manufacturing sites. However, raw material buyers may be able to provide enough detail for the purposes of drawing the process map and they should also be able to provide contacts at the raw material suppliers who should be consulted for further process information. It may also be necessary to consult these suppliers when data is being gathered to calculate the GHG emissions for the process or material.

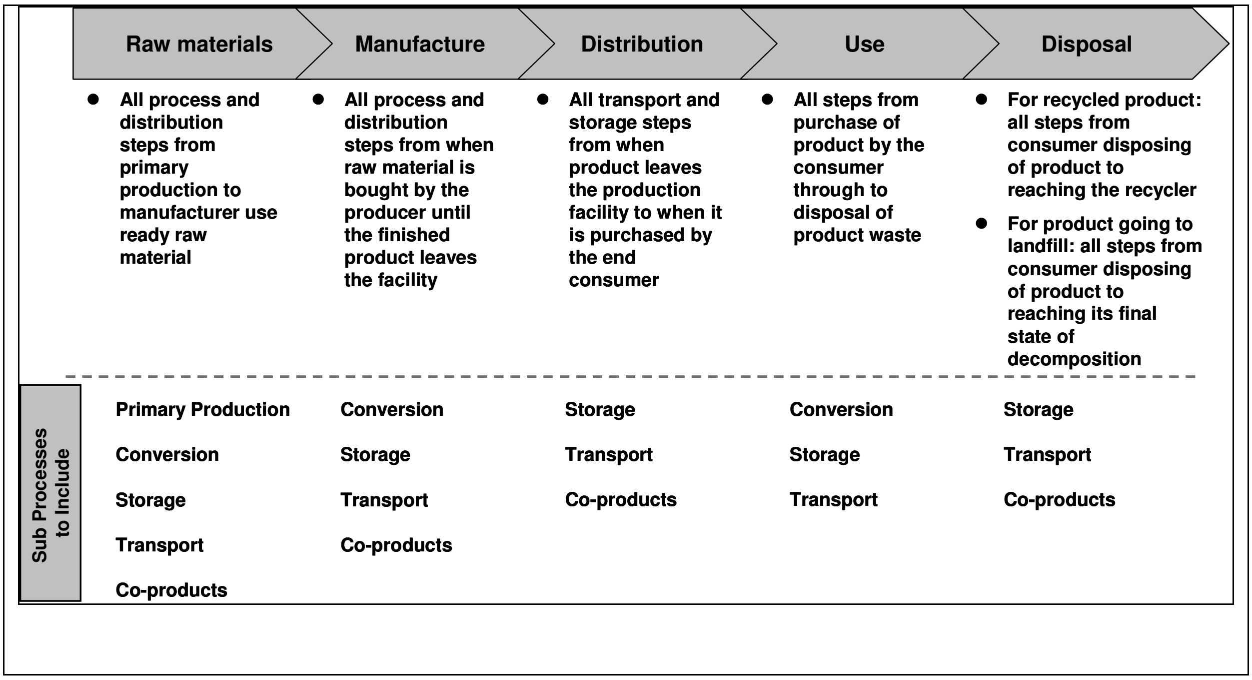
D.3 Build the life cycle process map

*<MARGIN>COMMENTARY ON **D.3***

The objective of this step is to define the product life cycle which will identify all inputs, outputs and unit processes that will be analysed as well as forming the basis for data collection and for mass balance calculation.

The simplified life cycle process map may cover the steps shown in **Figure D.2**.

Figure D.2 – Steps in the life cycle process map



The process map should include every significant process step and raw material. Each raw material might be a finished product from another life cycle, e.g. sugar is an input for making chocolate, but sugar is a finished product which has been manufactured from sugar cane. Therefore, in order to ensure that every relevant process step is included, each raw material process needs to be detailed back until it is possible to identify primary raw materials which have zero associated GHG emissions.

*<MARGIN>COMMENTARY ON **D.3***

When constructing the process map it is important to use a structured approach which helps to avoid missing important process steps and working both forwards and backwards from the final functional unit is a good way to avoid missing any steps.

