KBBPPS
Knowledge Based Bio-based Products' Pre-Standardization

Work package 5

Bottlenecks and impacts on functionality tests

Deliverable N° 5.3:
Market entry barriers

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1 Publishable summary

Deliverable D5.3 “Market entry barriers” of the KBBPPS project (Knowledge Based Bio-based Products’ Pre-Standardization”) presents the results of the analysis of existing barriers hampering market entry for bio-based products (BBP). The main focus of this research was on technical bottlenecks for BBP stemming from regulations, codes, norms and standards, but another aspect of the analysis were also barriers in the process chain such as access to raw materials, unsuitable political framework, lack of information, inappropriate communication and labelling as well as finance.

The main aim was to check whether existing product specifications, test standards, certifications and labelling present hurdles to bio-based variants. This was done via two different methodologies: A survey, led by nova-Institute (nova), among producers and experts of bio-based products investigated the main barriers faced by the industry. In parallel, NEN led the desk research on existing regulations, norms and standards, which was complemented by a specific focus study on bio-based products in the agro-food sector by AUA. Several consortium partners provided input and feedback during the process to fine-tune the results. The focus of the research was exclusively on those products that were identified in task 5.1 which resulted in a list of 26 bio-based products.

The survey led us to identify three categories of barriers stemming from norms and standards:

1. Commonly used product specifications are not addressing favourable bio-based properties
2. Commonly used product specifications cover properties that are not really necessary for or related to product functionality, but these are not fulfilled by bio-based products
3. Bio-applicability is missing due to “old thinking” in terms of conventional products

Sometimes, these categories are overlapping or the distinction cannot be made sharply. Especially the third category is quite broad, but necessary in order to classify broad barriers.

The survey also resulted in a multitude of non-technical barriers, mostly in the fields of political framework, communication and marketing or finance. Public procurement of bio-based products was suggested by some participants as a tool to strengthen market demand, but for the other issues, not many concrete solutions came up.

During the synthesis of the results and discussions with partners for further research, seven products (groups) were selected for further study, based on the factors: existence of relevant barriers in terms of technical product properties, relevant market shares and existing testing facilities within the project consortium. The selected products are packaging films, disposable cups, WPC decking, natural fibre insulation, NPK fertilizer, bio-based mulch films and adhesives and binders.

2 Introduction

This document presents the results of the analysis of market entry barriers that exist for bio-based products (BBP). The main focus of this research was on technical bottlenecks for BBP stemming from regulations, codes, norms and standards, but another aspect of the analysis were also barriers in the process chain such as raw materials, political framework, information, communication and labelling as well as finance.

The main aim was to check whether existing product specifications, test standards, certifications and labelling present hurdles to bio-based variants. This was done via two different methodologies. A survey, led by nova-Institute, among producers and experts of bio-based products investigated the main barriers faced by the industry. This was complemented by a desk research on existing regulations, norms and standards, led by NEN. A specific focus study on the functional and technical bottlenecks of bio-based products used in the agro-food sector was executed by the Agricultural University of Athens (AUA). Several consortium partners provided input and feedback during the process to fine-tune the results. The focus of the research was exclusively on those products that were identified in task 5.1 which resulted in a list of 26 bio-based products.

The first part of the report presents the findings on technical hurdles, fed by the survey and the desk research. The second section is only informed by the survey and deals with the other barriers and suggestions of respondents how to overcome them. The conclusion illustrates what the findings mean for the subsequent research, both in KBBPPS as well as in the follow-up project Open-Bio.

3 Technical barriers

3.1 Survey

3.1.1 Methodology

The survey on the market entry barriers was conducted from February to April 2014. A pre-test was conducted with approx. ten selected industry experts in order to validate the methodology. With those experts, phone interviews served to collect their feedback. The general survey was then disseminated as an online survey through nova's newsletter, direct mailings, nova's LinkedIn networks as well as through the networks of the consortium partners. Approx. 120 respondents filled out the complete survey.

The survey was kept deliberately short in order to obtain a high respondent rate, which worked out moderately well. The questions were kept open in order to encourage own thinking of the respondents and not to influence the tenor of the replies. The first question addressed the issue of how norms and standards influence the market entry of BBP in both negative and positive ways:

> ***1) Several norms and regulations might act as barriers for bio-based products to enter the market, because they can contain provisions in terms of product properties (functionalities) that bio-based products cannot fulfil.***
>
> *a) Do you see any such norms or regulations hindering bio-based products from entering the market? If yes, please specify them.*
>
> *b) On the other hand, do you think that norms or regulations could help your bio-based product to be successful in the market? If yes, how do you think that could work?*

The replies to these questions form the basis of the following analysis.

3.1.2 Survey results of the technical barriers

The open structure of the questionnaire made it necessary to find a categorization of the replies before they could be analysed properly. We were able to sort the responses into three types of barriers:

1. Commonly used product specifications are not addressing favourable bio-based properties
2. Commonly used product specifications cover properties that are not really necessary for or related to product functionality, but these are not fulfilled by bio-based products
3. Bio-applicability is missing due to "old thinking" in terms of conventional products

Sometimes, these categories are overlapping or the distinction cannot be made sharply. Especially the third category is quite broad, but necessary in order to classify broad barriers. Table 1 summarizes the results of the research, including the categorisation for 26 different bio-based products that was defined to be in the focus of interest, in earlier product stage:

Table 1: Survey results of the technical barriers

Bio-based product		Hurdle	Type of hurdle		
			1. BBP properties not addressed	2. BBP do not fulfil non-related properties	3. Bio-applicability missing
1	**Packaging films (PLA + PBAT / PBAT + additives)**	Lack of European standard for compost and digestate			X
		Disposal via anaerobic digestion is not regulated / incentivized enough			X
2	**Disposable cups and plates (PHA-coated paper), high calcium carbonate containing (mineral fillers)**	High temperature requirements (which are not even reached by the contents of the cups) cannot be fulfilled by bio-based materials		X	
3	**Beverage bottles (bio-based PET from bio-based MEG)**	—			
4	**Packaging chips (starch-based loose fill flips)**	—			
5	**Seat cushions (25% soy-based polyols in PU foams)**	GM regulations			X
6	**Door trimming, hemp / flax / kenaf / PP - mat, press moulded**	End-of-life vehicle directive and its recycling rules	X		
7	**Tires**	—			
8	**CO_2-based PPC-PHA vacuum cleaner casing**	This type of materials mixing is not considered in any regulations			X
9	**Technical high performance polyamide**	—			
10	**Consumer electronics casing; cellulose acetate and additives**	Regulations for additives not sufficient			
11	**Particle board (over 95% wood particles, adhesives and waxes)**	Regulations for VOC emissions in construction CEN/TS 16516			
12	**WPC decking from extruded profiles (60% wood flour + PP + additives)**	Combusting and technical properties for construction products		X	
		No regulations for end-of-life options			X

Table 1: Survey results of the technical barriers

Bio-based product		Hurdle	Type of hurdle		
			1. BBP properties not addressed	2. BBP do not fulfil non-related properties	3. Bio-applicability missing
13	**Pre-manufactured construction and insulation components**	Insulation: insulation performance /thermal conductivity of natural fibre materials not measured fairly, “correction factors” for moisture content (see below)	X		
		Insulation: Moisture permeable vapour open construction is not acknowledged in some Member States.	X	X	X
		Insulation: good properties such as high heat transfer (decrement) delay and good acoustic performance are not included in standards		X	X
14	**NPK-Fertilizer**	Purity regulations which cannot be fulfilled by processes other than chemical synthesis		X	
15	**Mulch films (starch blend)**	No European regulation available (only French standard NF U 52-001)	X		X
		General standard specifications are not 100% applicable and they not comply with the specific application of the mulching films			X
		Confusion because of lack of standards that distinguish between biodegradable in soil and oxo-fragmentable.	X		
16	**Natural paint; plant oil based, inorganic fillers, volatile compounds**	—			
17	**Surfactant (brake cleaner)**	No incentives for soil protection	X		X
18	**Lubricant**	CEN/TC 19/WG 33 is preparing the standard for biodegradability in soil and aquatic environment	X		X
19	**Facial scrub cream with PHA pearls**	Avoidance of micro-particles not covered in any regulation	X		X
20	**Blended fabric: viscose, cotton, wool, polyester**	—			

Table 1: Survey results of the technical barriers

Bio-based product		Hurdle	Type of hurdle		
			1. BBP properties not addressed	2. BBP do not fulfil non-related properties	3. Bio-applicability missing
21	**Boat hulls (glass / carbon fibre mats in bio-based matrix, hand-laminated)**	—			
22	**Natural Oil Polyols (NOPs)**	—			
23	**High grade pulp**	Missing regulations for nano-cellulose	X		X
24	**Adhesives and binders**	Overly ambitious norms for adhesive powers; best before date		X	
		Missing regulations on emissions, bio-degradability	X		X
25	**Liquid biogas (LBG / "bio-LPG")**	Missing regulations for material use			X
26	**Bio-butane**	GMO regulations			X

As can be seen from Table 1, some products in the list face several barriers from norms regulations due to their technical properties, whereas others are not concerned by this problem at all. For drop-in solutions like bio-PET (product number 3) that are chemically and technically identical to their fossil counterparts, this is obvious. But also for bio-based products that have been successful on the market such as starch-based filling chips (packaging industry) or Natural Oil Polyols (NOPs, automotive industry) the problems do not seem to exist.

Of course, the survey cannot guarantee a complete coverage of all 26 product categories since the results are very much dependent on which industry group replied to the questionnaire, but we put very much effort on collecting feedback from as broad a group of experts as possible. Our respondent group was an excellent representation of the sectors plastics, chemical industry, composites industry and research and development; however specialty materials such as boat hulls made of a glass/carbon fibre mats in bio-based matrix (product number 21, selected in the product list for its testing challenges) were not covered.

In reply to question 1b *(Do you think that norms or regulations could help your bio-based product to be successful in the market? If yes, how do you think that could work?)*, most respondents reacted quite cautiously. A few stated that it would help in general with consumer confidence and thus with market access. More specifically, it was mentioned that uniform standards and regulations would help to reduce doubts about product functionality and performance or safety issues, which is a prerequisite to enter any market. Another more specific aspect was that it would be easier for public authorities to consider bio-based product in their procurement once standards and regulations gave legal security.

An in-depth analysis of barriers was done for two exemplary cases, based on detailed feedback of the concerned experts: Natural fibre insulation (part of product list item no. 13, premanufactured construction items) and mulch films based on starch (item no. 15).

