



# **Renewable Feedstock for Sustainable Materials**

**- BIOPRODUCTS -**

## **Their Importance to Wales: A Scoping Study**

**November 2002**

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## **FOREWARD**

In early 2002, the Welsh Development Agency commissioned this present study to provide a snapshot of the current level of activity within the Welsh 'bioproducts' industry, to scope the potential for further development as well as to put forward suggestions for a strategy to support this nascent sector. Whilst this study was originally conceived as short 'look-see' type of a project, it rapidly became apparent that this was an extremely complex area, often dealing with rather nebulous concepts. This, originally, short project has run into a fascinating 'journey' for those involved in it. The project team is extremely indebted to Mr Anthony Armitage of the WDA for his forbearance. The lengthy 'gestation period' has, nevertheless, allowed for a period of reflection which, it is to be hoped, has resulted in a far more rounded and comprehensive study.

The project team consisted of Dr Robert Elias (Centre for Advanced and Renewable Materials), Dr Mark Hughes, Mr Andrew Norton and Dr Saija Turunen (The BioComposites Centre, University of Wales). All members of this team were involved in the authoring of this report. Grateful thanks are extended to Dr Jeremy Tomkinson also of the BioComposites Centre for his critical review of the early drafts of the report and to Mr Gary Newman of BioFibre Ltd for his valuable comments on the final draft. Finally, the team is greatly indebted to the individuals, businesses and organisations that gave freely of their time and expertise.

## EXECUTIVE SUMMARY

### Introduction:

Renewable biomass feedstock forms the basis of many successful industries. The pulp & paper and wood products industries are admirable examples of enterprises that use renewable feedstock extremely effectively and profitably. As a means of supporting long-term sustainable technological growth, the development of industries, based substantially upon a renewable feedstock and that are independent of fossil reserves, are of paramount importance.

Annual industrial crops, grown for fibre, oils or other materials could provide the necessary feedstock to supply a number of industries. Whilst there has been some limited commercialisation of processes based upon these 'renewables', many other industries could begin to utilise this raw material to manufacture their products in a more sustainable fashion; to manufacture so called 'bioproducts'.

This present study was envisioned to provide the necessary platform upon which to develop an effective strategy to support the emerging bioproducts industry in Wales. Background research for the study consisted not only of an appraisal of the status of bioproducts world-wide and the drivers and barriers dictating commercial growth, but also an extensive survey of industry and recognised experts in the field. The survey consisted of both personal interviews and a questionnaire sent by mail. Through this, the authors believe that a 'rounded' assessment of the current state of play of the bioproducts industries within the UK, and especially within Wales, has been achieved. The findings of the study have been developed into a series of recommendations and proposals, comprising a strategy for the further development of the bioproducts industry in Wales.

At the outset 5 major industrial sectors were identified – composites, construction, pharmaceuticals, resins, plastics & coatings and chemicals. There has, inevitably, been a degree of crossover between sectors (for instance composites are frequently used in the construction industry) and bioproducts appear in sectors other than those noted above.

### Key Findings:

A number of general findings arose from the survey:

- There is a steadily developing world-wide bioproducts market driven on by a number of factors. In Europe, it is recognised that, amongst other benefits, the use of industrial crops can help in the reduction of greenhouse gas emissions [1]. This is set against a backdrop of increasingly stringent legislation on waste disposal and increasing awareness, at a corporate level of sustainable development. This has already led to the commercialisation of a number of "eco-products", such as thermal insulation materials based on natural fibres and composite products that incorporate such fibres.
- A high general level of awareness and a positive attitude towards sustainable development was recorded, with over half of the respondents to the mail survey indicating that sustainable development was currently part of their business plan.

- 60% of companies polled considered their current raw materials and processes to be sustainable; the main reason being recyclability. However, only 18% currently use a bio-derived raw material.

A number of drivers and opportunities for, as well as barriers to, the development of sustainable industries based upon renewable resources were also identified. Amongst these were:

- Environmental issues and the desire to produce a greener product are the main reasons why companies are using, or are considering using, renewable materials.
- Current and proposed legislation is seen as the major factor in the move towards the widespread introduction of products from renewable resources.
- There is, however, only a small demand from customers for such products and the majority of industry has experienced no significant increase in this demand.
- Encouragingly, 75% of businesses would like to increase their use of renewable materials.
- In the bid to reduce CO<sub>2</sub> emissions, all industry sectors understood that guidelines and grants are becoming more widely available, but it was perceived that these programmes are not geared toward developing alternative sustainable feedstock.
- Cheaper materials, tax refunds and grants were seen as the key incentives to promote these technologies.
- The lack of a developed supply chain was seen as a barrier to the widespread development of products and processes based on renewables.
- There is a perception that the cost of these materials would prohibit development.
- A lack of adequate (and in many cases any) technical information is a barrier.
- The perception of renewable materials as being somehow inferior to synthetic alternatives is a potential hindrance.
- The introduction of appropriate standards may well assist in changing this perception.
- The cost of raw material or product certification is seen as a barrier.
- Development should be integrated. It is essential that if an industry based upon renewable feedstock (industrial crops) is to be developed then the cost structure must be adequately addressed. It is pointless to consider developing a supply chain if, financially, it is not viable for any part of that chain, as ultimately this could not be sustained.

## Recommendations:

To promote the development of an industry utilising renewable resources to manufacture materials and products in a more sustainable fashion, a number of measures are proposed. These measures, which fall broadly into three main categories, MUST be adopted in an integrated fashion in order to form an holistic strategy, for progress in this sector to occur. These are:

- Market development and stimulation of consumer demand for “eco-products”.
- Development of the supply chain.
- Product research and development.

Within each of these sectors a number of specific recommendations are proposed.

### Market development

- It is vital that public awareness be raised and adverse perceptions challenged. The current lack of knowledge or demand by the general public for sustainable products has made the transfer to bio-derived materials too risky for the majority of businesses.
- Coupled with the need to raise the profile of products manufactured in a more sustainable fashion, is the need to inform and educate designers and specifiers of the benefits of these materials. Furthermore, there is a need to provide reliable and unbiased technical information on raw materials and products from renewable resources. In conjunction with this, standards will need to be implemented to ensure confidence in their use.
- Chemicals and composites have been identified as the main areas to focus attention in the short term.
- With regard to the composite sector (with some crossover into the construction industry) there is a need for demonstrator products and industry friendly data to promote awareness. Further work would also be required to create new supply chains and assist with technical problem solving.

### Supply chain development

- Industry lacks confidence in the supply and logistics associated with renewable materials. Assurances on the continuity of supply, quality and price are necessary and the development of a ‘Trade Association’ was suggested as the best way to provide this information. In the first instance, such a service need to be implemented and subsequently developed by specialists, such as seed merchants, processors, waste handling companies etc. The service must be available to a number of companies but with no conflicts in commercial interest. This is also an opportunity for joint marketing approaches for a cluster of companies who employ renewable materials in their processes.