As an additional method of including all relevant steps, it is helpful to work through each possible sub-process within each supply chain area:

- **primary production** – the initial production of raw materials, e.g. farming or mining (primary production can only take place at the raw materials step);
- **conversion** – the conversion of materials from one product to another (can be applicable in the pre-processing of raw materials, in manufacturing, or in use);
- **storage** – the storage of raw materials, semi-processed materials, finished product or waste at any stage in the supply chain;

- **transport** – the transportation of raw materials, semi-processed materials, finished product or waste at any stage in the product life cycle;

- **disposal** – the disposal of waste products from primary production, conversion or after use (such as decomposition in a landfill site).

Each sub-step may be repeated several times within a supply chain step, in any order, and it is important to take multi-step processes into account. This repetition of steps is particularly likely in the distribution stage, e.g.: transport to retail distribution centre → storage at retail distribution centre → transport to wholesaler → storage at wholesaler → transport to retailer.

This stepwise approach to mapping the supply chain is repeated until all inputs have been traced back to their ultimate source and all outputs have been tracked until they have stopped attributing GHG emissions to the final functional unit.

D.4 Define boundary conditions and identify data requirements

*<MARGIN>COMMENTARY ON **D.4***

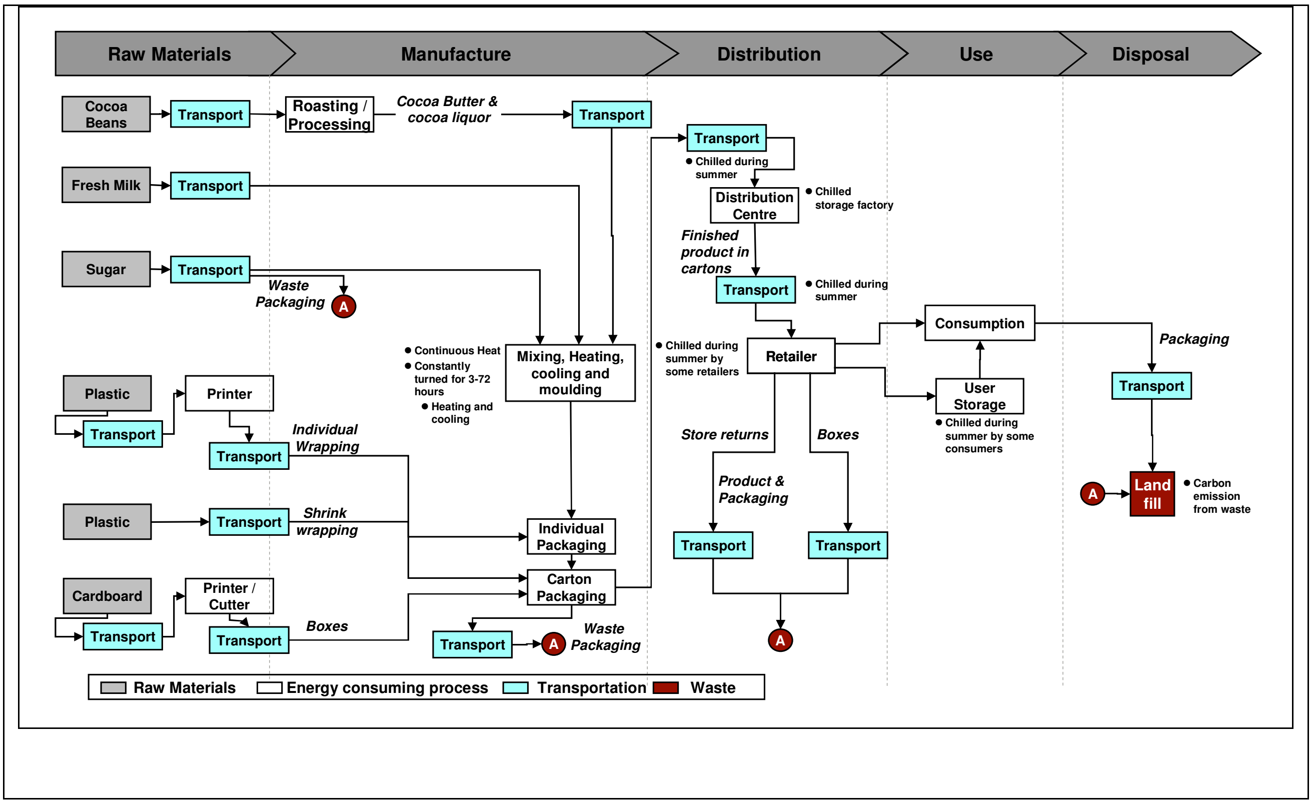
The objectives of this step are to identify and define the boundary conditions which should be followed for the product, to identify the data required for building the product mass balance and CO_2e calculation, and to identify the potential sources for each of the required data points.