3.1.2.1 Natural fibre insulation

Building insulation made from natural fibres is a small niche market compared to insulation made from mineral wool, expanded polystyrene (EPS) or Polyurethanes (PUR). Market research by nova-Institute showed that natural fibre insulation accounts for only 4 % of the overall European insulation market:

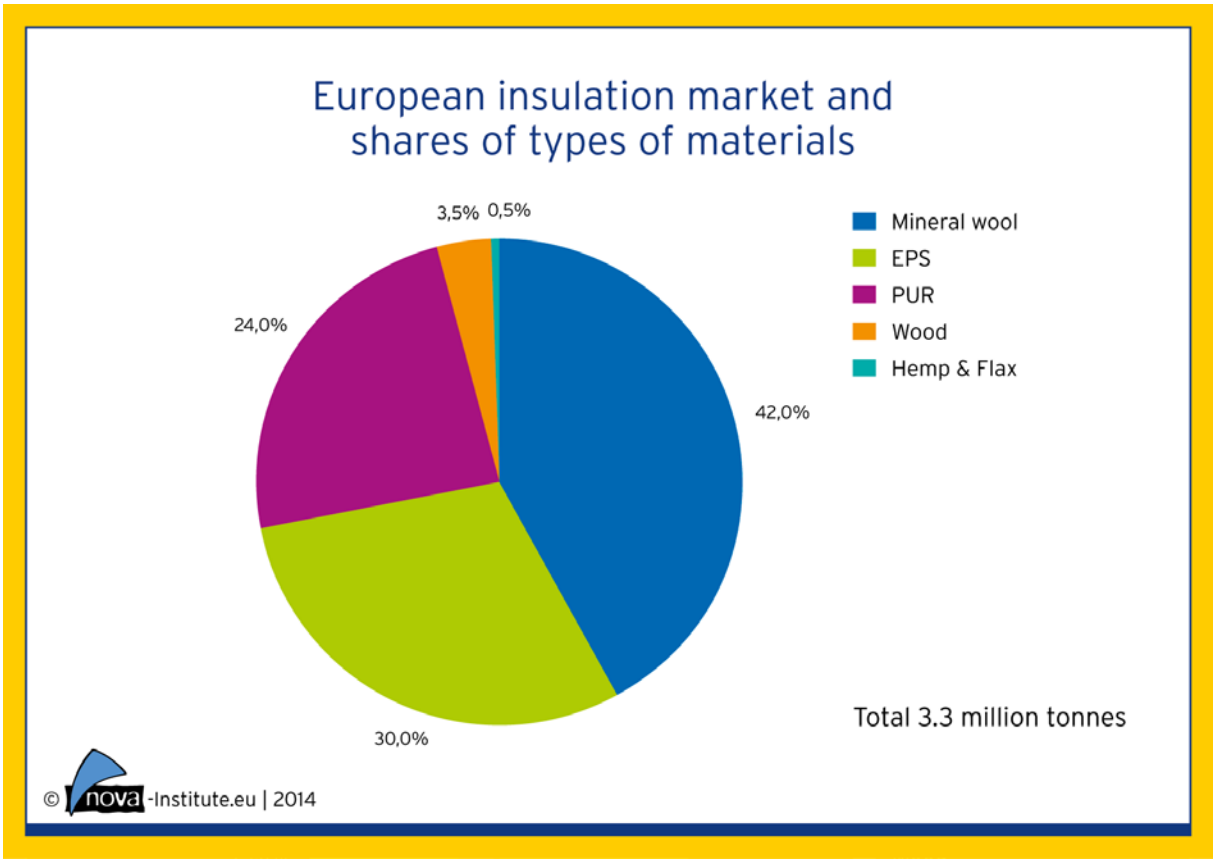


Figure 1: European insulation market and shares of types of materials, total 3.3 Mtonnes[1]

This market power situation is clearly mirrored in the existing regulations for insulation. Advantageous properties of natural fibre insulation are not recognized by norms, and in one case a good property is paradoxically even clearly forbidden by regulations. And this even though these natural materials offer excellent environmental advantages, too.

First of all, producers claim that the insulation performance of natural fibre insulation is not evaluated fairly in connection to moisture content. The Lambda value is the measure for the thermal conductivity of an insulation material (Unit: W/(m*K) and is therefore a measure of its ability to prevent the passage of heat in defined conditions. The Lambda value is the decisive

claim of an insulation material when it enters the market, and a lower value is better than a higher value. It is usual practice to automatically add a “correction factor” (from “declared Lambda value” to the corrected “design Lambda value”) to the measured lambda value of an insulation material if it collects moisture, making the declared value worse. This stems from the fact that conventional insulation materials mostly have only small moisture uptake and there are solidly calculated low correction factors for their Lambda values. However, natural fibre insulation materials are perfectly happy to collect (and also release) moisture – up until a moisture content of about 17%, the insulation performance is not really influenced. This means that if the thermal conductivity were to be measured correctly – even in a moist state – the Lambda values would not be as high as they are due to the automatic “correction” which is currently practiced. Producers of natural fibre insulation materials claim that this is an unfair treatment of their products and the norms should be re-evaluated with a view on these claims.

The problem is even bigger, because in some Member States there are discussions to allow only insulation materials with a Lambda below 0.035 W/(m*K) – this is a problem for several natural insulation materials with only Lambda = 0.040 W/(m*K), partly because of an unsuitable “correction factor”. Also a slightly higher Lambda is not a problem in construction: The wall just needs to be a little bit thicker.

The different behaviour of natural fibre insulation in terms of moisture content leads to another paradox situation: In some EU Member States, moisture permeable materials (vapour open construction) are not allowed as insulation in buildings at all. These regulations do not recognize that bio-based insulation is perfectly happy to become moist temporarily and still perform thermally and even provides advantages compared to moisture tight insulation, since it serves to better regulate moisture contents in a room and to minimize the risk of condensation and mould growth. Only conventional insulation materials producers profit from the current regulations, while natural fibre insulation manufacturers and consumers suffer unfairly from them.

Another issue, according to producers of natural insulation materials, is that high density wood and other natural fibre insulations provide a high heat transfer (decrement) delay, which means that apart from the absolute insulation effect, the residual heat also reaches the room later than with conventional insulation. This can have extremely positive effects for example in work environments, but is not reflected in any testing in order to comply with norms. That means that the producers of these natural materials cannot obtain any advantage in marketing for their more expensive materials (consumers pay double the price for natural fibre insulation than for the traditional mineral wool alternative) by showing their superior properties.

Norms on dust content and fungi of the building materials were claimed to constitute a market barrier in some cases. Also the good acoustic insulation performance of natural fibre

materials that is not shown by mineral wool is not covered by any norm, depriving the producers of one more selling point and consumers of increased well-being.

3.1.2.2 Bio-based mulch films

Mulch films are applied in agriculture in order to protect soil, protect plants, regulate temperatures, control watering etc. Traditionally, this was done by covering the soil with natural material such as bark or peat, but today also planes of plastics take over this role. This leads to the problem that more and more plastics are left in the soil and contribute to pollution. Bio-based mulch films that are completely biodegradable in soil would present a pragmatic and environmentally friendly solution to this, but their market entry is hindered to some extent by regulations.

The first problematic issue is that there is no European Standard specification available for biodegradable mulch films. There is a French standard (NF U 52-001), but no European one. However, work is on-going in CEN. There are several standards for biodegradability of plastics in soil, but not specifically for mulching films. General standard specifications are not completely applicable and they do not comply with the specific application of the mulching films.

Because of lacking information, a higher purchasing price and lack of enforcement of the environmental regulations, farmers prefer conventional PE mulch films. These PE films have to be removed from the field after use and disposed of properly (e.g. energy recovery). Because of the labour cost to remove the degraded PE mulching film and the cost to clean it from the soil and dispose of properly, many farmers burry it in the field. If this illegal practice was eliminated (i.e. application of “the polluter pays” principle) and if the farmer was better informed, they would had found out that the higher purchasing price of the bio-based biodegradable mulching film is fully compensated for by the saving of removal and disposal costs. However, since this knowledge is not widely spread yet, many small plastic parts remain in the soil, which might fragment to plastic micro particles even entering the water.

A pseudo solution are “oxo-degradable” plastic films, making the problem bigger instead of solving it: The issue of a missing, binding European standard for biodegradable mulch films is exacerbated by the fact that so-called “oxo-degradable” plastic films are currently being marketed as environmentally friendly alternatives by implying that they also degrade in soil. However, these are conventional plastics that are combined with additives that cause the material to disintegrate into fragments under influence of oxygen and UV radiation. This means that they do not truly degrade into CO_2, water and biomass in soil but simply are fragmented into micro-particles which remain in the soil and lead to an immense pollution. A strict regulation and protection of the term “biodegradable” would be very helpful in this context and is currently being discussed in the EU policy arena (Ißbrücker 2014, [2]).

3.2 Desk research on existing norms and regulations

3.2.1 Introduction

This part of the work consisted of an international stock-taking of product specifications as laid down in standards, codes, rules, environmental requirements, etc. NEN, as National Standardization Body, initiated and coordinated the check whether existing product specifications, regulations, certifications and labelling present hurdles to bio-based variants. The work involved checking official product specification and (related) test method, standards. The products chosen were based on the 26 product categories defined before (see Table 1). The goal is to identify specific requirements regarding properties that may present a problem towards bio-based products. This can be that requirements are tougher to meet for these bio-based versions; on the basis of the level to achieve or the test method that incorporates procedure steps difficult to execute. Alternatively, requirements may be set on the basis of non-bio-based variants but basically make no sense for the new products or even contradict their newly presented properties or nature.

The work has started with a basic identification of the applicable regulations, the applicable product (quality) specifications and the standard test methods called up in any of the two. Differentiation between European and other regulations or standards has been made in the research. Any Directives, rules, codes or regulative (even subsidy application) matters applicable to either the product, its use or the production thereof that were found have been checked on the implications. For specifications also the availability of and use in the market of industry standards has been considered. Product requirements can both be regulated or be agreed upon by the (global) industry leaders. An example of the first are the product properties linked to health, safety and the environment. Industry standards may have all different forms but can come from commonalities like machines used (packaging) or processes forming the basis of the mainstream production (dying of fabrics).

The desk research was carried out using standards' databases available to NEN. Obviously, without too much knowledge of all products only the title and scope of a standard were assessed. In-depth study of the requirements set by specifications or classification, or of the test procedures, may be a next step of the project. In addition, internet research, for instance on EU regulations or industry standards, was executed. Where possible, (mainly Dutch) producers of bio-based products were interviewed by telephone in order to explain specific requirements. As not all of the 26 categories seemed to make sense to investigate and the given timeframe of the work was limited, the following categories have not been investigated in depth:

- packaging chips (category 4) as it is expected that these have no other requirements than normal packaging,
- surfactants (category 17) as it is already investigated by CEN,
- natural oil polyols (category 22) it being an intermediate for other products,
- high grade pulp (category 23) as this is a product that has no non-bio counterpart,
- liquid biogas (category 25) it being specified by CEN/TC 408, and

- bio-butane (category 26) as no different requirements apply to this molecule.

The majority of the remaining categories have been investigated by NEN. The ones with agricultural usage (mulching films, lubricants and packaging) have been studied by AUA, which also developed a much wider report on bio-based plastics' use in the agro-food sector. The results thereof are presented in 3.2.4, whereas the results for other 17 categories are presented in 3.2.3. The next sub-clause presents a generic assessment of regulations and standards.