## Research and development

- Wales is well placed within the UK to exploit this emerging technology through strong links with agriculture, access to R&D capabilities and a wide portfolio of funding sources. At the present time there a number of funding opportunities available to Welsh industry and academia in support of R&D.
- A means of ‘fast tracking’ grant applications made to Welsh sponsors that can demonstrate potential for step changes in improvements to sustainability should be implemented. This might be through some form of ‘tick box’ on the grant application forms.
- The chemical industry has responded very positively to the issues of sustainability and is actively looking for replacements to the many petrochemical feedstock currently used. Research into selection and/or adoption of potential renewable feedstock will, if successful, unlock large receptive markets

### **Specific actions:**

A number of specific actions are proposed to stimulate development in the sector. These include:

- ⇒ Publish and disseminate the report and its findings.
- ⇒ Appoint, within the Agency, a ‘Champion’ for the development of an industry based upon renewable feedstock for sustainable materials within Wales.
- ⇒ Organise a workshop to bring together all stakeholders.
- ⇒ Establish a funded ‘hub’ within Wales to co-ordinate activities in the sector.
- ⇒ Establish a ‘fast tracking’ system for grant applications pertaining to sustainable materials from renewable feedstock, to Wales specific sponsors.

## 1 INTRODUCTION

### Background

One of the key factors hindering industry as it struggles to embrace sustainable development is the lack of a true practical, working definition of the concept. It is recognised that the three pillars of sustainability – economy (profit), environment (planet) and equity (people) must all be considered and the needs balanced, but in reality what does this mean for businesses? The United Nations Commission for Sustainable Development states that ‘while there is still no precise definition of sustainable development, indicators can help to show whether we are moving in the right direction’. Consequently, as industry and government move toward the goal of sustainable development, the need arises for indicative materials and products that can be produced and processed in a way that demonstrates the benefits of sustainable development. These benefits should apply, not only to the environment, but also to businesses in terms of fiscal performance, as well as to Society at large.

Renewable feedstock, in the form of industrial crops, has been mooted as a means of helping support sustainable development [1]. Industrial crops of this nature include oils (such as linseed or oilseed rape), fibres (for example flax and hemp) and starches. Whilst renewable raw materials are currently used to a certain extent by industry, there is significant scope for further exploitation in the manufacture more sustainable products – so called ‘bioproducts’. This present study aims to provide a ‘snapshot’ of existing practices, emerging trends and future opportunities for renewable feedstock, thus enabling the development of a strategy for the successful exploitation of sustainable materials from renewable resources within Wales.

An important distinction should be made at this juncture: whilst it is true to state that industrial crops are renewable, it is unreasonable to claim that they are, therefore, sustainable. It is true that industrial crops are *potentially* sustainable, however, for just about all processing – from field to finished product – energy and materials will be consumed. In doing so fossil reserves will invariably be used up together with other, most likely finite, resources. Bearing this in mind, what is of importance is the relative *impact* of renewable materials versus their synthetic counterparts. In this respect bio-based materials can fare far better.

The potential of crop-derived raw materials entered the EU political arena in 2000 with the establishment by DG ENTR of a working group “Renewable Raw Materials” (RRM) within the European Climate Change Programme [1]. Renewable raw materials have been identified as having the potential to mitigate the effects of CO<sub>2</sub> emissions and as a result there is much interest being shown in RRM to assist in meeting environmental legislation. Directives of note are the ‘Landfill of Waste’ (Council Directive 1999/31/EC), ‘Incineration of Waste’ (Directive 2000/76/EC) and ‘End-of-Life Vehicles’ (Directive 2000/53/EC). These directives, and others, will ultimately impact upon a number of industrial sectors, making renewable materials for industrial feedstock increasingly attractive.

## Renewable materials

The Forest Products industry is a prime example of the efficient use of renewable resources (trees), which if managed well can yield products with excellent “sustainability credentials”. There are, however, other industries that could utilise renewable materials from plant biomass in order to produce their products in a more sustainable and cost effective manner. The replacement of glass fibre with plant fibres, the development of bioresins and adhesives and the use of natural chemicals in the pharmaceutical industry are all examples for potential future growth.

Five key industrial sectors were identified at the outset as being potential areas where significant volumes of renewable materials could replace existing synthetic (petrochemical) based feedstock. These were composites, construction, pharmaceuticals, resins, plastics & coatings and the chemical industry.

In each of these sectors there are already a number of active players in the global market. Within the composites sector, for example, there has been a significant uptake of natural fibres such as flax and hemp as reinforcement in polymeric matrices. It has been estimated that in 1999, in excess of 21,000 tons of fibre were used in the EU in the automotive sector, the main components being door panels, passenger rear decks, pillars and boot linings. At present around 5-10 kg natural fibres may be used per automobile. Demand is expected to rise to 40,000-70,000 tons in the foreseeable future [2]. At present, most matrices are synthetic polymers, however, it is anticipated that with the development of bio-resins and plastics (which may have tailored biodegradability profiles), true ‘biocomposite’ materials will soon be a reality. A list of selected manufacturers and suppliers of bio-products appears in Appendix I.

## Survey methodology

A total of 27 personal interviews and meetings with experts were undertaken. These interviews were used to define the key areas of interest and identify industry relevant issues. This information was then used to formulate the survey instrument. The resulting questionnaire (see Appendix II) consisted of 5 sections covering: (i) business profile, (ii) general levels of awareness, (iii) current use of renewable materials, (iv) reasons for change and (v) opportunities for the future. The questionnaire was sent to 471 companies, out of which over 18% replied. Analysis of the responses resulted in the identification of significant trends. A comprehensive analysis of the data from the mail survey appears in Appendix III.

**Table 1: Response by sector**

<i>SECTOR</i>	<i>TOTAL RESPONSES</i>	<i>OUT OF</i>	<i>%</i>
<b>Composites</b>	<b>19</b>	81	<b>23.5</b>
<b>Construction</b>	<b>14</b>	74	<b>18.9</b>
<b>Pharmaceuticals</b>	<b>9</b>	105	<b>8.6</b>
<b>Resins Plastics Coatings</b>	<b>23</b>	111	<b>20.7</b>
<b>Chemical</b>	<b>23</b>	100	<b>23.0</b>
<b>TOTAL</b>	<b>88</b>	471	<b>18.7</b>

## 2 KEY FINDINGS AND OBSERVATIONS

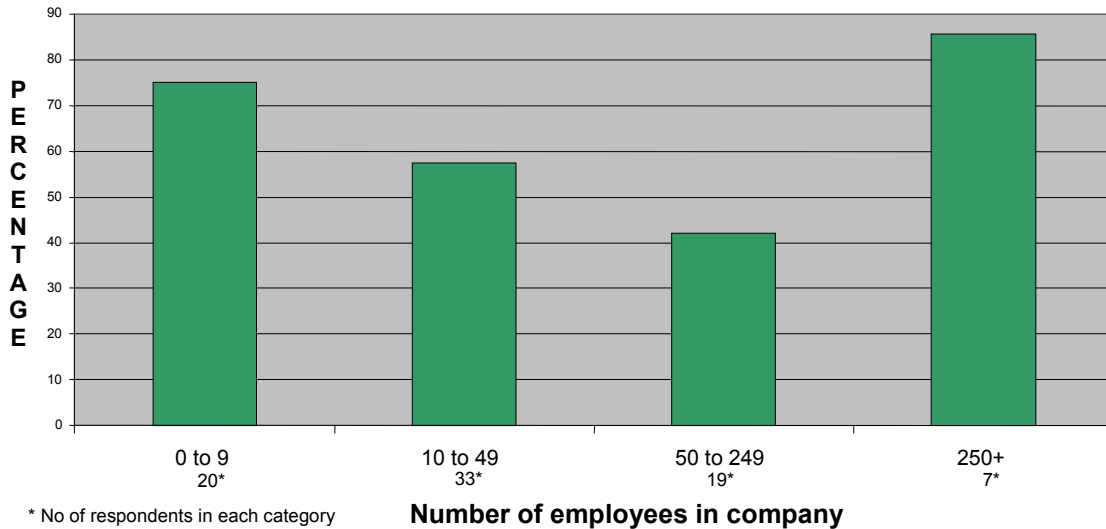
### 2.1 The issue of sustainability

The study revealed a high level of industrial awareness with regard to sustainable development. Results from both the interviews and questionnaires were extremely positive and supportive, with over 75% of the companies questioned confirming that sustainability is, or is about to be, an important part of their business plan.