To assist in identifying boundary conditions, both for the entire product life-cycle and for sub-systems that form part of the life-cycle of the product, process maps may be developed. These maps assist understanding of the product, its life cycle, and most importantly the supply chain structure and resulting sources of GHG emissions.

D.4.1 Supply chain process map

Process mapping is an iterative process which should be done with the input of all key stakeholders. The process map is a very useful document for explaining the background behind the project to buyers, technologists, marketing departments, etc. as it improves understanding of how each department fits within the supply chain and how each input contributes to the overall GHG emissions rather than be used in isolation. It takes the overall understanding of the process (see **Figure D.2**) and adds details of the flows of product (and waste and co-products) (see **Figure D.3**).

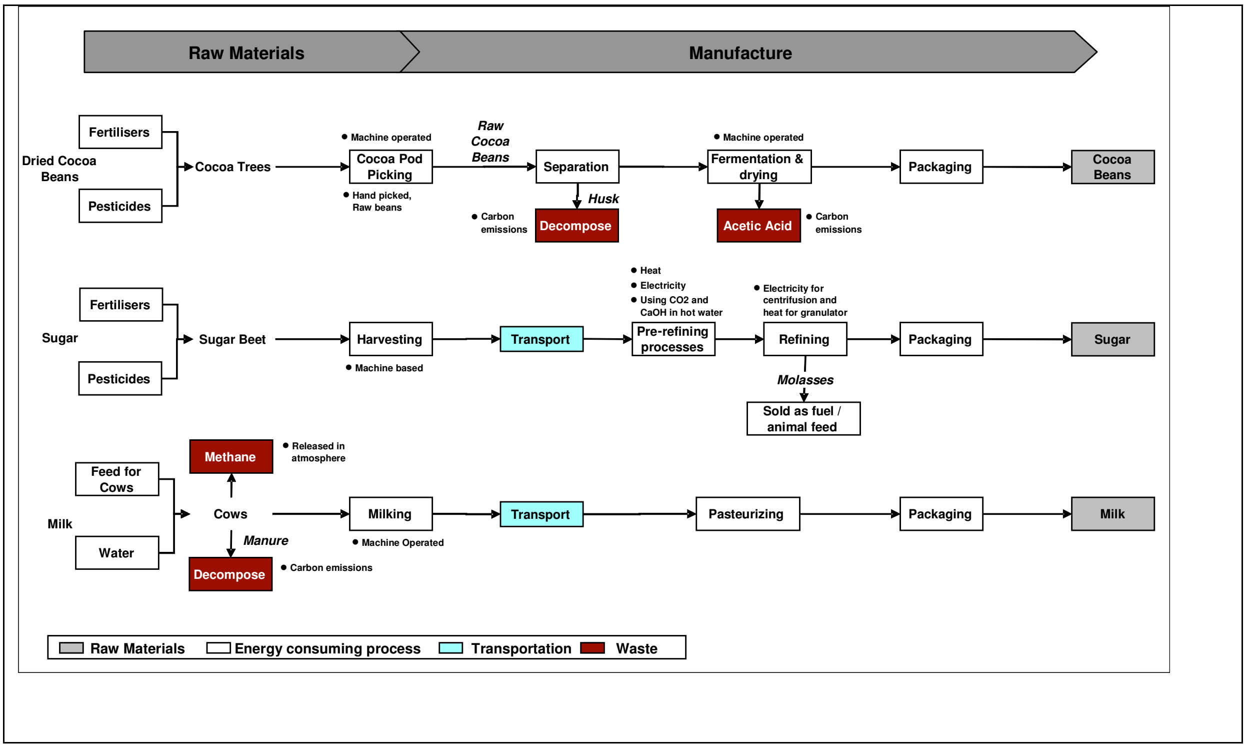
Figure D.3 – Example of part of a process map



D.4.2 Raw materials process map

To provide a full and complete process map, each raw material can be described by its own process map that characterizes the required steps from 'ultimate raw materials' to the raw materials depicted in **Figure D.4**.

