PAS 600:2013

BSI Standards Publication

Bio-based products –
Guide to standards and claims

bsi.

...making excellence a habit.™

Publishing and copyright information

Published by BSI Standards Limited 2013

ISBN 978 0 580 78758 4

ICS 13.020.60, 71.100.99

Publication history

First published October 2013

Amendments issued since publication

Date	Text affected

Contents

Summary of pages
This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 48, an inside back cover and a back cover.

Foreword

This PAS was sponsored by the UK Department for Business, Innovation & Skills (BIS). Its development was facilitated by BSI Standards Limited and published under licence from The British Standards Institution. It came into effect on 31 October 2013.

Acknowledgement is given to the following organizations that were involved in the development of this PAS as members of the steering group:

- Adapt Low Carbon Group, University of East Anglia
- Biocomposite Centre, Bangor University
- British Adhesives and Sealants Association
- British Plastics Federation
- EcoTechnilin
- Industry Council for Research on Packaging and the Environment
- National Non-Food Crops Centre
- Solvents Industry Association
- United Kingdom Lubricants Association
- Vegware

Acknowledgement is also given to the technical author, Aliya Serazetdinova of the Adapt Low Carbon Group at the University of East Anglia, and to the members of a wider review panel, who were consulted in the development of this PAS.

Information about this document

The British Standards Institution retains ownership and copyright of this PAS. BSI Standards Limited reserves the right to withdraw or amend this PAS on receipt of authoritative advice that it is appropriate to do so. This PAS will be reviewed at intervals not exceeding two years, and any amendments arising from the review will be published as an amended PAS and publicized in *Update Standards*.

Use of this document

As a guide, this PAS takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Any 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 a PAS cannot confer immunity from legal obligations.

0 Introduction

0.1 General

Bio-based products are products which are wholly or partly derived from biomass and include intermediates, materials and semi-finished or final products. They range from high-value added fine chemicals, such as pharmaceuticals, cosmetics and food additives, to high volume materials such as bio-polymers or chemical feedstocks.

Examples of bio-based products include:

- amino acids;
- chemical and pharmaceutical building blocks;
- composite materials based on natural fibres;
- cosmetics;
- enzymes;
- lubricants;
- organic acids;
- paints;
- plastics and polymers;
- solvents;
- surfactants; and
- textiles made from natural fibres.

Bio-based products have a shorter carbon cycle compared to products made from fossil-based resources (Figure 1). Carbon captured in biomass can be replenished within a relatively short period of time, for example, with plant oils or timber this period ranges from a few years to a few decades. Carbon dioxide emitted during the manufacture, use and disposal of bio-based products can be used by plants, as part of photosynthesis, and converted into new biomass.

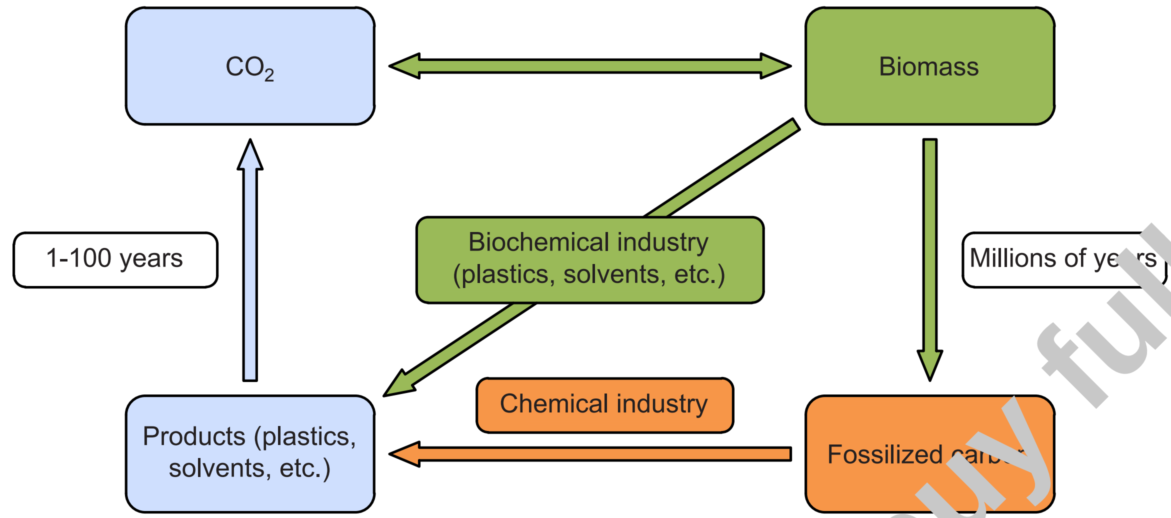
Carbon locked in petroleum originates from fossilized organic materials, such as zooplankton and algae that undergo anaerobic decomposition accompanied by high levels of heat and pressure causing the organic matter to alter chemically and form liquid and gaseous hydrocarbons. The age of the organisms and their resulting fossil fuels is typically millions of years, and sometimes exceeds 650 million years [1]. Therefore the rate of carbon dioxide fixation is much slower than the rate at which carbon dioxide is released from fossil-based materials. Bio-based products are themselves "carbon sinks" (i.e. they can lock away carbon). Biomass, such as plants or algae, capture CO_2 from the atmosphere to produce carbohydrates and other compounds that are used for the production of bio-based products. For some products that are degradable and have a short life, this carbon sink offers very little, however for products such as durable plastics or construction materials, this can be a substantial sink of carbon.