It is interesting to note that the concept of sustainability or sustainable development and the reasons for engaging in this ethos differed widely between businesses and sectors. To some, sustainability simply meant the continued existence of the business, whilst to others sustainable development was embraced in the wider context of balancing the “three pillars” of sustainability. Similarly diverse, were the reasons for adopting sustainable development as part of the business plan. A large multi-national, with a substantial presence in Europe, for instance, felt compelled to adopt sustainability in its corporate plan to retain its market share. Smaller, but nevertheless still significant, businesses adopted sustainable development because it was seen as “the right thing to do”. This approach is also observed in smaller micro- enterprises. It is worthy of note that the drivers for engaging in sustainable development are not only emotional, but are also hardheaded economic reasons.

Initiatives such as the Foresight Programme [3], have predicted that feedstocks based on the petrochemicals industry are set to become more expensive over the next 25 years. This will either be as a result of increased demand on a depleting oil reserve or through government and industrial actions based on resource conservation and CO<sub>2</sub> reduction. Consequently, there is a growing interest and demand forecast for alternative and renewable feedstocks. Industry feels it has already responded to the drivers for energy reduction, promoted by the climate change levy and when questioned about their involvement in sustainable development over 63% of organisations who responded to the survey claimed energy saving to be their top priority.

**Figure 1:** A breakdown by company size of businesses indicating that the raw materials and processes used are sustainable.

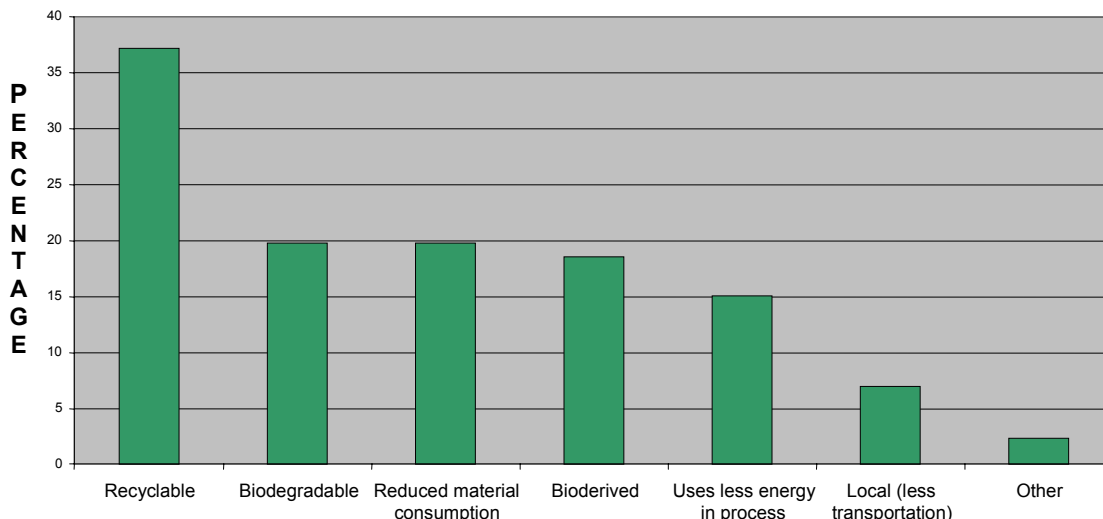


Nearly 60% of all companies polled returned questionnaires stating that they considered their current processes and raw materials to be sustainable. As observed in Fig. 1, an analysis of this finding by company size indicates that micro (0-9 employees) and large, non-SME companies are the most active in adopting sustainable practices. This finding was also supported by the personal interviews. Due to the low margins obtained from commodity manufacture, smaller companies prefer to exploit niche markets with low volumes and high margins. The need for continued improvements in the performance of niche market products lends itself well to renewable materials and sustainable processing. Large companies on the other hand rely on economies of scale to operate profitably and perceive small potential tax levies or environmentally based outlays as a major threat to their net income. These companies are reacting to the situation by streamlining their processes, investing in minimum waste practices and looking towards sustainable feedstock as an answer to avoiding potential taxation in the future.

On the whole, large industry will employ renewable materials if reliable sources are available. However, a major barrier to be addressed is industry’s perception that agricultural materials are not consistently available throughout the year, due to the seasonality of crops. Nevertheless, the many examples of large scale biomass extraction which exist (e.g., British Sugar, Cargill, etc), admirably demonstrate that this need not be problematic. Supply problems have been circumvented through primary and secondary processing; creating stocks of material that may then be distributed on a regular basis throughout the year, thereby avoiding peaks and troughs in supply. It can be demonstrated that in many sectors, biomass can supply a consistent and added value material (albeit the functional fraction of the biomass) throughout the year. The real barrier is generating a strong market demand. Products and materials must be designed and generated in order that the end user is made aware of the benefit. Without a strategic thrust coming from

the Governmental level, e.g., tax incentives, easier access to R&D funding, progress will be slow as there are too many barriers to change.

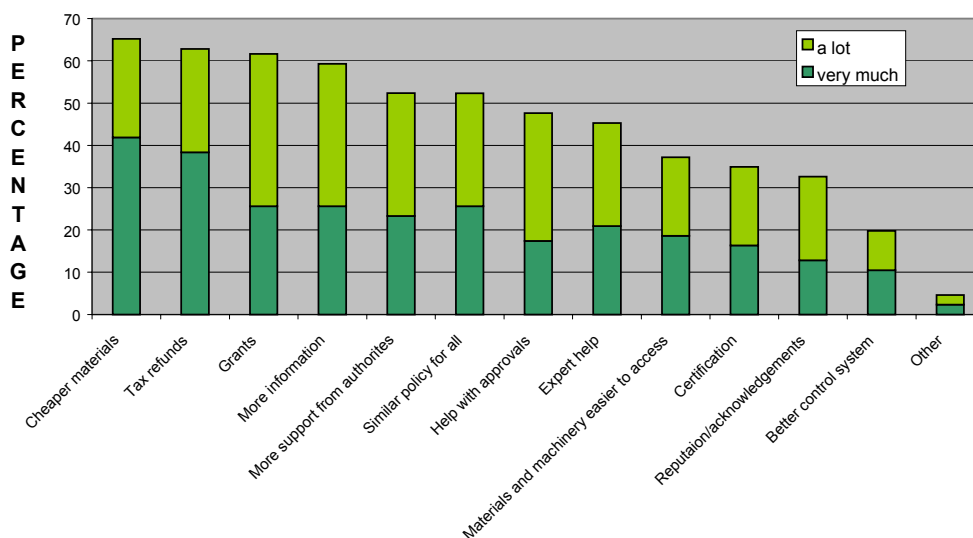
**Figure 2:** Reasons given for the claimed sustainability of raw materials and processes



The majority of companies consider their process to be sustainable if proportions of their raw materials are recyclable (see Figure 2). Only 18% actually use a bio-derived material in the bid to achieve a sustainable position. Recyclability and biodegradability were ranked highest as the increasing cost of landfill tax is establishing these practices within the working environment.