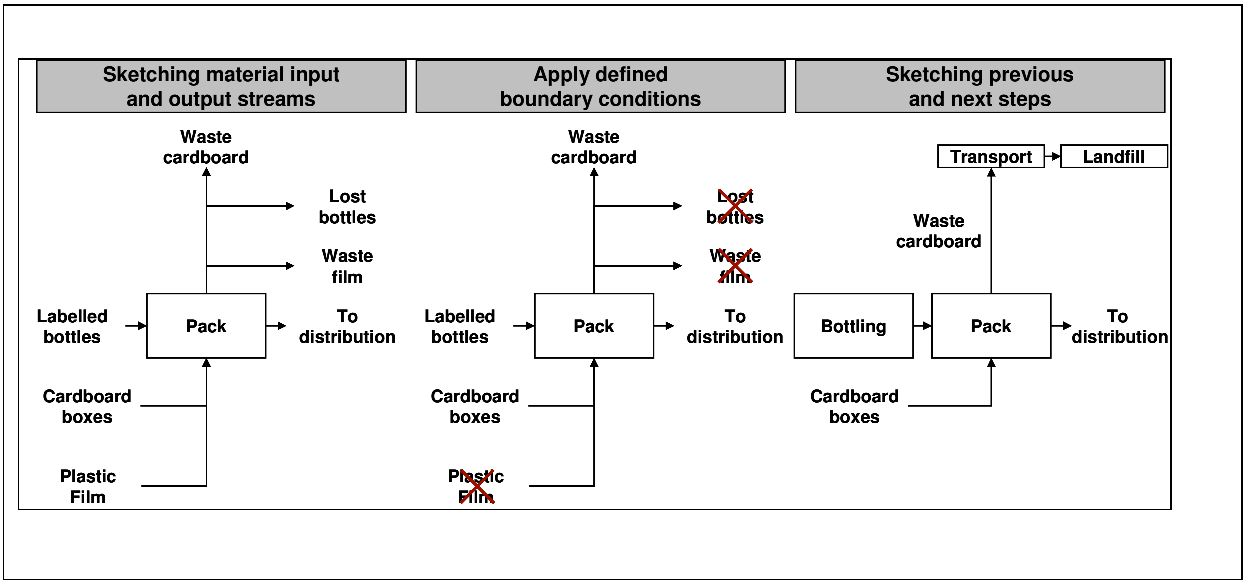
Figure D.4 – Example of a raw material process map



D.4.3 Stepwise process map

In order to apply boundaries to inputs, outputs and processes, all material input and output streams for the process first should be sketched (see **Figure D.5**). At this point, some input and output streams can be eliminated because they are a very small proportion of the final product mass. When working backwards from the final functional unit in the supply chain, the next previous process step is mapped for all inputs. Process steps for co-products and waste may also need to be mapped.

Figure D.5 – Constructing a stepwise process map



D.5 Collect primary and secondary data

The objective of this step is to collect the data required to develop the mass balance and calculate the GHG emissions from each process step.

D.5.1 Approach for initial data collection

Primary data sources are generally preferable to secondary data sources, if energy requirements/GHG emissions can be measured accurately, because primary data will reflect the specific nature/efficiency of the process (see Clause **7**). This also more accurately reflects the relevant GHG emissions at the manufacturer of the product in question. Increased use of primary data also leads to an increased identification of potential for GHG emissions reductions.

D.5.2 Collecting primary data

Primary data can be collected internally by the company or by a third party advisor. In both instances it is useful to introduce the project to supply chain contacts in the organization itself and to any raw material suppliers before contacting them to request data. Once an introduction has taken place, a clear data request should be made outlining the exact information that is required, and the format in which it is needed, to ensure that the contact is well informed about the type of data requested. In the longer term, raw material suppliers can use this methodology to determine the GHG emissions of their products, and therefore provide the company with all upstream information. This allows the raw material suppliers to compete in terms of GHG intensity.

When collecting primary data, top down energy and production data at a plant level can be used if the specific process being analysed can be isolated (e.g. the plant manufactures only one type of product and therefore all products have the same energy requirements).