Use of bio-based products has grown at a steady pace in the last decade. In 2005, they accounted for 7% of global sales and around US$77 billion (£49 billion) in value within the chemicals sector, with the EU industry accounting for approximately 30% of this value [2].

One estimate is that by 2020 the global market for bio-based products will grow to US$250 billion (£158 billion) and that by 2030, one-third of chemicals and materials will be produced from biological sources, including bio-polymers and bio-plastics [3]. This lies broadly within the range of the estimate of industrial biotechnology market size, which is predicted to be between £150 billion and

£360 billion by 2025, with the UK share of this market being between £4 billion and £12 billion [4].

Figure 1 **Carbon cycle of bio-based and fossil-based products**



NOTE This figure is adapted from Narayan (2001) [5].

Use of bio-based raw materials could enable UK companies to diversify on raw materials and promote an efficient and sustainable use of natural resources. In addition, bio-based products can contribute to companies' corporate and social responsibility programmes, sustainability agendas and aid the development of new consumer markets.

Bio-based products have potentially high societal and economic value due to several factors, the main ones being the use of renewable and scalable resources and the potential to reduce greenhouse gas emissions. Some bio-based products offer improved recovery and recycling options due to biodegradability or compostability. In some cases, bio-based products enable the use of less resource-intensive production methods (e.g. in terms of water and energy use) [6].

0.2 Production of bio-based materials

There are multiple steps in the production of bio-based materials and products (Figure 2 and Figure 3 give an overview of these steps for two bio-based product types), each of them having an impact on the overall environmental performance of a finished product or product system.

For example, numerous parts of plants can be used to produce bio-based products. In the case of plants such as flax, different parts of the plant can be used to make numerous different products. The other example in Figure 3 provides a schematic outline for production of PLA from corn or other plant material. Table 1 summarizes the steps in the production process and how they can affect the environmental impact of the product.