3.2.2 Product specifications' study

There is a broad array of EU legislation pertaining to the marking, labelling and packaging of products, with neither an “umbrella” law covering all goods nor any central directory containing information on marking, labelling and packaging requirements[7]. Manufacturers of containers, plates, cups, and other material that is intended to come into contact with food are required to check the compliance of their product with EU chemical safety requirements[8]. There are certain essential criteria that are expressed either in this Framework Directive or in specific Directives applied to plastics (relevant to bio-based):

1. Plastics must not transfer their constituents to foodstuffs in such quantities as to constitute a health hazard or cause unacceptable change in the composition of the foodstuff or alter the sensory properties of the food.
2. Plastics must be made from starting substances listed in the plastic directives or mixtures of approved substances, oligomers, or natural or synthetic macromolecular compounds or mixtures of the two as long as they have been produced from starting substances included in the list.
3. Authorized substances can be used only if they comply with restrictions applicable to them.
4. The substances must be ”of good technical quality as regards purity requirements”.

In the US, the Federal Food, Drug, and Cosmetic Act sets similar requirements to all packaging products.

The EU Packaging and Packaging Waste Directive[14] harmonized member state legislation regarding packaging material composition and the management of packaging waste. Composition of packaging material is addressed in a series of EU-wide standards. Their final disposal should be considered as a last resort solution. It covers all packaging placed on the European market and all packaging waste, whether it is used or released at industrial, commercial, office, shop, service, household or any other level, regardless of the material used and forces the Member States to introduce systems for the return and/or collection of used packaging setting quantitative targets. The Directive states that: “‘organic recycling’ shall mean the aerobic (composting) or anaerobic (biomethanization) treatment, under controlled conditions and using micro-organisms, of the biodegradable parts of packaging waste, which produces stabilized organic residues or methane".

The EU Ecolabel scheme is laid down in an EC Regulation[9], which is also part of a wider approach on Integrated Product Policy (IPP). The experience gained during the

implementation of the previous Regulation (EC) No 1980/2000 has shown the need to amend that Ecolabel scheme in order to increase its effectiveness and streamline its operation. The new 2010 scheme is intended to promote those products which have a high level of environmental performance through the use of the EU Ecolabel. The Directive establishes ecological criteria and the related assessment and verification requirements for the award of the Community eco-label. However, the requirements set depend strongly on the product application and are mostly of environmental nature. However, some physical properties or comparisons are also included, since a high level of performance is one of the marketing messages of the EU Ecolabel. Criteria catalogues therefore include different kinds of quality requirements in several product groups, such as textiles or hydraulic fluids (e.g. hydraulic fluids should at least meet the technical performance criteria laid down in ISO 15380, tables 2 to 5).

Similar to the EU Ecolabel, RAL UZ 48 of the Blue Angel (Blauer Angel, Germany) guarantees to the consumer the biodegradability and non-toxicity of chainsaw oils, mould releasers and hydraulic fluids. Nordic Swan, the official sustainability ecolabel for the Nordic countries, introduced by the Nordic Council of Ministers, is another voluntary license system used for bio-lubricants. For further background see CEN/TR 16227[11].

Obviously, the US Federal BioPreferred Purchasing and Product labelling ruling is the one most known in the market. Section 9002 of the Farm Security and Rural Investment Act of 2002 (FSRIA), as amended by the Energy Policy Act of 2005 and the Food, Conservation, and Energy Act of 2008, requires Federal agencies to give a purchasing preference to bio-based products designated by the U.S. Department of Agriculture (USDA), including products used in work performed under Federal agency contracts. The preference applies unless an agency determines that the bio-based products are not reasonably available within a reasonable period of time, fail to meet applicable performance standards, or are available only at an unreasonable price. The same act also requires USDA to establish a voluntary program and criteria for producers of bio-based products to use a “USDA Certified Bio-based Product” label. The label is connected only to a certification of the bio-based content ("… the term `bio-based product' means a product determined ... to be a commercial or industrial product (other than food or feed) that is composed, in whole or in significant part, of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials"). That determination is based on the bio-based carbon as measured via ASTM D 6866[13].

One generic issue for bio-based products that has come forward from the study of all available product specification standards is the questions around long-term stability. Both in case of biodegradable or non-biodegradable products (also those not intended for a gasification or composting end-of-life). Many standard test methods that test for durability use high temperatures or high speed/frequency in order to simulate long term degeneration in a shorter test time. These are based on experience with and have relevance to the old-fashioned materials. There is no relationship known with new products. Also the impact

(negative or positive) on the bio-based variants and materials is hardly known. These might result in false negative (most of the times) or positive determinations of limit fulfilment.

3.2.3 Product specifics' study

3.2.3.1 Packaging films

See also 3.2.2 for general, legal packaging requirements. The Waste and Packaging Directive[14] has mandated a set of CEN Standards:

- EN 13427, *Umbrella. Packaging – Requirements for the use of European Standards in the field of packaging and packaging waste*.
- EN 13428, *Prevention. Packaging – Requirements specific to manufacturing and composition.*
- EN 13429, *Reuse. Packaging – Requirements for relevant materials and types of reusable packaging*.
- EN 13430, *Material recycling Packaging – Requirements for packaging recoverable by material recycling*.
- EN 13431, *Energy recovery. Packaging – Requirements recoverable in the form of energy recovery, including specification of minimum interior calorific value.*

On physical properties some film specific standards can be mentioned:

- ISO 4591 *Plastics -- Film and sheeting -- Determination of average thickness of a sample, and average thickness and yield of a roll, by gravimetric techniques (gravimetric thickness)*
- ISO 4593, *Plastics -- Film and sheeting -- Determination of thickness by mechanical scanning*
- ISO 527-3, *Plastics -- Determination of tensile properties -- Part 3: Test conditions for films and sheets*
- ASTM D882, *Standard Test Method for Tensile Properties of Thin Plastic Sheeting*

On first sight none of these seem to present hurdles for bio-based films or sheets.

If bioplastics have proven their compostability according to international standards, they can be treated in industrial composting plants. Plastic products can provide proof of their compostability by successfully meeting the harmonised European standard, EN 13432 or EN 14995. These two standards define the technical specification for the compostability of bioplastics products. For instance, EN 13432:2000 includes requirements for packaging recoverable through composting and biodegradation and a test scheme and evaluation criteria for the final acceptance of packaging .This is a harmonised European standard linked to the European Directive on Packaging and Packaging Waste (94/62/EC). It allows for the presumption of conformity with essential requirements of the Directive.

Radiometric properties seem to be tested by in-house tests or generic tests (for plastics) such as ASTM D1003-13, *Standard Test Method for Haze and Luminous Transmittance of*

Transparent Plastics. For gas barrier properties the same seem to apply and only ASTM seems to have barrier test methods for water, oxygen and carbon dioxide for plastic films.

3.2.3.2 Beverage bottles and disposable cups

See 3.2.2 for applicable requirements for products in contact with food. The standard series indirectly related to bottles is EN 1186-1 to 15 '*Materials and articles in contact with foodstuffs – Plastics*' from CEN/TC 194 'Utensils in contact with food' describing several test methods on migration.

No standards specific for physical properties of bottles or cutlery could be found. Test houses provide material composition testing and bottles specifications. The specifications are based on the bottle testing services provided by the institutes themselves and contain a variety of properties:

- Burst pressure
- Colour
- Carbon Dioxide Retention
- Stress crack
- Thermal stability
- Tilt
- Dropping ((non)-carbonated)
- Top load (filled, empty)
- Volumes (overfill, fill line)
- Sidewall rigidity and tensile strength
- Permeability
- Impact (several types of test

3.2.3.3 Seat cushions

Here not a lot of publicly available documentation could be found. The standards under the scope of the vehicles TC's, CEN/TC 301 & ISO/TC 22 (Road vehicles), are not related to the interior of a vehicle (such as cushions). Producers of vehicles have extensive design briefs for seats, which are classified. A standard dealing with the performance of cushions has been developed by ISO/TC 45, *Rubber and rubber products*: EN-ISO 4651:2008, *Cellular rubbers and plastics - Determination of dynamic cushioning performance*.

3.2.3.4 Door trimming

As the product category was written towards the automotive sector, the same as before applies: hardly any publicly available documentation could be found. The standards under the scope of the vehicles TC's, CEN/TC 301 & ISO/TC 22 (Road vehicles), are not related to the interior of a vehicle (such as door trimmings). Producers of vehicles have extensive design briefs for seats, which are classified. The standard which includes a characteristic of trimming is developed by ISO/TC 45, *Rubber and rubber products*: ISO 6452:2007, *Rubber- or plastics-coated fabrics - Determination of fogging characteristics of trim materials in the interior of automobiles*.

3.2.3.5 Tires

Apart from the waste and end-of-life requirements (as with more automotive components), the only other EU regulation specific for tyres is 1222/2009/EC on the labelling of tyres with respect to fuel efficiency and other essential parameters. The regulation consists of information on three parameters: fuel efficiency/rolling resistance, wet grip and noise for communication to the consumers. Each of them has been specified further in terms of test procedures via Amendments, which are described in:
- 1235/2011/EC amending Regulation (EC) No 1222/2009 with regard to the wet grip grading of tyres, the measurement of rolling resistance and the verification procedure;
- 228/2011/EC amending Regulation (EC) No 1222/2009 with regard to the wet grip testing method for C1 tyres;
- 1235/2011/EC amending Regulation (EC) No 1222/2009 with regard to the wet grip grading of tyres, the measurement of rolling resistance and the verification procedure.
Noise emission has already been laid down before in 92/23/EEC Tyres for motor vehicles and their trailers and their fitting.

For wet grip reference is made to ISO 15222:2011, *Truck and bus tyres - Method for measuring relative wet grip performance - Loaded new tyres*. For noise the following two are referenced: ISO 10844, *Specification of test tracks for the purpose of measuring noise emitted by road vehicles,* and ISO 10534-1, *Acoustics — Determination of sound absorption coefficient and impedance by a tube method*.

Non-regulated properties for tyres are laid down by ISO/TC 31 and ASTM F09. They have a quite complete set on tyre capability, rolling and wet grip for all types of tires. None of these or the above mentioned test methods seem at first glance to present specific hurdles to the use of bio-based materials in tyres.

3.2.3.6 Vacuum cleaner casing

There is no known regulation specific on casing. There is also some legislation on professional (vacuum) cleaning equipment. Regarding electrical equipment, the main relevant EU Directives are on electronic equipment waste (WEEE [20]) and on hazardous substances[21]. These might have impacts on the choice of material used but not specifically on the bio-plastic product (functional) properties. It thus seems that assessment of the capabilities of a bio-based plastic product to be re-used, recycled or recovered is essential. The Ecodesign requirements[22] are also more related to the energy consumption and only require that for each product-phase possibilities for reuse, recycling and recovery of materials and/or of energy shall be assessed, taking into account the WEEE.