Otherwise, it may be possible to obtain bottom up estimates for energy requirements/GHG emissions in cases where individual pieces of equipment can be monitored/metered for a set period of time. This method may be appropriate, but care should be taken that the result will be representative of an 'average functional unit' (e.g. the energy requirements of a refrigeration unit in August will not be representative of an annual average energy requirement). If individual processes are being metered, it is important that every relevant process in the factory is taken into account in the bottom up calculations (e.g. sanitization of manufacturing vessels).

D.5.3 Collecting secondary data

In order to retain accuracy, it is important that where secondary data is used, it is as specific as possible to the relevant process step. Commercially available LCA databases may offer a reliable source of secondary data, alongside other data sources such as emissions constants.

It is equally important to research the exclusions and limitations that secondary data may have, by contacting the research body, or referring back to the original source of the data when it is quoted elsewhere. This is particularly important when life cycle assessment for a given raw material is being used as part of the calculation. Triangulation of the data point should be done where possible to ensure accuracy and to give a feel for the uncertainty regarding a given calculation.

Note also that there are some key pieces of secondary data, such as emissions factors for fossil fuels, GWPs of GHGs, and the emissions factor for the UK grid mix that are:

- very important to consistency across different products and companies; and
- very difficult for an individual company or consultant to establish.[1]

D.6 Calculate the GHG emissions by supply chain process steps

*<MARGIN>COMMENTARY ON **D.6***

The objective of this step is to develop a model to calculate the mass balance and the GHG emission from each process activity step.

D.6.1 Calculating the mass balance

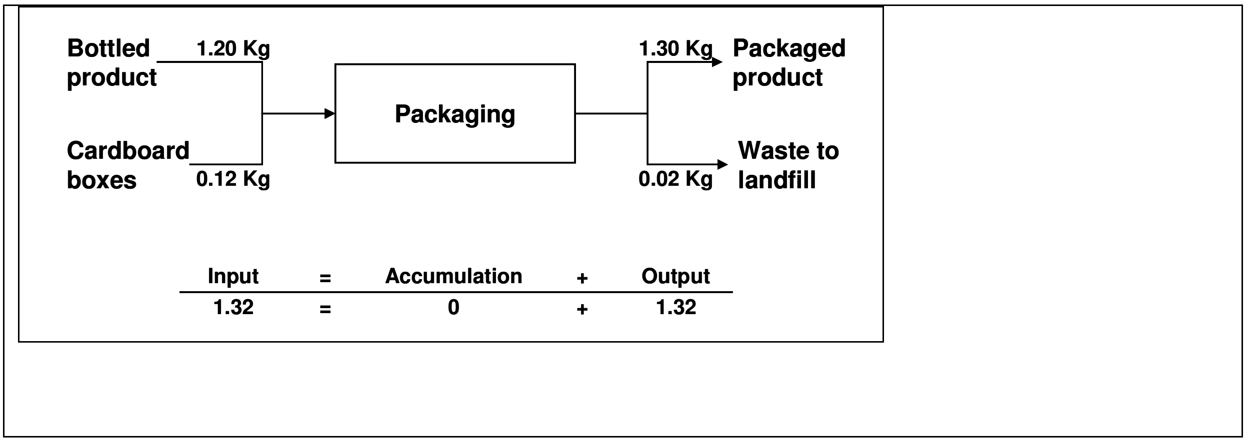
Once the process map is complete and data have been captured for every process step included in the process map, a mass balance should be constructed which will track the flows of materials through the process map required to produce one final functional unit. In a similar manner to constructing the process map, the mass balance is best completed in a structured stepwise manner working outwards from the final functional unit. All process steps

[1] *The future methodology may include a list of sources for these key pieces of data, and a process to update them as required.*

which have more than one input or output should have a mass balance step constructed. It is important to include small waste streams as many small losses across the supply chain may have a significant cumulative effect once aggregated.

Each mass balance step should be considered as having its own system boundary. Once inside the system boundary, mass cannot be created or destroyed. In terms of mass: Input = Accumulation + Output (see **Figure D.6**).

Figure D.6 – Mass balance step



Once the mass balance stepwise methodology is repeated for the entire process map, the mass of each ultimate raw material is known per functional unit, and the mass of waste and/or by-product produced at each process step per functional unit is known.