Figure 2 **Production of bio-based materials and products from flax plant**

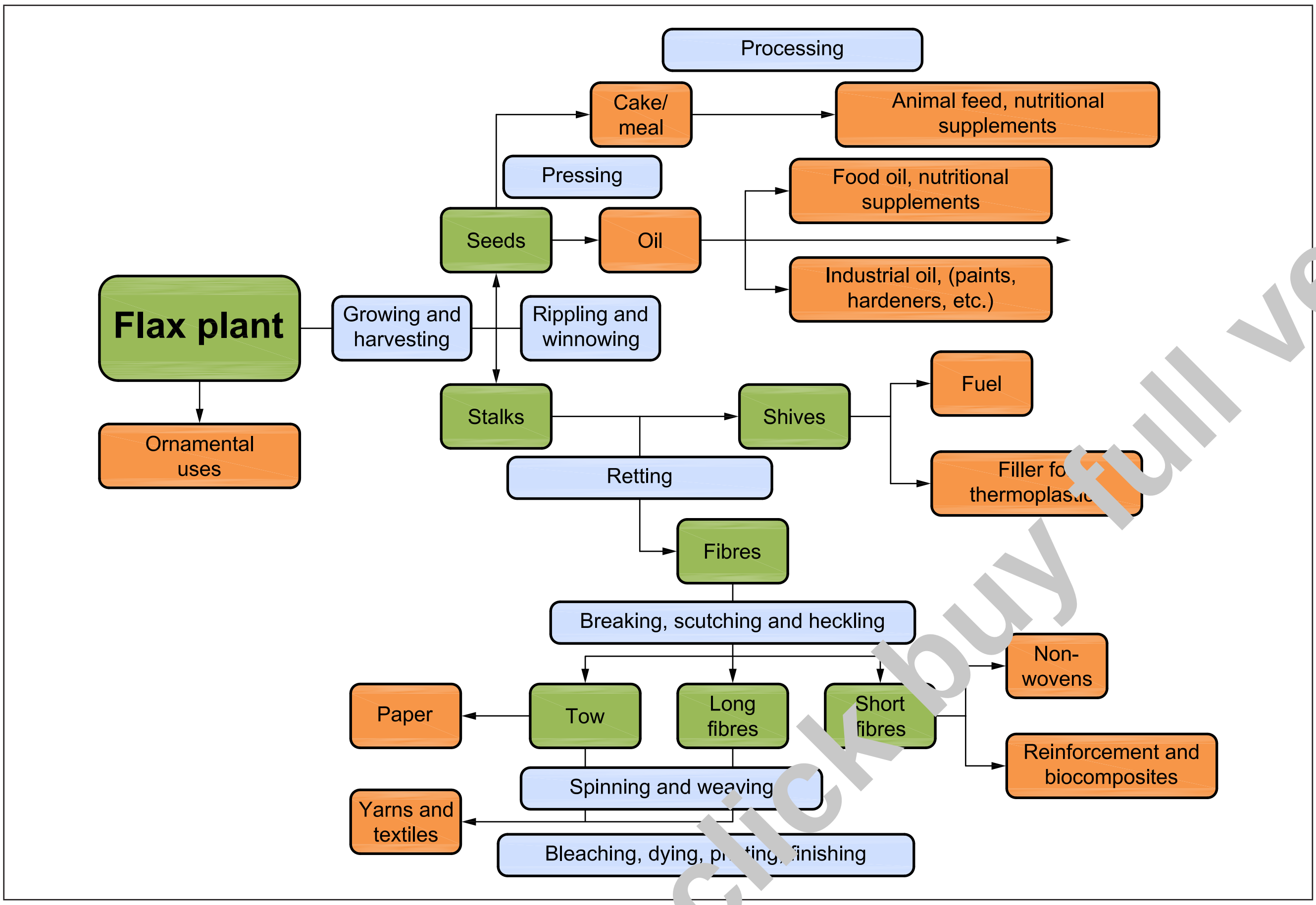


Figure 3 **Production of PLA and PLA-based products from plant material**

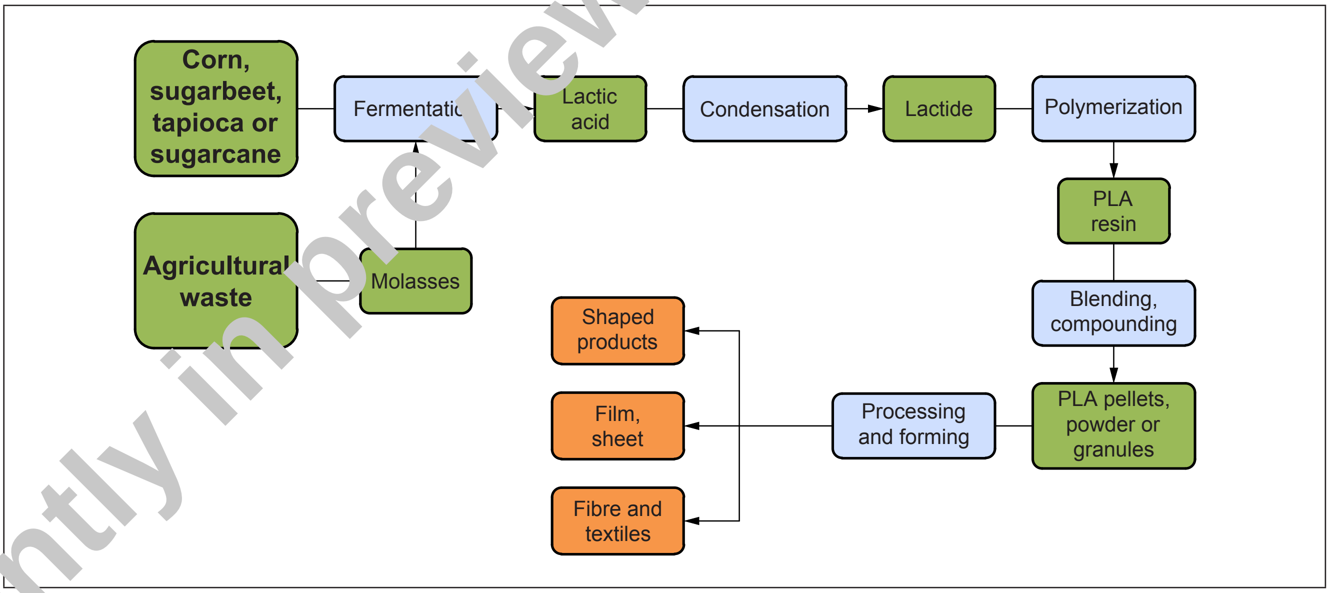


Table 1 **Plant-derived bio-based product production steps and their environmental impacts**

Production stage	What the stage can involve	Environmental impact considerations	Comparison with non-bio-based products
Growth and harvesting	Raw material harvesting and pre-processing	Fertilizer use, harvesting method, transportation	Mining the materials, oil drilling, cracking and refining; transportation
Processing	Processing of plant-derived materials can involve mechanical (e.g. hackling or weaving), chemical and enzymatic breakdown steps	Use of energy, water, chemicals and additives, e.g. solvents	In some cases, processing of non-bio-based products requires more energy and water
Formulation and blending	Physical and chemical properties of bio-based products are modified by the addition of other chemicals or materials, e.g. biocomposites where fibres are blended with plastics	Use of energy, water, chemicals and additives, e.g. plastics. Disposal of waste. Use and disposal of by-products.	Similar to bio-based products
Transportation		Mode of transport distance	Similar to bio-based products
Consumer use	Consumption and care	Water and energy use associated with consumption (i.e. washing or repair)	Similar to bio-based products
	Reuse and remanufacture	Potential waste reduction and materials reuse if products are designed for deconstruction and materials reuse	Similar to bio-based products
Disposal		Recycling, landfilling, compostability, and biodegradability	Recycling or landfilling. Some non-bio-based products are biodegradable and compostable if they conform to the relevant standards