For consumer electronics, the IP Code is used to indicate the level of protection against dust and water. In EN-IEC 60529[23] a few functional requirements in relation to the degree of protection is formulated. Electrical devices must according to IEC 60529, belong to a specific type of protection. The types of protection (classification and rating) are also called IP (ingress protection) codes and refers to protection against contact and the penetration of

solid foreign objects and dust and against the damaging ingress of water. Tests to be performed to verify that the enclose meets the requirements, are a part of this standard.

When it comes to the specific product, IEC/TC 59 (in coordination with CLC/TC 59X) have laid down the following on the performance of household and similar electrical appliances:

- EN-IEC 60312, *Vacuum cleaners for household use*, consisting of *Part 1: Dry vacuum cleaners - Methods for measuring the performance* and *Part 2: Wet cleaning appliances - Methods of measuring the performance*
- EN-IEC 60335-2-2:2010, *Household and similar electrical appliances - Safety - Part 2-2: Particular requirements for vacuum cleaners and water-suction cleaning appliances*
- EN-IEC 60704-2-1:2001, *Household and similar electrical applicanses - Test code for the determination of airborne acoustical noise - Part 2-1: Particular requirements for vacuum cleaners*
- IEC/PAS 62611:2009, *Vacuum cleaners for commercial use - Methods for measuring performance*

ASTM, Committee F11 on Vacuum Cleaners has a more abundant set of standards on components of the cleaner, performance, motor life and durability and reliability of the plastic used.

Another option for defining functional characteristic is to follow EN-IEC 61386-1[24]. Conduct systems can (more or less) be compared with a casing which protects the electric material inside. IEC 61386-1 specifies tests for mechanical (e.g. impact, bending, tensile), thermal and electrical properties and external influences. Examples of tests are:
- IEC 60695-2-11, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods - Glow-wire flammability test method for end-products*, and
- IEC 60695-11-2:2003, *Fire hazard testing – Part 11-2: Test flames - 1 kW nominal pre-mixed flame - Apparatus, confirmatory test arrangement and guidance*

3.2.3.7 Polyamide

The applicable regulation is linked to the intended use of polyamide for example in the situation of construction material (305/2011[15]) or in contact with food (10/2011[9]). Several sectors are subject to regulatory compliance such as construction, packaging, food contact materials, electrotechnical devices, waste management. Considering the scope of this technical committee as well as other ones, CEN/TC 249 (Plastics) is principally concerned with the so-called "Construction Products Directive", EC 305/2011. There is no particular regulatory requirement as far as the technical standards related to test methods are concerned. As standards under the scope of CEN/TC 249 do not deal with the chemical composition of plastics, REACh[16] legislation is only considered as guidelines in a responsible approach and sustainability of materials and products covered by the TC. Harmonized standards in the context of the CPR will need to address the release of dangerous substances, according to testing procedures set up by CEN/TC 351 (Construction Products - Assessment of release of dangerous substances).

On standards in general for polyamide ISO/TC 61 has developed the following:

- ISO 3451-4:1998, Plastics -- Determination of ash -- Part 4: Polyamides
- ISO 11337:2010, Plastics -- Polyamides -- Determination of e-caprolactam and w-laurolactam by gas chromatography
- ISO 307:2007, Plastics -- Polyamides -- Determination of viscosity number
- ISO 1110:1995, Plastics -- Polyamides -- Accelerated conditioning of test specimens
- ISO 1874-1:2010, Plastics -- Polyamide (PA) moulding and extrusion materials -- Part 1: Designation system and basis for specification
- ISO 1874-2:2012, Plastics -- Polyamide (PA) moulding and extrusion materials -- Part 2: Preparation of test specimens and determination of properties

Material properties can be tested by institutes specialized in plastics, such as mechanical properties (tensile strength, flexural strength, hardness, compression strength, impact strength, tear strength, abrasion resistance, adhesive properties), physical (density, specific gravity), thermal, chemical, electrical, weather, optical, etc. There are no specific polyamide specifications as they are all product specific. Hurdles in functionality (standards) are however not expected for bio-polyamide.

3.2.3.8 Consumer electronics casing

There is a lot of legislation on consumer goods, which is not specific for injected moulded bio-plastic products, which this part of the work focusses on (for electronics see 3.2.3.6).

There are no standard quality or product specifications specific on casings. The test methods under the ISO/TC 61 and CEN/TC 249, that cover the (bio)plastics area, are basically in relation to intrinsic material properties and not functional requirements. Such requirements are linked to the intended use.

When we take an example for instance on cellulose acetate CEN standards and requirements are adopted from ISO (which are not recent, but apparently still valid):

- ISO 585:1990, *Plastics -- Unplasticized cellulose acetate -- Determination of moisture content*
- ISO 1061:1990, *Plastics -- Unplasticized cellulose acetate -- Determination of free acidity*
- ISO 1598:1990, *Plastics - Cellulose acetate -- Determination of insoluble particles*
- ISO 1599:1990, *Plastics -- Cellulose acetate -- Determination of viscosity loss on moulding*
- ISO 1600:1990, *Plastics -- Cellulose acetate -- Determination of light absorption on moulded specimens produced using different periods of heating*
- ISO 1875:1982, *Plastics -- Plasticized cellulose acetate -- Determination of matter extractable by diethyl ether*
- ISO 3451-3:1984, *Plastics -- Determination of ash -- Part 3: Unplasticized cellulose acetate*

Without immediate in-depth study of the texts, there is no apparent hurdle for bio-plastics. This shall however be studied.

Standards for biodegradation and other environmental aspects are under ISO/TC 61/SC 5 (Physical-chemical properties), where similar standards by ASTM are in use by industry as well:

- ISO 10210:2012, *Plastics -- Methods for the preparation of samples for biodegradation testing of plastic materials*
- ISO 13975:2012, *Plastics -- Determination of the ultimate anaerobic biodegradation of plastic materials in controlled slurry digestion systems -- Method by measurement of biogas production*;
- ISO 14851:1999, *Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium -- Method by measuring the oxygen demand in a closed respirometer*
- ISO 14852:1999, *Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium -- Method by analysis of evolved carbon dioxide*
- ISO 14853:2005, *Plastics -- Determination of the ultimate anaerobic biodegradation of plastic materials in an aqueous system -- Method by measurement of biogas production*
- ISO 14855-1:2012, *Determination of the ultimate anaerobic biodegradation of plastic materials in an aqueous system -- Method by measurement of biogas production*
- ISO 14855-2:2007, *Determination of the ultimate aerobic biodegradability of plastic materials under controlled composting conditions -- Method by analysis of evolved carbon dioxide -- Part 2: Gravimetric measurement of carbon dioxide evolved in a laboratory-scale tes*t
- ISO 15270:2008, *Plastics -- Guidelines for the recovery and recycling of plastics waste*
- ISO 15985:2004, *Plastics -- Determination of the ultimate anaerobic biodegradation and disintegration under high-solids anaerobic-digestion conditions -- Method by analysis of released biogas*
- ISO 17422:2002, *Plastics -- Environmental aspects -- General guidelines for their inclusion in standards or the recovery and recycling of plastics waste*
- ISO 17556:2012, *Plastics -- Determination of the ultimate aerobic biodegradability of plastic materials in soil by measuring the oxygen demand in a respirometer or the amount of carbon dioxide evolved*

3.2.3.9 Pre-fabricated constructions

Pre-manufactured construction and insulation components (category 13) appeared to have a lot in common with particle boards and WPC decking (category 11, respectively 12) as they are used in construction and both fall under the Construction Product Directive[15]. The categories had originally been chosen by the project partners due to their different (bio-) constituency, but as they were all semi-finished construction products, the regulations and standards study of these was combined.

3.2.3.10 Fertilizer

The Directive relating to fertilizers is EC/2003/2003. This Regulation lays down rules relating to the placing of fertilizers on the market, i.e. the conditions for designating 'EC fertilisers'. It only applies to mineral fertilisers made up of one or more plant nutrients (or fertilising elements). The Regulation identifies 4 types of fertilizers, as well as the provisions regarding their labelling and packaging:

- main inorganic nutrient fertilisers, i.e. nitrogen, phosphorus and potassium;
- secondary inorganic nutrient fertilisers: these are calcium, magnesium, sodium and sulphur;
- inorganic micro-nutrient fertilisers: these contain elements required in small quantities such as boron, cobalt, copper, iron, manganese, etc.;
- ammonium nitrate fertilisers of high nitrogen content.

A type of fertiliser shall only bear the words "EC fertiliser" if:

- it has no adverse effect on the health of humans, animals, plants or the environment under normal conditions of use;
- it is effective;
- relevant sampling and analysis methods are being provided.

These properties are not well defined in the legislation. The first three types as indicated above are only basing their properties on the composition which is described in the Regulation. Given the dangerous nature of the ammonium nitrate type of fertiliser, the Regulation lays down additional measures such as a detonability test and the following:

- porosity (oil retention) (with test method described in the Regulation)
- combustible ingredients (on composition basis, test method given)
- pH (with test method described in the Regulation)
- particle size (with test method described in the Regulation)
- chlorine content (maximum set at 0,02 % by mass, test method given)
- heavy metals content (copper content maximized and AAS test method indicated, but no limits are specified for other heavy metals).

Functional requirements are not standardized under the relevant standardization committees (CEN/TC 260, ISO/TC 134). The main priorities defining methods of analysis (quality and composition, including testing for unwanted components), size distribution, water content, sampling and harmonized terminology. Elements of fertilizers typically provide, in varying proportions, depending on the crop and environment:

- six macronutrients: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S);
- eight micronutrients: boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn) and nickel (Ni).

CEN/TC 260 had a working group on non-EEC fertilizers, but that has been dormant for a while.

The above means that for bio-based fertilizers there seem to be no standard specification barriers, apart from the fact that most of the determination techniques are based on testing inorganic material. This means that the composition tests methods may not always be applicable from the sample preparation or reference standard perspective. It may mean that new standards shall be developed for organic fertilizers

3.2.3.11 Mulching films

No European Directive specific to the bio-based soil biodegradable plastic mulch films was found. In the U.S., biodegradable plastic mulch products to be acceptable for organic production should conform to NOP standards [25]:

- must be entirely composed of constituents derived from natural resources
- cannot contain synthetics such as petroleum-derived ingredients or additives
- cannot be chemically modified during the manufacturing process
- feedstocks, such as corn, used to produce the polymer, must be free of genetically modified organisms (GMOs) although there is no available test to verify compliance.
- any polymer made from microbial fermentation, such as PHA, must be produced by organisms that have not been genetically modified although there is no available test to verify compliance.
- resins and any inert additives used in the processing and formulation of biodegradable plastic mulch products must be identified and compared to the National List of allowable substances.
- any biodegradable plastic mulch must completely biodegrade into carbon dioxide, water, and microbial biomass within a "reasonable" timeframe without forming harmful residues or by-products.