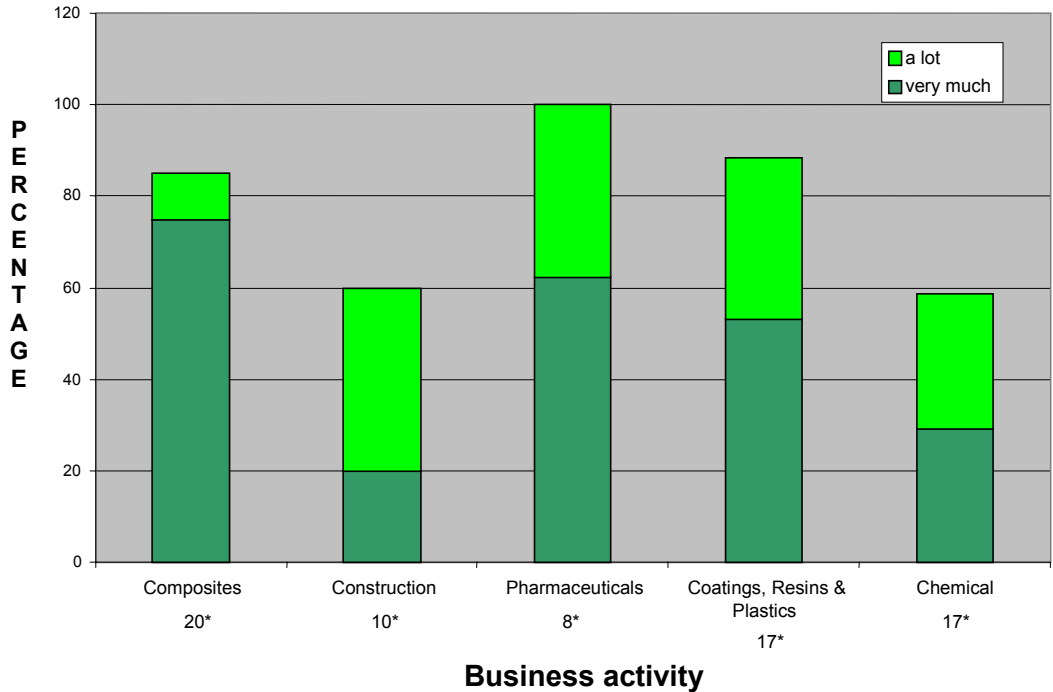
Nearly 70% of businesses that responded to the survey claimed that they use some form of sustainable material in their business. Environmental issues were cited as the main reason for doing so. Interestingly, cost was not rated highly, indicating that the expense of such materials at the present time could prove a hindrance.

**Figure 3:** Responses given by businesses as to how much different support mechanisms have or could prompt the greater use of renewable material feedstock.



When asked ‘what would or has helped you use sustainable and renewable materials?’ the most positive response was cost. Over 60% indicated that cheaper materials followed by tax refunds, grants, and then more technical/marketing information were important (see Figure 3). This theme was also reflected in the personal interviews. Many businesses currently not using renewable feedstock would only consider making a change to a renewable feedstock if the materials were of comparable or lower price than their existing resources. It seems likely that businesses would only consider making the change if the financial incentives were sufficiently attractive. Lower cost would appear to be an important issue, as many had noticed *no* increased demand from their customers for ‘green’ products (65% agreed with this statement in the mail survey). The availability of information was also a common theme found from the questionnaire and the interviews. Companies cited examples where opting for a renewable material could potentially help their business, but they were unable to progress changes, as there was no technical data or specifications for the material.

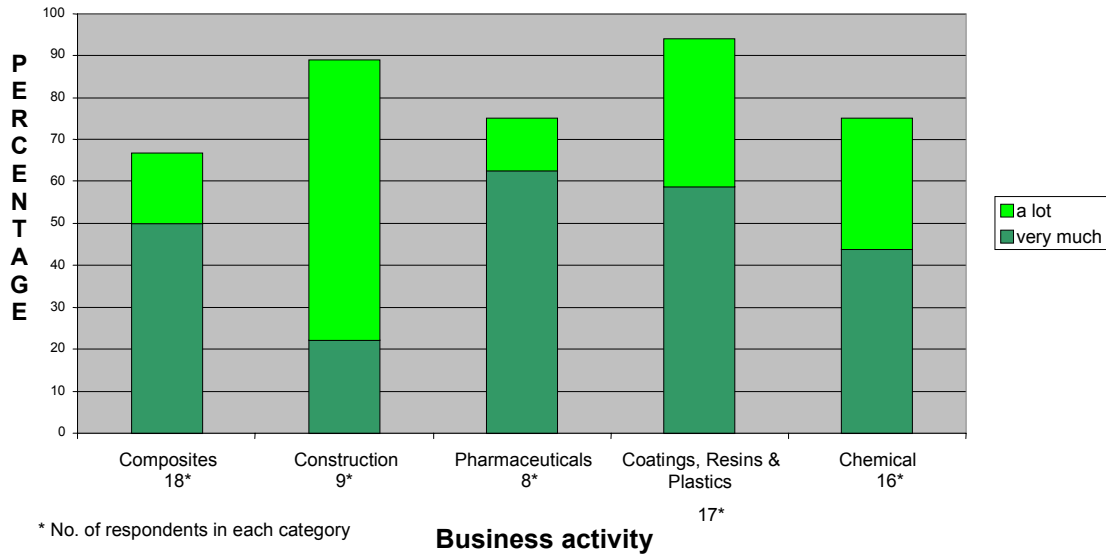
**Figure 4:** Responses given by businesses as to how much cheaper materials would be of help in switching to renewable feedstock.



\* No. of respondents in each category

The pharmaceutical industry indicated that lower costs would be of assistance in changing to renewable raw materials. The coatings, resins and plastics sector (followed by composites) also suggested that the high cost of materials was a barrier to the utilisation of renewable materials. This finding is in stark contrast to the finding from the construction and chemical industries in that both considered the cost of materials to be less of a factor – they both felt that material suitability is of higher importance. Similar response patterns were observed by sector regarding tax incentives (Figure 5). It is believed the reason for these findings lies in the margin being made by businesses operating within the different sectors surveyed. The pharmaceutical industry has to *fully* understand the raw materials and processes it employs. It knows what property it requires from an ingredient and therefore finding cheaper materials with identical properties or reducing overheads is of greater importance than in the construction industry. The construction sector relies on overall performance and whilst any saving is welcomed, finding materials that afford new properties is seen as a greater growth platform than simply shaving small costs off existing processes.

**Figure 5:** Responses given by businesses as to how much tax incentives would be of help in switching to renewable feedstock.



## 2.2 Barriers

Figure 6 ranks the main barriers highlighted by industry that are considered to be the key reasons for not using renewable feedstock for sustainable materials. Encouragingly, a total of 75% of all the companies polled stated a desire to increase their use of renewable materials. The remaining 25% of businesses were content and did not see any opportunities in moving toward increased use.