		Generation of renewable energy through incineration	Energy generated through incineration is not renewable

The principle of a biorefinery can underlie the industrial production of bio-based products. Efficient use of biomass requires integration of several value chains that make use of all components of the biomass. Biorefining is similar to petroleum refining and based on the principle of cascading use of biomass, driven by the need to use biomass in the most efficient way. Biomass is refined to separate complex materials into different valuable components, which then undergo further processing. During biorefining renewable feedstocks are converted into a wide range of valuable products such as fuels, building blocks for chemicals, including bio-plastics, bio-lubricants, bio-solvents and bio-surfactants, fine chemicals, including ingredients for pharmaceuticals and enzymes for bioprocessing.

In order to make biorefining economically viable, technologies used to separate and process biomass need to be optimized and work on a large scale, and the whole model needs to be integrated into more complex industrial systems, such as chemical industry, construction or automotive industry. The outputs from a biorefinery are linked to the feedstock used and the processing technology.

When establishing an industrial production of bio-based products, it is important to ensure a consistent supply of feedstock, to evaluate energy and water requirements, as well as to assess the indirect impact of the land use change.

0.3 Drivers

The main factors driving future markets and demand for bio-based products in the UK and EU are:

a) limited availability and increasing cost for fossil-based raw materials;

b) policy developments aimed at mitigation of climate change and supporting sustainable development and economic growth;

c) increasing consumer demand for products with lower environmental impact [6].