D.6.2 Calculating GHG Emissions

The methodology for calculating CO_2e emissions for a functional unit is as follows:

1. Energy data obtained through primary or secondary data is often collected in the form of (or can be manipulated into) MJ per kg of product produced. Data on direct GHG emissions should be collected in the form of kg gas per kg product produced.

2. Using emissions factors for the energy source used, or the type of direct gas being emitted, the data can be converted into CO_2e emissions per kg of product produced.

3. The mass balance results at the relevant process step can then be used to calculate CO_2 emissions per functional unit for each process step. This will include allocation or substitution to account for co-products.

4. The CO_2 emissions can then be scaled to account for the minor raw materials that were excluded from the analysis. To estimate the emission for the minor raw materials use the average emission from the other raw materials and adjust it for mass. Note that this step will not be required if minor raw materials are excluded on the basis of emissions, rather than mass.

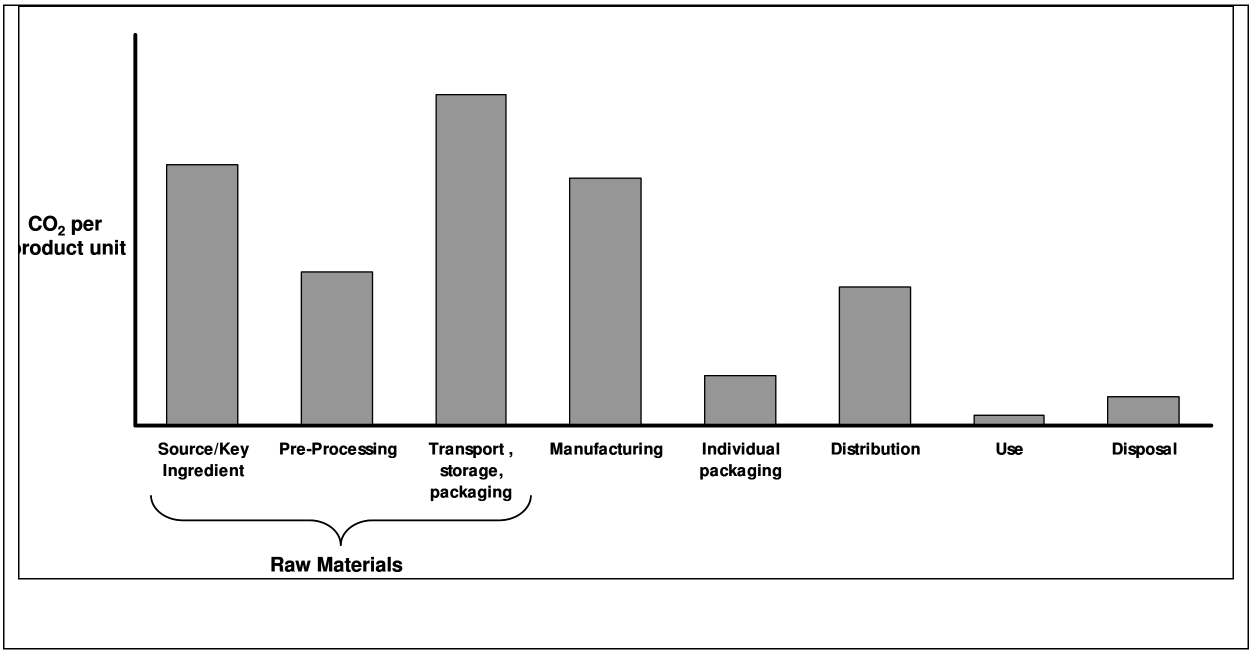
5. After the CO_2e emissions have been calculated for each individual process step, the results can be added together to obtain an overall GHG emissions in terms of CO_2e emissions per functional unit for the entire product supply chain.

Annex E (informative)
Using the life cycle GHG emissions results

E.1 Approach for analysing output

Output can be analysed on a process step basis as the data permits. It may also be useful to gain an overall perspective on how different parts of the life cycle contribute to the total GHG emissions of the product, and therefore help focus attention on key aspects of the life cycle from a GHG-emissions perspective (see **Figure E.1**). Groups of process steps need not be constrained to raw materials, manufacturing, distribution, use and disposal but may take the form of groupings which may be easier to identify with.

Figure E.1 – Distribution of life cycle GHG emissions for a food product



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