As a consequence of all these regulations, organic growers in the US may not use soil biodegradable mulching films to replace the conventional petroleum based plastic ones. These materials are expected to be allowed also in the US in the near future [26]. Relevant US regulations are available [27][28].

The Belgium Royal decree (9/09/2008) effective in July 2009 specifies the norms that the products should meet to be compostable or biodegradable. On that basis, Vincotte is running the OK biodegradable SOIL & OK biodegradable WATER certification label[1].

Standards are available such as EN 13655: Plastics - Mulching thermoplastic films for use in agriculture and horticulture. This European Standard is applicable to transparent films, transparent clear and diffusing films (thermic) and black or black/white films based on polyethylene and its copolymers, which are designed to be used for mulching the vegetable, fruit and flower crops. This Standard specifies the basic requirements for the optical and mechanical characteristics of various types of film. From a detailed consideration of the different mulching plastics films used in agriculture and horticulture in the European market, different types of film are considered: - transparent films (normal) - transparent clear and diffusing films (thermic) - black and black/white films The range of thicknesses considered is from 10 µm up to 250 µm. ASTM is still developing a standard under the title: New

[1] http://www.okcompost.be/en/recognising-ok-environment-logos/ok-biodegradable-soil-amp-ok-biodegradable-water

Specification for Virgin Plastics that biodegrade in Soil under Aerobic Laboratory Conditions (WK29802).

Certification by Organic Growers & Farmers for use in organic growing systems (Reg. no. UKE0461) requires a 100% biodegradable film made from GMO free renewable raw materials. The statement made by the EPI-AGRO organic growers association [29] is that mulching films fit to some specific crops, but it cannot be used (for practical and economic reasons) on main arable crops. Recent developments try to fit biodegradable mulching films to corn cultivation, but the cost is still the limiting factor.

Apart from the mulching as such and the biodegradability properties, films do have specific functionality standards that may apply:
Functional properties testing methods

- ASTM D 1003 Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics
- ASTM D 638-10 Standard Test Method for Tensile Properties of Plastics.
- ISO 4591:1992 Plastics -- Film and sheeting -- Determination of average thickness of a sample, and average thickness and yield of a roll, by gravimetric techniques (gravimetric thickness)
- ISO 4593:1993 Plastics -- Film and sheeting -- Determination of thickness by mechanical scanning
- ISO 4592:1992 Plastics -- Film and sheeting -- Determination of length and width
- ISO 527-3:1995 Plastics -- Determination of tensile properties -- Part 3: Test conditions for films and sheets
- ISO 7765-1:1988 Plastics film and sheeting -- Determination of impact resistance by the free-falling dart method -- Part 1: Staircase methods
- ASTM F739 - 12 Standard Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Continuous Contact
- ASTM E96 / E96M - 13 Standard Test Methods for Water Vapor Transmission of Materials

All of these test standards do not seem to present direct barriers for bio-based (mulching) films.

3.2.3.12 Paints

Applicable European regulation is Directive 2004/42/CE of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC. This Paints Directive covers paints for use on buildings, their trims and fittings and structures associated to buildings and products for vehicle refinishing. It is basically limiting VOCs but not setting functional requirements. Of course for the components used for paints, the REACh regulation applies (mainly on te solvents)

The only harmonised standards for paint are under the Regulation on construction products (305/2011) is EN 1504 'Products and systems for the protection and repair of concrete structure', part 2 to 7 (by CEN/TC 104 Concrete and related products). The requirements in market product specifications are based on the testing of coatings provided by the testing organizations such as TUVRheinland and Chemir. Properties that are certified are then: thickness, porosity, adhesion, hardness, scratch resistance, impact resistance, abrasion resistance, dirt retention, water vapour permeability, tensile tests, internal stress, slip resistance, colour, gloss, coverage, density, solids percentage, fineness, surface tension, or viscosity.

Next there is a long list of standards developed by CEN/TC 139 for testing of paints, most of the developed in coordination with ISO/TC 35 and ASTM D01. They also depend on the type (or application) of the paint. There are however no standard (quality or product) specifications. A brief look through the test methods standards doesn't give any functionality test barriers for bio-based paints. Because of the long existence of bio-based paints it seems also that these have been taken into account from the beginning of the standards' development

3.2.3.13 Lubricants

The EU Ecolabel for lubricants sets specific requirements considering criteria for the bio-based share of raw materials[16], biodegradability[17] and bio-accumulative potential[18] for the labelled fluids. A series of national regulations promoting bio-based lubricants have been reported in [10]:

- French law 2010-788 (12/7/2010) article 112 (amending the Farming Bill section 44, Act 2006-11 of the 5th of January 2006) prohibits, in natural areas classified as “sensitive”, the use of fossil based lubricants which can be easily substituted with biodegradable non-ecotoxic lubricants that meet the criteria for the European Ecolabel (2005/360/EC directive).
- In Germany, Austria, and Switzerland regulations are in place that forbid the use of mineral oil-based lubricants around inland waterways and in forest areas. In addition, the German federal government has introduced a program called “Market Introduction Program (MIP) Biolubricants and Biofuels” for the reimbursement of costs associated with substituting mineral oil-based lubricants for lubricants based on renewable resources with a mass content greater than 50%.
- In Italy, there is a tax on mineral oils and products that contain them.
- Belgium has enacted legislation that requires bio-lubricants to be used in all operations that take place near non-navigable waters.
- In the Netherlands, the Dutch Ministry of Spatial Planning, Housing and the Environment issued a policy and action program in favour of bio-lubricants in 1996. Tax incentives affecting bio-lubricants are operated, which allows for the accelerated depreciation of environmental investments.

Apart from ecotoxicity, biodegradability and bio-based content, not much is required from a legal perspective when it concerns bio-lubricants. Obviously there are several ISO specifications for lubricants, greases and other lubricating fluids. ISO 6743 sets a single class wherein 18 families of products are defined to cover all applications for which lubricants are used, apart from many industry specific requirements. The newly developed CEN specification[12] for bio-lubricants and bio-based lubricants has chosen to require similarity in the properties.

3.2.3.14 Cosmetics

Here sun lotion is taken as the exemplary product. Regulation 1223/2009/EC on cosmetic products applies. The Regulation establishes rules to be complied with by any cosmetic product made available on the market in order to ensure the functioning of the internal market and a high level of protection of human health. It basically requires that all products to be marketed in the EU must be registered in the Cosmetic Products Notification Portal (CPNP) before being placed on the market. Colorants, preservatives and UV-filters, including those that are nanomaterials, must be explicitly authorised. The only standard harmonised under the cosmetics regulation is EN ISO 22716:2007, Cosmetics - Good Manufacturing Practices (GMP) - Guidelines on Good Manufacturing Practices. In general it doesn't set functional requirements to the products. Same is valid for the USA, where there is the FDA Guidance for Industry Cosmetic Good Manufacturing Practices[2].

Several (national) certification schemes and labels are available for cosmetics[3], for example:

- Italian Association for Organic Agriculture's certification. They certify organic products and companies in a broad range of categories, including cosmetics and bio-fibres.
- International Organic and Natural Cosmetics Corporation BDIH Standard
- Coalition for Consumer Information on Cosmetics' (CCIC) Leaping Bunny Program make a voluntary pledge to eliminate animal testing from all stages of product development
- Ecocert natural cosmetics (ICCO)

These systems focus on the absence of GMOs and other constituents, the use of bio-based or organic farming-based ingredients or even on the packaging but not on the products as such.

CEN/TC 392 Cosmetics and ISO/TC 217 Cosmetics standards developed specific on sun lotions are:

- CEN ISO/TR 26369:2009, Cosmetics - Sun protection test methods - Review and evaluation of methods to assess the photoprotection of sun protection products
- EN ISO 24442:2011, Cosmetics - Sun protection test methods - In vivo determination of sunscreen UVA protection
- EN ISO 24443:2012, Determination of sunscreen UVA photoprotection in vitro
- EN ISO 24444:2010, Cosmetics - Sun protection test methods - In vivo determination of the sun protection factor (SPF)

[2] http://www.fda.gov/Cosmetics/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/default.htm
[3] see: http://www.ecolabelindex.com/ecolabels/?search=cosmetics&as_values_095=

It doesn't seem that functionality standards barriers exist for bio-based cosmetics and sun lotion in specific

3.2.3.15 Fabrics

Legislation in place in Europe is Regulation 1007/2011/EC of on textile fibre names and related labelling and marking of the fibre composition of textile products. The regulation concerns the composition of the textile products which must be provided using harmonised fibre names. All products containing at least 80% by weight of textile fibres, including raw, semi-worked, worked, semi-manufactured, semi-made, made-up products are covered in the Regulation. It also stipulates methods to check on whether the composition of textile products is in conformity with the information supplied (on the label). Another more generic Directive is 2001/95/EC on general product safety, which lays down general safety requirements that apply to all consumer products placed on the EU market, whether used, new or reconditioned.

There are several ECO labels applicable, for example:

- GOTS (Global Organic Textile Standard), the aim of which is to define world-wide recognised requirements that ensure organic status of textiles, from harvesting of the raw materials, through environmentally and socially responsible manufacturing up to labelling in order to provide a credible assurance to the end consumer;
- Organic Content Standard is a chain-of-custody standard that give third party verification to a final product containing a given amount of organically grown cotton. It does not address the use of chemicals or any other aspects of production beyond the integrity of the organic fibre;
- OEKO-TEX.

Test methods are for textiles are under the scope of:

- CEN/TC 248, Textiles and textile products
- ISO/TC 38, Textiles
- ASTM Committee D13 on Textiles
- AATC (American Association of Textile Chemists and Colorist)

For example:

- ISO 5085-1:1989, Textiles - Determination of thermal resistance - Part 1: Low thermal resistance, and
- EN ISO 9237:1995, Textiles - Determination of permeability of fabrics to air

The requirements in the market are based on the testing of textile provided by the testing organizations such as Intertek and Precision. Producer or buyer requirements are not publicly available

Functional requirements for fabrics are for instance:

- physical and mechanical characteristics (weight and thickness, fabric strength, tensile strength, tear strength, seam strength, burst strength, stretch properties, fabric abrasion resistance, aesthetic properties of fabrics);

- appearance (pilling testing, wrinkling, Seam puckering, dimensional stability, light reflectance),
- permeability,
- comfort (thermal, moisture and comfort, ease of movement, sensory comfort)
- dyeing and colouring (assessing colour and colour change, change in shade and staining, light fastness, wash fastness),
- flammability, and
- other such as antibacterial or UV protection properties

It however doesn't seem that the testing as such present barriers for bio-based fabrics.