Bio-based materials can complement or substitute for a proportion of petroleum and gas-based raw materials, as well as metals and mineral-based materials. Bio-based products can also offer new functionalities and specific innovative properties that can have advantages over other products. For example, in sensitive environments, hydraulic equipment and chainsaws can use biodegradable lubricants that are non-toxic in soil and water (see Annex A, Case Study 1). The main driver for use of bio-lubricants is lower environmental risks associated with unintended disposal in environmentally-sensitive industrial applications, such as in agricultural machinery or machines used in close proximity to water. In packaging, bio-based compostable materials can offer a significant advantage to disposable packaging in conjunction with responsible waste disposal.

Another key advantage of renewable feedstock is its short reproduction cycle, which ranges between several days for algae and several years for trees, compared to the much longer reproduction cycle of fossil feedstock. A proportion of CO_2 emissions released during the manufacturing and consumption of bio-based products can be counterbalanced by the CO_2 captured during the growth of the biomass used for their production.

Policies supporting the mitigation of climate change and energy efficiency (namely EU "20-20-20" targets [7]) support the development of markets for bio-based products, alongside those for renewable energies. The EU "Europe 2020 Strategy" for smart, sustainable and inclusive growth [8] recognizes that tackling the climate and energy challenge contributes to the creation of jobs, the generation of "green" growth and a strengthening of Europe's competitiveness. The UK Government supports the EU 2020 Strategy by encouraging investment in low carbon power, supporting infrastructure development, promoting the development of new markets in green goods and services and capping the costs of policies funded through energy bills. Further details on legislation supporting the development of the market for bio-based products are given in Clause **6**.

Governments can play an important role in developing market for bio-based products. In 2002, the US federal government set up its BioPreferred programme [9] to increase the purchasing of bio-based products. This programme has two major initiatives:

a) certify and award labels to qualifying bio-based products; and

b) designate categories of bio-based products that are afforded preference by federal agencies when making purchase decisions.

In this programme, any bio-based product that can be proven to match its conventional alternative on cost and performance is listed to have preferential consideration in purchasing by federal agencies and their contractors. By 2013, 9000 designated bio-based products in 89 different categories were made available for preferred federal purchasing, and about 3000 of these are currently listed in the BioPreferred catalogue [10]. The US Department of Agriculture (USDA)-certified bio-based products are also listed in the BioPreferred catalogue. However, due to an absence of funding in the Farm Bill extension legislation [11], the USDA has had to suspend the processing of applications for voluntary certification of bio-based products [12]. According to the USDA [13], federal agencies and the US Department of Defence spent approximately US$500 billion (£316 billion) on bio-based products by 2012. The impact of the BioPreferred programme has been to increase awareness about bio-based products that are available and their manufacturers. The USDA BioPreferred programme was the first example of a government procurement programme for bio-based products, which influenced the European strategies in the area of bioeconomy, such as the Lead Market Initiative [14].

On a company level, corporate social responsibility (CSR) programmes can drive the development of environmentally sustainable solutions. Organizations that have a CSR policy have self-regulatory mechanisms integrated into a business model, whereby a business monitors and ensures its active compliance with the law, ethical standards and international norms. Environmental sustainability issues can represent one of the elements of an organization's CSR programme. Under such a programme, an organization ensures its compliance with environmental regulation and acts responsibly on a variety of levels, for example, from purchasing materials and products, to use of energy and water, and disposal of waste, all in an effort to minimize any negative environmental impact of its activities.

In other cases, like for bio-plastics, the adoption of bio-based products is stimulated by the availability of commercial quantities of bio-based resins at prices acceptable to the market, as in case of bio-based polyethylene (PE) and polyethylene terephthalate (PET) becoming commercially available in 2010. Bio-based materials can contribute, in some instances, to raw material security, both in the sense of availability and the affordability. Biomass is a renewable source of industrial raw materials especially in production of chemicals which depends on carbon-based-materials. Fluctuation of crude oil prices and their increase represent a significant threat to industries relying on this resource.

Bio-based products can offer additional or different end-of-life options. For example, some bio-plastics can be organically recycled via composting or anaerobic digestion.

0.4 Barriers

Although there are a number of factors driving the development and commercialization of bio-based products, currently only a small portion of bio-based products are available on the market. A number of factors limit the demand for bio-based products. Bio-based materials generally have higher costs. For example, bio-plastics on average are currently two to four times more expensive than conventional plastics, although some bio-plastics are already cost competitive.