**Figure 6:** Perceived or encountered barriers to the greater use of renewable feedstock for sustainable materials

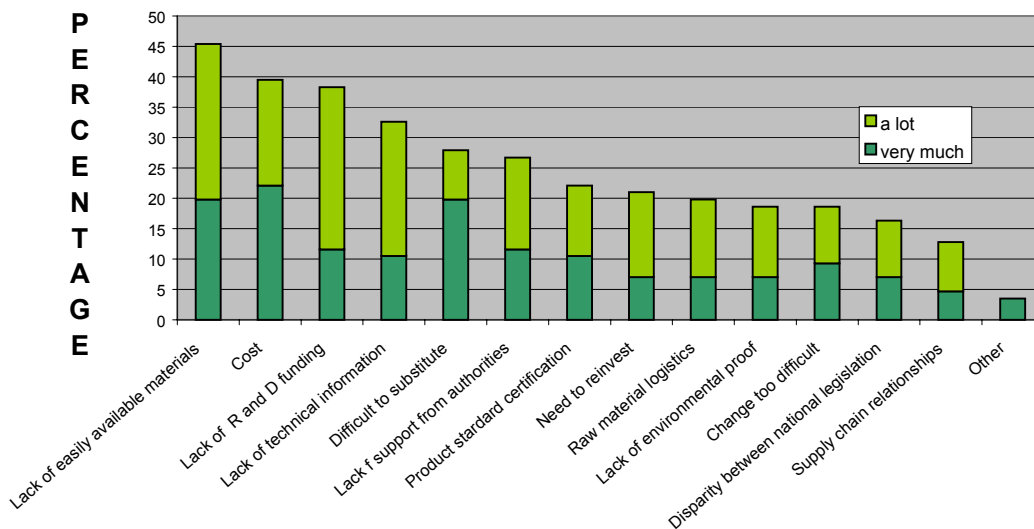


Figure 6 demonstrates the major barriers to be availability, cost, R&D and the lack of technical information. Lack of information is seen as a major barrier across all sectors (less in the pharmaceutical sector) in switching to a new feedstock, especially one from a bio-resource. There is also an overall reluctance to be one of the first to use a new material. Other common perceptions are:

- The cost of a new feedstock is a major barrier. The economies of scale enjoyed by conventional materials are not in place with a novel material. Therefore, cost will always initially be higher than in an established industry.
- There will be an intrinsic lack of established data with regard to the materials performance in manufacture, e.g. the materials will not be tried and tested by others within the sector. As such there will be inherent risk factors.
- The possibility of investment in a new process to accommodate the innovative feedstock is never welcomed. This is not helped by the apparent lack of R&D funding to overcome this hurdle.
- The image of bio-derived feedstock is often that of a second rate material, lacking the performance of its alternatives and as such it is often overlooked.

Industry standards are seen to be a major barrier. Few examples could be cited where current legislation has even considered the use of a bio-derived material. This is probably one of the most significant barriers to the adoption of renewable feedstock. In many cases a single company cannot afford the cost outlay to get a new material or process recognised and authorised. A good example of this issue is the use of natural materials in simple surfactant systems. Nonyl phenol ethoxylates (NPE's) were the most common non-ionic surfactants used by industry until concerns were raised about their ecotox profile. It was subsequently identified that certain NPE's cause sex reversion in aquatic organisms and a committed action was undertaken by the industry to find suitable replacements. Both academia and industry have assessed the use of many naturally occurring chemicals as potential replacements for NPE's. Several bio-derived molecules were identified, but none were subsequently registered for use. The principal reason for this was cost; registration for a single molecule exceeded £100,000. Whilst these alternatives had increased performance, it is not surprising that industry found lower performance solutions using pre-registered compounds preferable!

Growing concern also surrounds the implementation of the Integrated Pollution Prevention and Control (IPPC) regulations and their impact on new production processes. To date there has been little or no practical guidance provided by the authorities. Companies with a desire to use a renewable ingredient found that they were stymied by the regulations that appeared to favour existing practices. Little consideration is given to the benefits of a renewable material. Many examples were cited where an opportunity had been identified but the local authority was unwilling to look at the production process. In some cases the authority insisted that the processes were classified into preordained categories that did not acknowledge the use of a renewable material. This approach also emphasises the lack of technical knowledge surrounding the use of renewable feedstocks.

### 2.3 Opportunities

A driver that should not be overlooked is an individual's personal interest in sustainable development. Throughout this study it appeared that people's perception of using sustainable materials and products was "*that it is the right thing to do*". However, as there are few examples of "off the shelf" solutions, this goal was seen to be out of reach in most cases. In some cases it was evident that there was simply a lack of understanding that alternative, bio-derived, materials were available. In such instances it is clear that the promotion of these alternatives would raise awareness and thus create improved demand. These initiatives could help kick-start the bio-products industry, developing the supply chain and moving away from concept into reality.

Legislation has played a major part in pushing forward environmental topics. These regulations, which initially impacted upon the larger companies, are now affecting smaller businesses. Increased landfill taxation has created an interest in waste reduction, recycling and to a certain extent choice of feedstock. The Climate Change Levy has driven the need for energy conservation and new non-petrochemical derived feedstocks. However, feedstock considerations are still low on the industry priority list. It is expected to become more of an issue as product lifecycle analysis grows and is widely accepted. The inclusion of such analysis in taxation could drastically change industrial feedstock choice. This would enable companies to offset one levy on energy usage or disposal, against a more sustainable raw material.

Guidelines such as the Best Practicable Environmental Option (BPEO) [4] are being embraced or at least adapted in many sectors. In the construction industry, designers are actively searching for environmentally sound alternatives for their materials. In other sectors such as the chemical industry, stricter, self-imposed guidelines such as the Natural Step Framework for Sustainability [5,6] are being implemented. These schemes have a limited following in the UK and often only companies with European ties are involved.

New grants are now emerging such as the Carbon Trust ([www.thecarbontrust.co.uk](http://www.thecarbontrust.co.uk)), Waste Resources Action Plan ([www.WRAP.org.uk](http://www.WRAP.org.uk)) and Bio-Wise ([www.biowise.org.uk](http://www.biowise.org.uk)) Companies wishing to develop new products and alter their practices can bid for funding through these schemes. For example, the Carbon Trust is able to provide funds to successful bidders who can demonstrate that their projects will lead to reduced CO<sub>2</sub> outputs over existing practices or materials.

Other schemes like SustAinable Business IN Action (SABINA) have been launched with a great deal of interest in the Severn Estuary area of the UK ([www.sabina.co.uk](http://www.sabina.co.uk)). The general aim of these schemes is that of reducing carbon emissions and this objective is strongly supported by regional businesses.

### 3 SECTOR ANALYSIS

#### 3.1 Pharmaceuticals

The pharmaceutical industry is knowledge driven and heavily dependent on research and development into new products for growth. Basic research is both time consuming and expensive. Timeframes often exceed 7 years before any income can be realised. It is, therefore, unsurprising that only large global multinational companies can consider significant R&D expenditures.

The UK pharmaceutical industry employs approximately 60,000 people. It is Britain's third biggest earner by trade surplus (£2,300 million in 1997) and accounts for 10% of world pharmaceutical R&D expenditure [7].