3.2.3.16 Boat hulls

The European Directive on recreational craft in general is Directive 2003/44/EC. The Recreational Craft Directive establishes safety requirements for the design and construction of craft, requirements for exhaust emissions from propulsion engines and requirements for noise emissions from propulsion engines. There are harmonized standards under this Directive[4]. Harmonized standards for boat hulls are developed under ISO/TC 188, *Small craft (less than 24 metres in overall length)*:

- EN ISO 12215-1:2000, Small craft — Hull construction and scantlings — Part 1: Materials: Thermosetting resins, glass-fibre reinforcement, reference laminate
- EN ISO 12215-2:2002, Small craft — Hull construction and scantlings — Part 2: Materials: Core materials for sandwich construction, embedded materials
- EN ISO 12215-3:2002, Small craft — Hull construction and scantlings — Part 3: Materials: Steel, aluminium alloys, wood, other materials
- EN ISO 12215-4:2002, Small craft — Hull construction and scantlings — Part 4: Workshop and manufacturing
- EN ISO 12215-5:2008, Small craft — Hull construction and scantlings — Part 5: Design pressures for monohulls, design stresses, scantlings determination
- EN ISO 12215-6:2008, Small craft — Hull construction and scantlings — Part 6: Structural arrangements and details
- EN ISO 12215-8:2009, Small craft — Hull construction and scantlings — Part 8: Rudders
- ISO 12215-9:2012, Small craft — Hull construction and scantlings — Part 9: Sailing craft appendages

Classification societies (such as Lloyd's Register, Bureau Veritas, American bureau of shipping) set technical rules (i.e. market specifications), confirm that designs and calculations meet these rules. They also survey ships and structures during the process of construction and commissioning, and periodically survey vessels to ensure that they continue to meet the rules. For example Lloyds register has a series (8 parts) on the market 'The Rules & Regulations for the Classification of Ships 2013[5]. Two of those parts are more directly related to sport yachts:

[4] , http://ec.europa.eu/enterprise/policies/european-standards/harmonised-standards/recreational-craft/index_en.htm
[5] http://www.scribd.com/doc/164195759/Rules-and-Regulations-for-the-Classification-of-Ships-July-2013.

1) *Rules for the manufacture, testing and certification of materials*. This part describes the required tests per material. For example, metallic materials required tests: tensile, impact, bend, corrosion, hardness, crack tip opening displacement, embrittlement. Based on this documents the characteristics per material used for boats can be derived.
2) *Ship structures (general)*. Describes requirements of the hull, such as hull bending strength, hull shear force and quality insurance scheme for the hull construction of ships.

ECO Labels are normally applicable to 'whole' ship and not particular on the hull. Blue Angel certifies environmentally friendly ship design and ship operations (RAL-UZ 110).

In general it is difficult to determine if test method hurdles exist as all depends more on construction and design.

3.2.3.17 Adhesives

Apart from REACh, no specific regulations have been found. CEN/TC 193 "Adhesives" develops standards. Some examples of product specifications are:

- EN 12436, Adhesives for load-bearing timber structures - Casein adhesives - Classification and performance requirements
- EN 14259, Adhesives for floor coverings - Requirements for mechanical and electrical performance
- EN 14814, Adhesives for thermoplastic piping systems for fluids under pressure – Specifications
- EN 15274, General purpose adhesives for structural assembly - Requirements and test methods
- EN 15425, Adhesives - One component polyurethane for load bearing timber structures - Classification and performance requirements

Furthermore there are a lot of test methods. Next, ISO/TC 61/SC 11 has a few standards on test methods for isotropic electrically conductive adhesives and on the evaluation of the adhesion interface performance in plastic-metal assemblies.

Looking at the above it seems that already some bio-based adhesives are covered. Each of the above specifications gives requirements and test methods so it gives quite good idea f the market requirements. There are no immediate obvious hurdles from within the test methods standards

3.2.4 Bio-based plastics used in the agro-food sector

The Agricultural University of Athens has used the results of the work of nova-Institute and NEN to study the functional barriers due to the perceived uncertainty about bio-based product properties certified through alternative test methods, and weak market transparency that hinder the fast take-up of these products. That work included communication, standardisation, labelling and certification as well as disposal routes and environmental

regulations on the planned legal controlled or accidental disposal of the bio-based products (e.g. ecotoxicity, biodegradation, recyclability, etc.). The effect of these functional barriers on public acceptance and market value of these products (e.g. disposal management and possibilities and disposal cost) with the view to adjusting, developing, harmonising and validating test methodologies have been judged.

The categories studied are: agricultural bio-based (mulching) films, bio-based packaging films and bio-based lubricants used in agro-forestry. In all of the three product categories, the physical properties depend on the feedstock and on the process intermediates. These do not present inherent issues for bio-based variants. Water vapour permeability and radiometric properties (colour or sun-light blocking) can be different for bio-based products. These properties can be beneficial or not depending on the application, the local conditions and season. Oxidation stability is an inherent weaker property for bio-based lubricants so they might need additional work or additives compared to their fossil-based competitors.

The main properties that have an effect on the bio- and non-bio-based variants of these products are the degradation of mechanical properties during useful life-time versus the effective bio-degradation in soil or surface water or under composting conditions. These are properties that can be made equal but mostly at a cost. They therefore form barriers on one hand for some product applications, but not necessarily for the whole agro-food market. On the other hand they also present several advantages and new market applications.

Biodegradation in soil is a particularly relevant end-of-life option for bio-based materials used in agricultural applications. Bio-based materials that are compostable are not necessarily biodegradable in soil. For bio-based materials which do degrade in soil, the rate of degradation can vary considerably, depending not only on the molecular structure of the material, but also on soil characteristics and soil conditions such as temperature, water and oxygen availability which influence microbial activity. There are a few norms and standards, or non-standardised testing methods on testing plastics for biodegradation in soil. They all determine biodegradability under normalized circumstances, which may deviate from the behaviour of biodegradable plastics under real soil conditions and can cause questions on transferability of results in different soil types. It is important that the tests should be run in media simulating the conditions of the end of life management of these materials. Besides a biodegradation test method, also pass levels and a time frame need to be defined in order to determine that a bio-based product will biodegrade sufficiently under soil conditions. Currently no European or international specification exists that defines criteria for biodegradation of bio-based products in soil, whereas an ASTM Standard is under development [4].

Currently there are no standards for measuring the biodegradability of lubricants in soil. Concerning biodegradability in fresh water, international and American test methods have already been developed [5]. These standards already include more guidance for resolving difficulties related to complex mixtures. Besides the ISO and ASTM standards, there are

several testing methods concerning pure chemicals or the constituents of the lubricants. For instance in Europe OECD guidelines are widely used. In order to apply the OECD test procedures for evaluating biodegradability of complex mixtures, further research is necessary

As recycling of bio-based food packaging materials may not be technically sound or economically feasible, composting of biodegradable food packaging waste is a viable alternative. ASTM, ISO and CEN standards on (industrial) compostability exist. The standard specifications by the same organizations for the compostability under municipal and industrial aerobic conditions for different product categories (plastics, packaging, etc.) are based on the same criteria (biodegradation, disintegration and environmental safety including ecotoxicity tests and chemical characterization). In addition, the CEN documents provide detailed guidelines for evaluation of biodegradability and compostability of packaging and packaging components, and plastics, respectively, based on their characterization, biodegradability, disintegration, and compost quality/ecotoxicity. So far, no international standards exist with regard to specifications for home compostability. Only in Australia a norm has been published[6].

The total study on the agricultural sector barriers and solutions will be part of the next deliverable of the KBBPPS project

4 Other barriers – political framework, communication and information

4.1 Non-technical barriers assessment

Even though the main focus of the survey was on technical barriers of bio-based products that can be resolved through improved testing procedures, also other market barriers were examined. The four main areas covered by the survey were:

- Political framework
- Marketing / image / information
- Standards / labelling
- Finance

The respondents were also asked to make suggestions for ways of solving the identified barriers. The following sections will therefore summarize and analyse the indicated barriers and also the solutions, if any were proposed. For the purpose of keeping the results concise and informative, this text will only focus on concrete examples and measures – barriers such as “unfavourable political framework” or “image needs to be improved” will not be included in the analysis, since they do not contribute to identifying the real underlying causes and helpful steps. Since such general answers were given quite frequently, the sample sizes for each group of non-technical barriers are significantly smaller than the overall sample. Also solution proposals such as “legislation should be guided by science, not by financial interest” will not be considered, since they are too general and not conducive to our goal of coming up with realistic and concrete proposals for measures to resolve barriers.

4.2 Barriers in political frameworks

A total of 13 respondents gave concrete answers to the question “Can you think of any other barriers for the development of the bioeconomy in Europe? a) Political Framework”. Figure 2 shows the clustered answers. Since the question was an open one, multiple answers were possible:

Interestingly, more than half of the answers revolved around the **subsidy system for bioenergy and biofuels, embodied in the Renewable Energy Directive** on the European level. Respondents indicated that the support for the energy use of biomass makes feedstocks too expensive, thus creating market distortions since the support is not counter-balanced by any incentives for the material use of biomass.

Solution-wise, not many ideas were collected. Two respondents suggested to introduce a support system for bio-based materials similar to the RED, but did not go into detail. nova-Institute published a paper: ”Proposals for a Reform of the Renewable Energy Directive (RED) to a Renewable Energy and Materials Directive (REMD)” on this exact problem in May

2014. The paper analyses the market distortions in much detail and presents very concrete ideas how they can be resolved (Carus et al. 2014b, [1]).