Bio-based materials generally have complex value and production chains starting with agricultural resources, branching out in different intermediates and processing steps, resulting in numerous co-products and final products ranging from fuels to fine chemicals, with an end use in different markets. In order to develop the market for bio-based products, these value chains need to be established, linking raw material producers to manufacturers (chemical and other industries), retailers and end users.

Availability of land and how it is used can be considered as a barrier to adoption of bio-based products on a large scale. This is as a result of a perception that crops used for the manufacture of bio-based product take up land that can be used to grow food and feed. However, figures suggest that, currently, this is not the case. For example, in 2011, bio-plastics required 0.006% of the global agricultural area of 5 billion hectares, compared with the area used to grow crops for food and feed (27%), or biofuels (1%) [15].

According to the Food and Agriculture Organization (FAO) and the Organization for Economic Co-operation and Development (OECD), currently there is enough land to support both bio-plastic, bioenergy and biofuel crops, food crops for a growing population, and use for conservation and biodiversity protection. However, with the growing global economy the demands for bio-based products, bioenergy and biofuels are set to increase. Some estimates predict that by 2050, more than 730 million hectares of land would be required to meet demands for bio-plastics, biofuels and bioenergy, which could test the limits of the amount of land sustainably available for crops [16]. Competition for land is forcing material developers, designers and product manufacturers to use scarce resources, such as land, energy and water, more efficiently by driving innovation (for example, by utilizing crops that can be grown on marginal or degraded land, such as that lignocellulosic crops, algae, as well as using agricultural residues and wastes).

Due to higher costs, fluctuations in prices and, in some cases, due to risks associated with reliability of supply and quality of bio-based raw materials, demand for bio-based products has not been sufficient to achieve economies of scale because producers and users choose cheaper alternatives. In most cases bio-based materials have to compete against petroleum-based materials, which are being manufactured and distributed in well-established value chains.

Like any other products, bio-based products face some technical barriers to achieve the same properties and performance offered by petroleum-based products, for example, some bio-plastics have a low melting temperature or low transparency and some are brittle. In addition, different processing and manufacturing properties of bio-plastics can require adaptations in the manufacturing plant or a complete refit in order to function efficiently. Although this is a barrier, most of the bio-polymer manufacturers adapt their products so that they can be run on traditional moulding/extruding equipment with few setup alterations. Also, a lack of practical knowledge on how to design for, and manufacture with, bio-based materials, which often have different processing and performance characteristics, presents a further barrier. This could be overcome with time as more experience accumulates in handling bio-based products.

The performance and functionalities of bio-based materials are improving. For example, one of the first commercially available bio-plastic materials, PLA, has undergone a significant improvement since it was first developed, which has enabled its use in a wide range of applications. Although the range of available bio-based materials is still limited compared with the range of non-bio-based materials, the bio-based industry is an evolving sector with new materials and products being developed.

Financing large-scale demonstrators that allows an up-scaling of bio-based production and new bio-based product innovations represents a significant problem, especially for SMEs. Funding for research and development (R&D) and product innovation are of particular importance for bio-based materials as this area represents a new field and new technologies and processes need to be developed to address the functionality, feedstock availability, cost and environmental performance of bio-based products.

Potential contamination of plastic recycling streams has posed a significant barrier for wider adoption of bio-plastics, especially for packaging such as bottles and household waste. This barrier can be overcome with adoption of a clear labelling system used at collection point, and communication across the product manufacturers, waste recycling industry, and local authorities.

Lack of clear and unambiguous standards and sustainability criteria for bio-based products represent a significant barrier. A relative lack of awareness is another barrier to wider adoption of bio-based products, especially among small and medium-sized enterprises.

0.5 Funding for R&D and demonstration projects

Information on grants and other funding opportunities can be obtained from various sources, including business support organizations and Local Enterprise Partnerships. In addition, information on funding and partnering can be found via Knowledge Transfer Networks (KTNs).

NOTE A KTN is a national network in a specific field of technology or business application, which brings together people from businesses, universities, research, finance and technology organizations to stimulate innovation through knowledge transfer and sharing of ideas. For example, the KTN for Energy Generation and Supply hosts a low carbon funding landscape navigator (www.lowcarbonfunding.org.uk), a database of funding providers in the low carbon sector.