The industry is generally driven by legislation. Typical pharmaceutical products consist of an active ingredient, often only present in small quantities in the preparation, combined with an excipient (non-active), or delivery system. Many factors need to be balanced before a decision can be made to change from existing active ingredient feedstock to a renewable alternative. Interestingly, whilst over 75% of active ingredients are based upon compounds derived from plants, it is currently more economical to synthesise these ingredients rather than to extract them from a harvested plant. On the other hand, excipients offer better opportunities as an end-use for renewable materials in pharmaceuticals.

#### Case study: Soft gel capsules

Soft gel capsules are used in a wide variety of drug delivery applications. The capsules are commonly produced using gelatin derived from the bovine waste trade. Although this can be classified as a renewable bioproduct, issues such as BSE and Foot and Mouth disease have seriously affected public confidence in animal derived materials. Research work to date has investigated the use of plant-derived alternatives such as starch. Starch-based feedstock has received some interest, as efforts are beginning to demonstrate opportunities in this application. Starch is a very well characterised material, is easy to functionalise and can have superior properties to that of existing, or petrochemical, alternatives. However, it is still necessary to complete extensive in-house research to generate data, as there is little or no information available. A new pharmaceutical delivery system must comply with good manufacturing practice, pass stability trials and toxicity testing before a license can be granted.

Significant improvements could be achieved by the use of more functional materials in certain device or delivery applications. However, the change in the degree of functionality can result in the need to apply for a new license. Whilst it is explicitly understood that clinical safety is of paramount importance, there is also a need to provide a balanced approach to risk management. Complex and inappropriate testing is seen as a barrier to change. It is, therefore, worthy of note that the recent introduction of the "Miscellaneous Food Additives Regulation" for the UK will introduce increases in testing [8]. This contrasts dramatically with current practice in the USA, where delivery system ingredients only have to be regarded as "*generally safe*".

### Case study: Naturally derived active ingredients

Emerging businesses are increasingly looking to plants as a means of providing the pharmaceutical industry with active ingredients. One of their main activities is the identification of active ingredients from substances often used in the so-called “nutraceutical” sector. The pharmaceutical properties of extracts from common or local plant species are often considered to have superior efficacy and it is claimed that ingredients can be cheaper than synthetic equivalents. Companies working in this sector find that securing financial backing is not easy. The majority of fund managers are unable to understand the technology and thus see the business as high risk. As a consequence, recognition in the market place is difficult to achieve. Collaborations between other bio-resource users and the formation of cluster groups are proposed as the only way of raising market awareness. This will improve the chances for increased funding, market recognition and promote consumer demand.

### 3.2 Construction

The British construction industry contributes around 8% of GDP and employs around 2 million people. The UK accounts for some 12% of total European output. The sector is dominated by Small to Medium Sized Enterprises (SME’s) with only a few large companies operating in the sector. The industry is regulated by British building standards and codes, which are well recognised and form the basis of governance in many construction industries all over the world [9].

From the responses given to the survey, it is clear that the sector views itself, principally as manufacturers and suppliers and not as either designers or, specifiers. It is, therefore, especially important in this sector to engage with architects, designers and other materials’ specifiers and to appraise them of the technical, as well as environmental, benefits of utilising bio-resource materials.

The UK construction industry is still dominated by the traditional brick and mortar design in the domestic dwellings market. There is little consumer demand for innovative building techniques. Only 1% of the UK new build sector is based on modular systems. Nevertheless, it has been reported that in Germany, 15% of the market is modular, whilst in some Scandinavian countries it represents 50% of the new build market. Modular (prefabrication) building offers great opportunities for step changes in sustainability in the construction sector. It also offers excellent opportunities for materials based upon renewable resources (especially wood). A number of research projects are currently underway that will help underpin future developments in this area. It is, therefore, expected that there will be an increase in modular and timber-framed building within the UK. This is viewed as an excellent opportunity for materials based upon renewable resources to make a significant impact.

In the construction sector, especially in commercial projects, customer specifications dictate material selection. The industry is also governed by performance standards that are enforced by legislation. These standards are performance driven and there are opportunities to interpret specifications allowing a wider spectrum of materials to be considered. However, both designers and the general public are not aware of the alternatives on offer. Past building projects that have utilised agricultural feedstock have been pilloried, receiving comments

such as “*houses built of straw*”. This has certainly not assisted public perception even though the science has demonstrated a physical benefit. More effort is, therefore, required to get the correct messages out to the general public.

In the private build market, material selection is often the responsibility of the buyer. The general public is still satisfied with traditionally built homes and the designer/architect is unaware of the alternatives. Therefore, the cost of any new material is the primary consideration in the procurement process. The majority of materials will be considered and purchased with price as the main criterion. This is a barrier to exploiting new materials.

Construction industry standards were also cited as a block to change. Drives to improve workmanship and safety within the industry have resulted in the development of new standards. These standards are based around the existing materials and technologies that were available at the time of writing the standards, rather than specific end-use performance criteria. As a result it is difficult to gain certification for new materials. For example, the use of flax fibre to make thermal insulation is becoming common in parts of Europe such as Scandinavia, France and Germany. However, no standard exists for such a product in the UK. A potential manufacturer must first gain certification from British Board of Agreement (BBA) before a product can appear on a list of approved suppliers of companies offering quality assurance to their clients. Achieving BBA certification involves time and expense (approximately £17K) and is a daunting prospect for any small business.

### **3.3 Coatings, resins & plastics**

The coating, resins and plastic sector is a diverse group of markets governed by the end-using chemical and construction sectors. This sector provides significant opportunities for bio-product utilisation in niche applications.

Key to profitable production in this sector is economy of scale and this restricts the development and utilisation of new bio-derived materials. However, examples are beginning emerge with the new Cargill/Dow joint venture (JV). The JV aims to produce a 100% bio-degradable plastic from cornstarch. Production is scheduled to come on stream early in 2003. To date bio plastics have only been exploited in very high value added applications such as human prosthetics. The new plastic produced under the brand name “Natureworks” will be sold at or around the price of polypropylene. It is, therefore, highly competitive but this only became feasible when many millions of tonnes of production were guaranteed.

There are good prospects for the substitution of organic solvents by renewable materials. The rationale behind sustainable processes is the need to reduce the emission of volatile organic compounds (VOCs) from products. This has led to a significant change in the industry towards water-based solvents. However, this issue is not a simple one to solve. In many respects, the technical performance of organic solvents makes them ideal. For example, they possess good solubility properties, ease of recovery and low boiling points etc. These technical advantages cannot simply be met using water. Alternatives to organic solvents exist with the development of natural oils. Oilseed rape, linseed and castor oils are easily derivatised into a wide range of products that include glycerides of oleic acid (a common fatty acid present in virtually all UK vegetable oils). The volatility of these glycerides is very low but their power to solubilise oleochemicals like

plastics and resins is often as good, if not better, than the current range of organic solvents. It has also been shown that polysaccharide dispersions and solutions have some limited applications as solvents. This technology is only in its infancy and many exciting discoveries are taking place that could become viable within the next few years.

Case study: Paint manufacturer.

The paint industry is very polarised. Three main companies dominate the £1 billion UK market (AKZO, ICI and Sigma). Smaller businesses lack command over potential markets other than small niche areas, as they generally rely on large companies for their feedstock. There are possibilities of using bio-resourced materials, as current technologies are based upon polymers like acrylics. Even though these materials are cheap, they are becoming less popular due to VOCs.