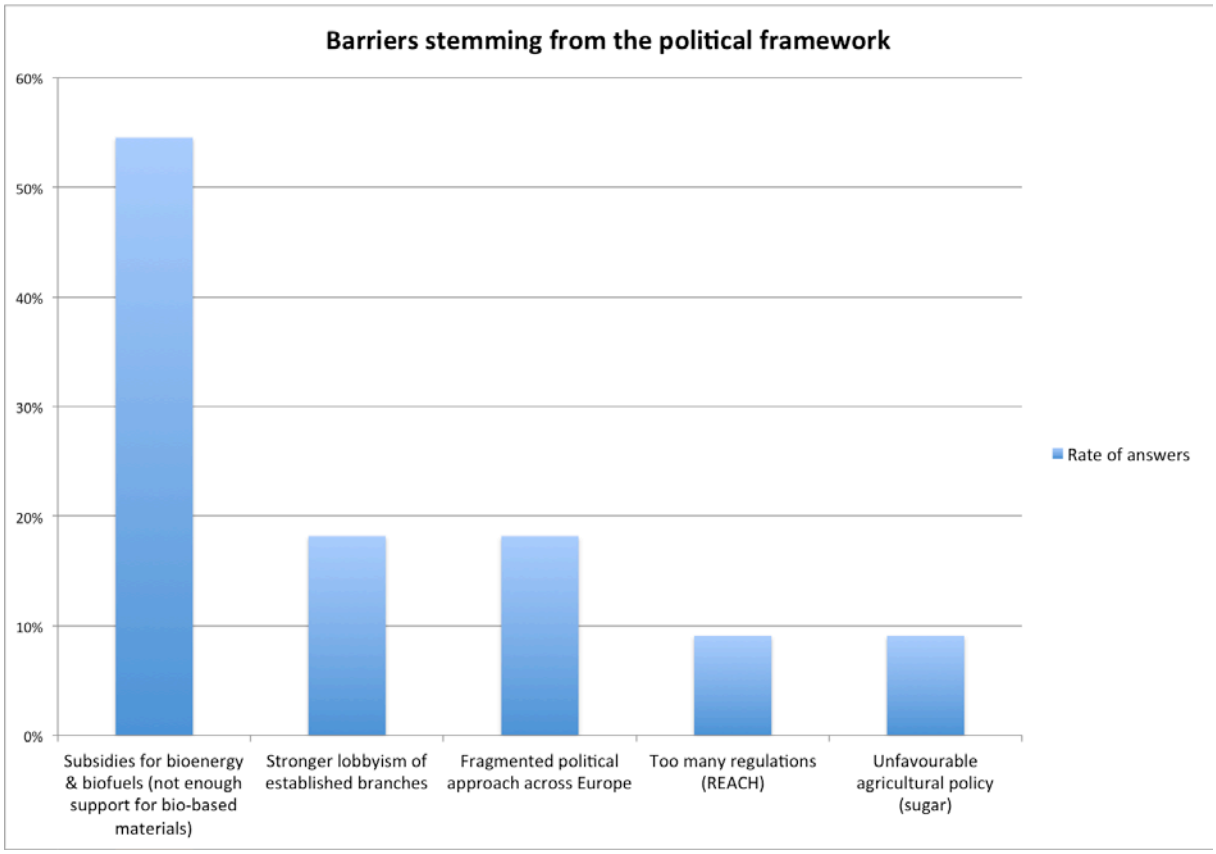


Figure 2: Barriers due to political framework, clustered answers

The second-most named barriers were the circumstances that firstly, policy making is strongly influenced by **lobbyism** and that new bio-based materials are therefore disadvantaged, since the established branches have much more standing and resources to take care of their interests; and secondly that policies for bio-based materials are currently **too fragmented** as there is very little awareness for a bio-based materials as a joint group of interest to be effective. It is recommended that more policy initiatives on this topic are summarized under the European umbrella, since also the market for BBP is not national, but at least European if not global.

The difficult procedure of admitting new chemicals to the European market via **REACH** was also given as one of the problems of new, bio-based chemicals. Furthermore, the **Common Agricultural Policy (CAP)** of the EU and its sugar quotas was mentioned, since it makes bio-based feedstock more expensive. The remark did not reflect the fact that the sugar quotas will be abolished from 2017 on due to the recent CAP reform, so it remains to be seen how the price levels of sugar will develop from then.

In terms of solutions of market barriers for BBP, some other ideas were collected: One respondent suggested to introduce market quotas for BBP, one suggested to impose taxes on fossil materials or fossil CO_2 emissions. Both proposals seem too difficult to achieve under the current political circumstances to follow up on.

More accessible was the idea to make **public procurement of bio-based products** preferable. The EU is currently already looking into the possibility of using public procurement as a market pull for BBP, but the legal security, tender specifications etc. still need to be checked. Two more specific ideas of regulations that could be addressed to remove market entry barriers were also:

- **The European Food Safety Authority's (EFSA) regulations** make it necessary to prove every new plastic that is introduced as food packaging. This procedure is very expensive and lengthy. It would be helpful to offer intermediate solutions for plastics while they are being accredited or to make the process easier as a whole.
- The **Waste Framework Directive** 2008/98/EC should set up **end of waste criteria for compost and digestate**, so that they are not defined as waste and could therefore be marketed as bio-based products (e.g. as fertilizer and soil improver) or as precursors to even more high-value BBP. This would also serve to strengthen the declared EU goal of a circular economy and cascading use of resources.

4.3 Barriers in marketing, image and information

Concerning marketing, image and communication of information, the most commonly seen barrier is unclear communication that might lead to a sense of green-washing, driving customers away due to "false claims". Figure 3 shows the clustered answers in this category.

As a result of the inadequate and misleading communication, consumers' awareness of bio-based materials and products is very low. One respondent claimed "In spite of the many conferences, events etc., most (also educated) people have a very confused idea on bio-based products. As a consequence, no specific recognition is possible or if it happens is not based on clear ideas but it is just emotional. Emotions are labile…", with another confirming "Communication and education are very important to get matters in the right perspective. Even journalists who write often about the subject sometimes make disturbing mistakes (technical, not opinion), but also politicians often don't understand the subject." Many respondents recommended as a solution measure to start education on bio-based products and their properties already early so that young people know more about these topics. As consumers of the future, their decisions will be crucial for this also young industry.

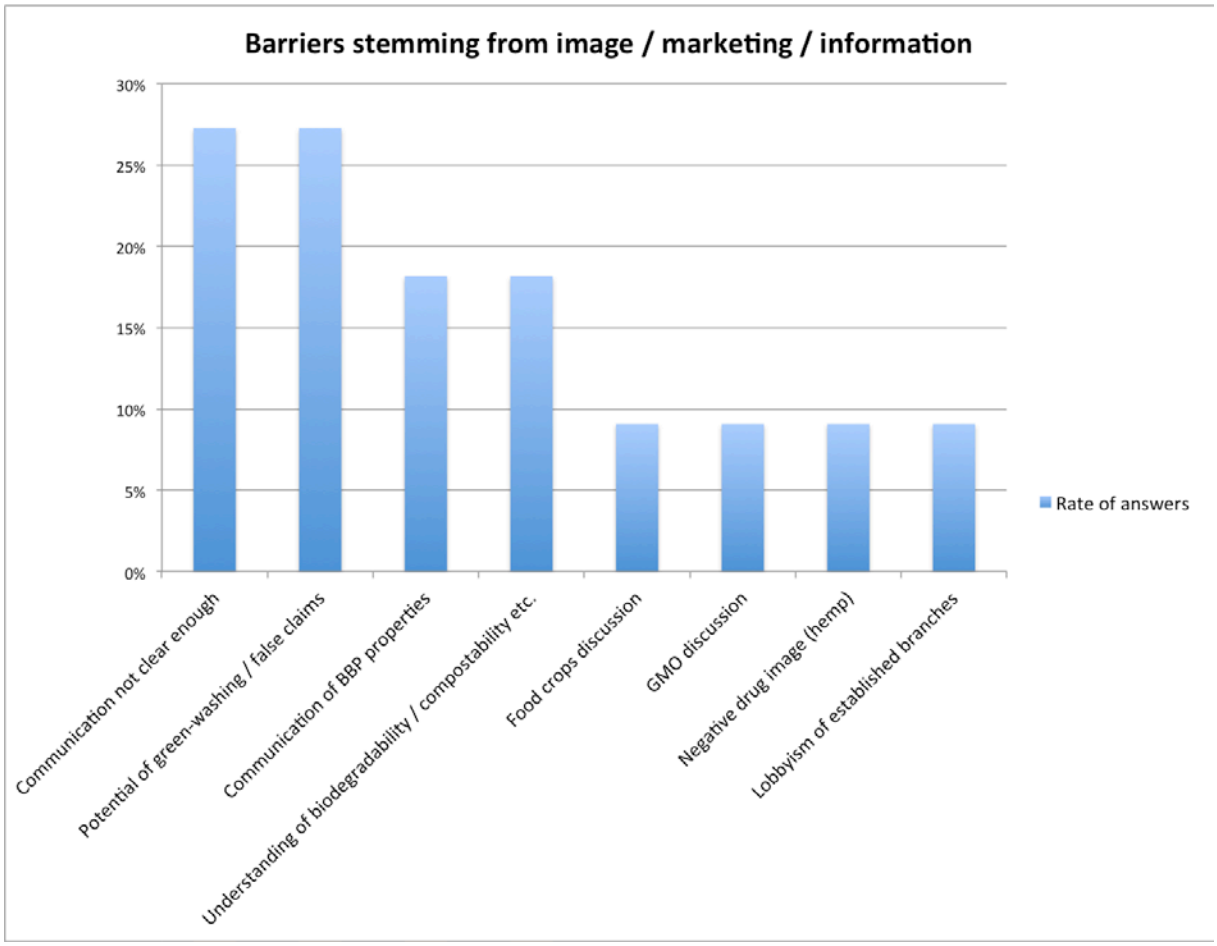


Figure 3: Barriers in image, marketing and information, clustered answers

In order to avoid false claims and green-washing, many respondents thought that it is necessary to establish strict rules about product communication, to make it clear and reliable. Especially for bio-degradability, it was warned that "strong market action against 'fake' biodegradable products" should be taken. This was most probably directed against so-called "oxo-degradable" products, but not clarified in the answer (on the difference between biodegradability and oxo-degradability, see Ißbrücker 2014[2]).

Another interesting proposition was to increase education about home-compostability not via companies, but via the local authorities that are in charge of collecting bio-waste. This seems like a very practical suggestion, since this would automatically include the main stakeholders of a given region and make it possible to adapt any communication campaign to the specific local context.

4.4 Barriers in finance

The financing and investment climate for bio-based industries in Europe is not easy. It is expected that overall global capacity of e,g. bio-based chemicals will double to 13.2 million tonnes, but that Europe's share of that will drop from 37% in 2005 to 14% in 2017 (Bio Based Press 2014 [19]). This reason for this lies to a large extent in the circumstance that a lot of

research and development is done in Europe, while the commercialization and production is often done in other parts of the world, mainly the Americas or Asia, where framework conditions are easier for many entrepreneurs (Carus et al. 2014 [1]).