In the UK funding for bio-based products can be given by various governments departments (in particular, DEFRA, DECC, BIS), and government funding bodies such as the Technology Strategy Board (TSB). The TSB is a business-led, government-funded organization that promotes and invests in technology-enabled innovation to boost UK business and prosperity. TSB has identified a number of technology areas and application areas where its efforts are focused, including biosciences, high-value manufacturing, advanced materials, environmental sustainability, energy generation and supply, and built environment. TSB invests in projects involving business and researchers working together to deliver successful new technology-based products and services. In addition, TSB champions the Small Business Research Initiative (SBRI), a programme that brings innovative solutions to specific public sector needs by funding short-term development contracts.

In the EU, Horizon 2020 [17] is the financial instrument that will support research and innovation with a budget of €80 billion (£67 billion), of which €4.7 billion (£4 billion) has been proposed for the tacking challenges of food security, sustainable agriculture, marine and maritime research, and the bioeconomy [18].

Small- and medium-sized enterprises (SMEs) will be encouraged to participate across Horizon 2020 programmes through a new dedicated SME instrument. It aims to fill gaps in funding for early-stage, high-risk research and innovation by SMEs as well as stimulating breakthrough innovations. It is expected that through this integrated strategy around 15%, or €6.8 billion (£6 billion), of the total combined budgets of the "Tackling societal challenges" Specific Programme and the "Leadership in enabling and industrial technologies" objective will be devoted to SMEs [19]. The first calls from Horizon 2020 are expected to be issued in early 2014.

In 2012, the UK Government launched the UK Green Investment Bank [20], which is dedicated solely to supporting the development of a "green" economy. Its mission is to provide financial solutions to accelerate private sector investment in the green economy. One of its aims is to increase growth capital for innovative green technology. Bio-based products will form a key part of the bio-based economy and so could receive support from the Green Investment Bank. This initiative was operational from October 2012.

0.6 The role of standardization in creating a market for bio-based products

The lack of product quality standards and data on environmental performance for new bio-based products can present a significant barrier for wider adoption of bio-based products. Without clear standardization and labelling, the acceptance and commercialization of bio-based products could be difficult to achieve. Standards and certification can give assurance as to a bio-based product's quality, its performance, as well as its bio-based content. This assurance can in turn result in an increased uptake of bio-based products.

Standards and certification can help to:

a) define a market for bio-based products;

b) ensure that environmental declarations are understood and are based on objective evidence;

c) enable consumers to make an informed choice.

While bio-based products might offer economic, environmental and social benefits, these can vary significantly between bio-based products. Life cycle assessment (LCA) standards can provide a means of comparing a product's environmental impact. Manufacturers and end users wanting to minimize their environmental impact can then make an informed choice between bio-based and non-bio-based products.

LCA takes into account all stages of product life cycle from raw materials to intermediate and final products, considering the impacts associated with use, disposal or re-use on the environment, as well as economic and societal impacts. For manufacturers it is important to communicate objectively and clearly, the benefits of bio-based products in manufacture, use and disposal.

However, caution needs to be applied when comparing products based on their LCA, as parameters and methodologies can vary. For example, one LCA could take into account the impact of the products from cradle-to-gate (from resource extraction, "cradle", to the factory gate, i.e. before it is transported to the consumer), while another LCA might take into account the impact from cradle-to-grave (from resource extraction to use phase and disposal phase, "grave"). These two LCA variants will produce different results. In addition, different methodologies or reference data could be used, thereby adding to the variability of the end result (see **4.4**).

1 Scope

This PAS provides a signpost to key standards, codes of practice and guidance that can be adopted in the production, use and disposal phases of bio-based products. Guidance is also provided on the communication of the benefits of bio-based products in a way that is accurate, verifiable, relevant and not misleading. It covers:

a) standards that are relevant to the life cycle of a product;

b) labelling;

c) future areas for standards development;

d) existing and potential future regulatory impacts.

Standards coverage is limited to the UK and EN/ISO standards, where adopted by the UK. Other highly relevant international standards are also included.

Bio-based products described in this PAS refer to non-food products derived from biomass (plants, algae, crops, trees, marine organisms, wool, silk, and biological waste from households and food production).