Currently there is no noticeable demand for sustainable products in paints for the consumer DIY sector. However, certain large corporate clients are now specifying the use of environmentally friendly paints in the refurbishment of their offices. Although it is suggested that the main reason for supporting these environmental policies is predominately to improve corporate image, a precedent is set that could be the start for a new technology drive. Smaller companies must take full advantages of these opportunities and capitalise, by selling a range of products to customers on a similar basis.

### 3.4 Composites

Composites consist of a fibrous reinforcement surrounded by a matrix. The reinforcement is typically glass fibre and the matrix a thermosetting resin such as an unsaturated polyester. The current UK market for composites is estimated at £510M and this is forecast to grow at 3.7% pa to 2005 [10, quoted in 11]. The composites reinforcement market is dominated by glass fibre, which is valued at in excess of US\$ 4billion per annum with 2.3 million tonnes produced world wide. Glass provides some 99% of all fibre reinforcement [11].

The European automotive industry currently uses 20,000 tonnes of natural fibres for low stress applications such as interior panels for cars in the luxury market [2].

Wood plastic composites (WPCs) are a large growth industry in United States. Some 180,000 tonnes of WPCs are produced per annum [12]. In the automotive sector demand is expected to rise by 15-20%, with 50% anticipated in the construction industry [12]. These trends have stimulated interest in the UK and a number of companies are gearing up for production.

With a few notable exceptions, like "Flaxcat" (a catamaran produced by Natural Powered Speed Products of the Netherlands [13]), there has been limited industrial interest to date, in the use of natural fibres for high performance applications. There are signs now that this is changing and increasing interest is being shown in the potential of natural fibre reinforced composite materials. In addition to the technical challenges still to be overcome, a number of further barriers to the commercialisation of these materials still exist. A lack of reliable

technical information for designers and specifiers and an under developed supply chain are seen as key issues that must be resolved. Furthermore, difficulties associated with substituting renewables directly into existing processes is seen as problematic. This may, in part at least, be due to the lack of readily available materials in a form suitable for direct substitution. Nevertheless, the respondents to the survey indicated that whilst these problems are yet to be resolved these forms of material will become increasingly important in the future.

#### Case study: *SusCompNet*

Through *SusCompNet* (The Sustainable Composites Network – [www.suscomp.net](http://www.suscomp.net)), it has become apparent that there is a great deal of interest in the use of bio-based materials. However, there is a fundamental lack of industrial focused knowledge especially in the area of high performance materials. There is a notable absence of demonstrator products and data to provide industry with the know-how and confidence to switch to alternatives. There is also a widely held perception that these materials will be cheaper. This perception should be challenged by the bio-products industry and the technology should not be undervalued. A quality bio-derived feedstock demands a premium in order to provide an incentive for suppliers and manufacturers.

### 3.5 Chemical

The UK chemical industry is the country's largest manufacturing sector employing more than 400,000 people. It produces and sells products worth over £40 billion annually, of which £20 billion is exported. Many large international chemical companies operate and manufacture in the UK, although 80% of all the chemical companies employ less than 50 people [14].

The UK chemical industry is highly innovative and technologically advanced, with significant expenditure on research and development. The continued high growth of the industry is due to the constant flow of new and improved materials and products.

Some key areas of interest with regard to renewable feedstock in the chemical sector are lubricants, surfactants and natural oils. In Europe, the annual consumption of vegetable oils in chemical and technical applications amounts to 2.45 million tons. There is a great deal of interest in the replacement of existing mineral based oils used as hydraulic fluids in environmentally sensitive sectors like agriculture and forestry.

The use of surfactants derived from renewable raw materials is also widely believed to have a large potential. It is predicted that use over the next decade will grow to approximately 1.2 million tonnes and account for over 50% of the entire market by 2010 [1].

Within the chemical industry there is potential for renewable feedstock. The finding of this study indicated that 90% of the chemical companies who responded to the survey considered that their raw material and process were sustainable. This is likely to be a reflection of their efforts to minimise waste, reduce energy and prevent emissions, not in their use of non-petrochemical feedstocks. There are still many doubts over the capabilities of agriculture to supply materials on demand. It is, therefore, of paramount importance to promote and secure a reliable supply chain.

Other barriers include legislation. In comparison to the US, the EU is perceived to have tougher and more unreasonable rules regarding the use of bio-derived materials. EU legislation tends to cover a material with respect to the end product it forms. A bio-material like starch can be used in several non linked applications. Within the EU it is a requirement to cover and register each and every end use application, even though the same materials is employed. In the US, a feedstock on the list of food additives is treated as the same regardless of the end application. If the chemical properties of starch are known then each application does not require registration. The additional burden of individual registration is seen as a major disadvantage and is one of the key reasons why bio-renewables are more successful in the US.

## **4 CONCLUSIONS AND RECOMMENDATIONS**

The survey received an enthusiastic response from most sectors and it has established that there is a need for sustainable materials from renewable resources.

As well as drivers there are primary barriers throughout the sectors that hinder this development such as;

- the lack of readily available materials
- perceived cost
- lack of technical information on properties and areas of utilisation.

Secondary drivers such as tax incentives and grants were flagged as areas to be considered, but little growth can be expected if the primary barriers are not addressed.

There is an inherent need for a holistic overview of this growing industry. Awareness needs to be raised in both the private and public sectors as to the potential of renewable feedstock for sustainable materials. Demonstrator materials and products need to be developed that will provide data on the material use and applications. Once established, further assistance would be required to form the necessary associations to support the industry with consistent quality materials and with properties that meet the desired performance criteria. It is hoped that the agricultural industry can lead this development in it's strive to diversify. However, the agricultural industry does not have the vision, experience and skills necessary to undertake the market development of non-food products. Therefore, the following recommendations and strategies are proposed.

### **4.1 Technical development and funding**

Technical challenges still exist to understand how performance properties can be achieved. More scientific work is needed to gain a better knowledge of the functionality and structure of renewable materials so that effective agronomic strategies can be adopted. Out turns must be realised through added value materials/applications. These benefits must be shared with the agricultural community to provide an incentive. Without financial motivation it will be difficult to shift the agricultural community away from their reliance on subsidy and grant aid that has supported their businesses for many years. As such, there may be a

need to phase in and out subsidies and grants as these needs are met but this must be closely monitored.

Funding needs to be made available in order to raise the profile and awareness of existing and potential bio-products. The end-using industry must be provided with more information on the properties and cost structure of these new materials. Grant schemes are available but the lack of priority given to research in this important area is seen as a hindrance. This could be overcome by means of a “fast-track tick box” on grant applications for projects with an emphasis on renewable materials.

Other specific measures could include the introduction of a “voucher” scheme. Companies could trade one tax for a credit to assist the R&D of a sustainable product. Similar schemes exist like The Landfill Tax Credit Scheme (LTCS). A credit on landfill tax is given back to enable the development of a business improvement that will reduce waste or benefit a local project.