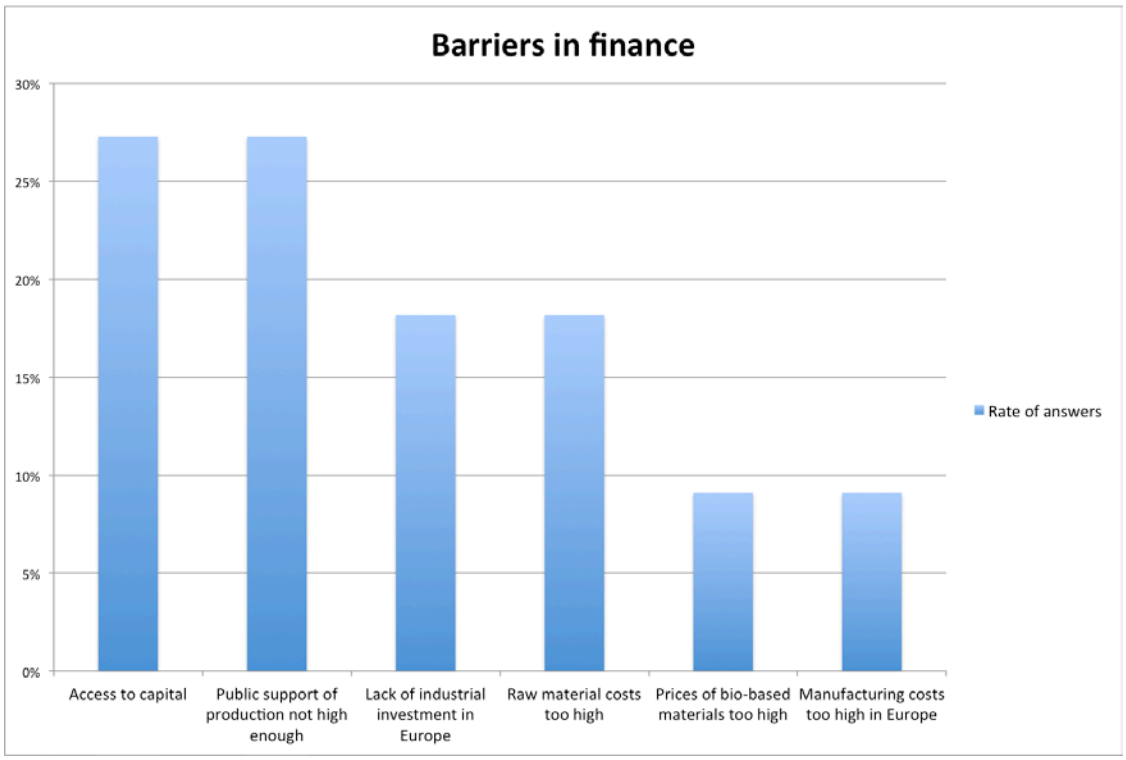
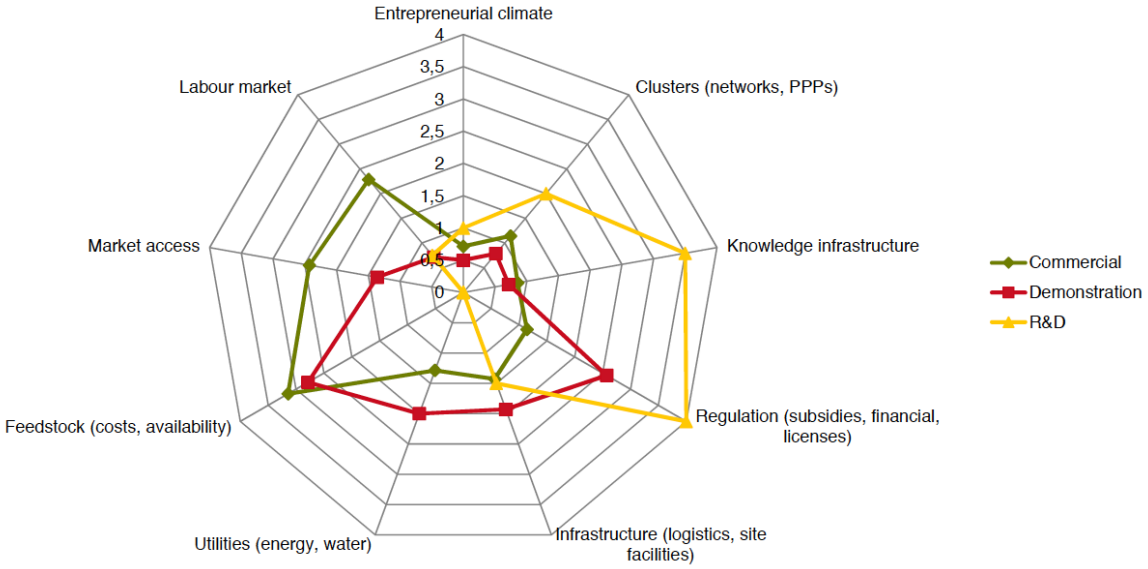


Figure 4: Barriers in finance, clustered answers

The main barriers quoted by the participants in this survey were “access to capital” and “lack of public support in production” (Figure 4). However, when looking more closely, it becomes clear that these two, and also the third answer “not enough industrial investment in Europe” are different aspects of the same issue, all of them closely linked to inappropriate political framework conditions. The above mentioned study on investment in bio-based industries illustrates that there are usually four different ways for companies to acquire funds for the development of new, bio-based products, but there are only three ways to acquire capital for the production process: The money for R&D can come from banks, venture capital funds, industrial investments or public funding. When companies enter the demonstration phase, public funds get very thin. And for the up-scaling to commercial stage, there is usually no public funding at all and the banks are not eager to support production of something which is not a proven standard but something new. “Access to capital” therefore is the umbrella problem, and both public funding as well as industrial investment are sub-categories for that.

The last three answers “raw material costs too high”, “prices of bio-based materials too high” and “manufacturing costs too high in Europe” on the other hand describe reasons, why investors shy away from putting money in innovative bio-based processes and materials. A parallel study that was done on investment in bio-based industries by TNO, Netherlands,

analysed the motivating factors for investors to make decision for or against an investment opportunity in the three different phases R&D, demonstration and commercialization:



For each type of investment the figure shows the **average weight of each criterion considered** for deciding on a go/no-go and/or chosing a location. Weights are calculated on the basis of a collection of 'top 5' rankings. A weight of 5 stands for an average rank score of 1; a weight of 1 stands for an average rank score of 5; a weight of 0 means absence from any individual top 5).

Figure 5: Criteria determining bio-based investment decisions[3]

Especially the feedstock costs, but also the labour costs and utilities that greatly determine the manufacturing costs, are clearly very important for any investment decision in the commercial stage. At the moment, Europe does not offer enough advantages in these cost categories compared to other regions in the world and therefore does not have enough competitive edge to secure bio-based production here.

Suggestions for solutions from our survey included more funding for start-ups to invigorate innovation, and to base funding decisions on clearer priorities, choices and strategies to avoid spreading the money too thin. Others suggested reducing taxes either in the manufacturing stage for market push, or on the consumer end (e.g. for compostable products) for market pull, easing the financial strain for companies.

4.5 Barriers in standards and norms

Apart from the technical barriers resulting from standards and norms that were analysed in Chapter 3, mostly general statements were made about the helpfulness of standards and norms. Most participants claimed that binding standards would be helpful for bio-based products to enter the market, since they create confidence with consumers and help prevent false claims. However, it was also mentioned a few times that the verification / certification of such a standard should not be too complicated and thus not too expensive for the

companies. Both norms and regulations, that support environmentally preferable products (not necessarily bio-based) were recommended as well as certificates that promote only the bio-based content.

Also, the “jungle” of certifications and labels was mentioned, creating confusion for the consumer. Accordingly, only a few, European-wide and horizontal systems should be put in place to label bio-based products.

5 Conclusions and next steps

5.1 General conclusions

The bio-based products industry today does not suffer from a lack of standards in general. It is very specific from product to product, whether standard specifications adequately address product functionality and especially whether they are correctly interpreted by the market.

On the product functionality as such it can be concluded that most of the products studied follow either industry internal specifications or are specified by applying international or European standards, however, in a broad and sometimes incomplete sense. Industry specifications and test methods are difficult to obtain. This means that bio-based products need to present similar-or-better properties compared to conventional products. They may even be claimed or assumed as such, without an effective assessment. Especially when the requirements as such are not too strict for the effective functioning of the product. Historic reasoning prevails in many of these cases.

Where product specifications are set by (EU) regulations they merely focus on a specific property (bio-content, re-usability, toxicity, etc.). These tests are mostly not a barrier for bio-based products. Constructive or design limitations for bio-based products are rare and hardly specified by regulations or international standards. The product specifications are mostly accompanied by (an abundance of) standard test methods, but these can also be quite specific depending on the material or the specific application. Further study is required whether the test or the limit in each case presents an actual barrier. A brief assessment and the industry enquiries, both as part of the project, brought no immediate barriers forward. Except in a few cases (see also Table 2), for which the essence (or even the validity) of the identified barriers also need to be investigated.

The general barriers in terms of regulations, standards and common market requirements can be listed as follows:

a. Where bio-based products present a benefit in terms of end-of-life options (biodegradation, compostability, recyclability) this is not recognised or the benefits are not (reliable) comparable due to the lack of standardized or accepted test methods;
b. Some technical requirements (and related test methods) based on experience with traditional materials are not relevant or they are set too strict for the actual application of the product and therefore present a barrier to bio-based alternatives;
c. Long term stability of essential properties (under the influence of air, moisture, UV radiation or micro-organisms) is sometimes difficult to prove because of the lack of good test methods and then causes insecurity (with the users) in the market;
d. Related to c., knowledge about the impact on bio-based alternatives of high impact degeneration processes as part of durability test methods is lacking;
e. Some environmental limitations (such as for instance VOCs) ,

Apart from the above it might make sense to check some specific test methods to see if they have specific technical drawbacks towards bio-based products (see §3.2.3).

5.2 Synthesis and further steps

In the next part of the KBBPPS project, the most relevant bottlenecks will be further studied and a resolution plan developed. In the follow-up project Open-Bio, further research will be conducted in order to pinpoint and resolve bottlenecks in mechanical, chemical and other functionality testing. In order to prepare this, the results of the bottleneck analysis were combined and discussed with the partners involved in the follow-up research. Aside from discussions during the 2014 project meetings in York in February and in Wageningen in November, the Advisory Workshop in Cologne in April 2014 and several teleconferences held between NEN, nova, DLO-FBR and AUA on 23 April, 28 April and 1 December 2014, were used to agree on the further steps.

As a result of these discussions, the list of the original 22 product categories has been shortened to seven (see Table 2) for further study. The factors for selecting these product groups were existence of relevant barriers in terms of technical product properties, relevant market shares and existing testing facilities within the project consortium. The resolution plan, being the next deliverable of the project, shall merely focus on these product categories and also the specific functionality (test method) standards of them will be part of it.

Table 2: Selection of products for further study

Bio-based product		Hurdle	Type of hurdle		
			Specification lacking favourable BBP properties	Less important specification not fulfilled by BBP	Bio-applicability missing from regulations
1	**Packaging films** (PLA + PBAT / PBAT + additives)	Lack of European standard for compost and digestate			X
		Disposal via anaerobic digestion is not regulated / incentivized enough			X
2	**Disposable cups and plates** (PHA-coated paper, mineral fillers)	High temperature requirements (which are not even reached by the contents of the cups) cannot be fulfilled by bio-based materials		X	
12	**WPC decking from extruded profiles** (60% wood flour + PP + additives)	Combusting and technical properties for construction products		X	
		No regulations for end-of-life options			X
13	**Pre-manufactured construction components** (insulation)	Good properties such as high heat transfer (decrement) delay and good acoustic performance are not included in standards	X		
		Moisture Permeability Vapour Open Construction is not acknowledged in some Member States. Airtight moisture permeable membranes are not understood.	X	X	X
		In some Member States only lambda values < 035 are accepted, discriminating against natural materials		X	X
14	**NPK-Fertilizer**	Purity regulations which cannot be fulfilled by processes other than chemical synthesis		X	
15	**Mulch films** (starch blend)	No European regulation available (only French standard NF U 52-001)	X		X
		General standard specifications are not 100% applicable and do not comply with the specific application of the mulching films			X
		Confusion because of lack of standard specifications that distinguish between biodegradable in soil and oxo-fragmentable.	X		
24	**Adhesives and binders**	Overly ambitious norms for adhesive powers; best before date		X	
		Missing regulations on emissions, bio-degradability	X		X

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