The growing interest in carbon taxes could potentially be of great advantage to this new industry. Companies will have to offset their CO<sub>2</sub> production in an attempt to ensure that there is a balance in the world’s carbon cycle, which has lead companies to reduce emissions and energy. However, the use of CO<sub>2</sub> neutral materials is not a common practice. A biomass has the unrivaled ability to lock up CO<sub>2</sub> and release carbon at the end of the product lifecycle. This can be reused by next year’s crop. However, without incentives companies are unlikely to change. It is suggested that future practices may include opportunities to trade CO<sub>2</sub> allowances. This may make it feasible for companies to take up and use bio-derived materials and offset this against taxes. Such schemes could be based and developed on existing initiatives like the Packing Waste Regulations.

Initial industry targets have promoted short-term actions to reduce energy and lessen the environmental impact (e.g. the production of energy from biomass and the purchase of forests by large corporations). A better and more practical solution must be the growth and use of bio-materials. This is a logical way to balance carbon.

Guidance would have to be provided as to what crops should be grown and how funding should be spent. As such the Common Agriculture Policy would play a crucial role in maintaining balanced subsidies. If subsidies were found to shift or be politically unreliable then confidence would be lost. As a consequence supply chains would not form or would ‘wither on the vine’. A secure feedstock is vital in the early stages of supply chain development, as there will be no returns on investment to fall back on.

#### **4.2 Market development**

The need for a “business park/cluster group” approach has been recognised. This will enable the sheltered growth of embryonic companies and provide assistance in the competition with larger rivals. A hub could provide the expertise needed to utilise the agricultural feedstock and aid grant applications.

The development of a ‘one-stop-shop’ for enquiries, marketing, intellectual property and for networking within the industry is seen as paramount and is often cited as the reason why petrochemicals are predominant.

Careful consideration must be taken in developing the markets for these products. The perception that natural materials should be cheaper is a double-edged sword for the bio-materials industry. Reducing product cost is an easy approach to gain market share, but this could have a detrimental effect. Low cost materials are likely to give the impression of low performance. The cost of a quality bio-derived feedstock should be passed on at a realistic rate. Renewable materials should be sold on performance tailored to specific applications not just on the environmental profile. Achieving these application specific properties is critical in securing a premium for value added crops.

The need to develop a network for the bio-products industry in order to have more lobbying power and presence is deemed crucial. It would be good for Wales to be noticed in promoting and leading in this area, attracting new companies to the region. Cluster groups also have more success for funding applications and can generate buffer zones that enhance the local employment opportunities.

It is acknowledged that the market structure, performance requirements, demand and opportunities vary significantly by industrial sector. An approach would be to adopt a sector by sector rationale in order to target the most responsive areas displaying potential and thereby maximise the opportunities for the bioproducts industry. The following sectors are ranked in order, starting with the most responsive:

#### *Composites*

The composites industry is a sector with greatest potential for bio-renewable implementation. To unlock this potential, work should concentrate on the production of demonstrator products for consumer testing. These products will raise awareness, generate technical information and focus industry research. Data will be generated that will aid the utilisation of these materials and support the formation of the supply chain needed by the industry. Dissemination of information through vehicles such as *SusCompNet* will provide an immediate step forward.

#### *Chemical*

The chemical industry has responded very positively to the issues of sustainability and understands the need to embrace non-petrochemical feedstocks. It is actively looking for replacements, but there is little demand from current users and therefore no incentive to change. Key areas for future development are securing feedstock of consistent quality and access to processing expertise at production facilities. Assistance in technology transfer is, therefore, vital in this market.

#### *Construction*

In the construction market there is also a need for demonstrator products. Technical information must be in a format that is suitable for specifiers and architects to enable them to make confident material choices. Manufacturing companies wishing to supply renewable materials into this sector must have more assistance in gaining certification and ensuring confidence.

To achieve successes in this sector, strategic partnerships must be generated with SME businesses and customers that are the most responsive to these new materials; such as the modular and temporary building industry. Here, there are possibilities for the development of strategic links to end-user business as there

are performance drivers that can be uniquely satisfied by bio-derived materials (e.g. light weight and easy to recycle). When developing new products for this sector, it is necessary to provide a great deal of on site product support through experts trained in installation. This extra resource may be significant and could be a major issue for a small company with limited time and reserves.

### *Pharmaceuticals*

It is possible to cultivate crops to provide feedstock for active ingredients. However, the lower cost of synthesising ingredients over extracting an active ingredient from plant matter suggests that this is less likely to become a wide spread reality. There are some examples of niche markets that hold far higher value that will make some end products viable.

The main area of potential in the pharmaceuticals industry is that of delivery systems (excipients) with company based research steadily progressing in this area. In many cases the degree of functionality of the excipient has been limited by regulations that stipulate inappropriate grades of material. Improvements in bio-derived excipients can be achieved but, a small change in the material can result in the need to complete a series of toxicological tests. This is expensive and is seen as a barrier to development. Further work is, therefore, required to illuminate the gray areas of change in excipient functionality and provide a more informed framework for the regulations.

### *Resins plastics and coatings*

Although this sector grouping is diverse there are some common themes. In general there is some movement toward environmentally friendly products. A significant barrier to change in these businesses is the supply chain. The route from manufacturer to customer is complex and the primary producer has little feeling of control over the market. Low cost materials are seen as key and as the primary producers have little control of the markets and their ability to add value is limited.

The drive to reduce the emission of volatile organic compounds (VOCs) in this sector is the major technical driver for change. VOC reductions have been achieved by altering existing technology and industry has not developed new alternatives.

Further research and development is required to support this industry and to develop new materials that are able to meet the performance requirements. Replacement for plastics in packaging applications of household products is seen as a good initial target. Bioresins for applications in environmentally sensitive areas should also be considered.

## **4.3 Proposed specific actions to be taken by the agency**

A number of immediate key actions arise from the foregoing general conclusions and recommendations. The following points are listed in the suggested order in which the actions should be taken:

1. Publish and disseminate the report and its findings as widely as possible through the Agency, CARM and *SusCompNet*.
2. Appoint, within the Agency, a 'Champion' for the development of an industry based upon renewable feedstock for sustainable materials within Wales.

3. Hold a workshop to bring together all stakeholders, with the intention of agreeing a co-ordinated pan-Wales strategy for the rapid development of these technologies.
4. Establish a funded 'hub' within Wales to co-ordinate activities in the sector along the lines of the proposals made for a 'one stop shop'. The activities of this hub should include:
  - ✓ Dealing with inquiries from industry (e.g. funding opportunities, technical or supply information)
  - ✓ Information and data collection and dissemination
  - ✓ MarketingIn the first instance, it is vital that this organisation receives financial support from the public sector, as it is highly unlikely that the fledgling bio-products industry will be in a position to support such an infrastructure immediately.
5. Establish a "fast tracking" system for grant applications pertaining to sustainable materials from renewable feedstock, to Wales specific sponsors (e.g. Knowledge Exploitation Fund, WDA initiatives etc)

### ACKNOWLEDGEMENTS

The project team would like to extend its warmest thanks to all those who participated in the survey, giving freely of their time and effort. Grateful thanks are also extended to Mr Anthony Armitage of Welsh Development Agency for his unstinting support and interest throughout the project.

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## APPENDICES

### Appendix I – Example Products

The following are example products or product ranges that typify the use of bioproducts throughout the varied sectors:

#### Pharmaceuticals

- A number of pharmaceutical and medical products are made from natural resources rather than by synthesis, for example Insulin products made by CP Pharmaceuticals of Wrexham.

#### Construction

- Real Architecture (based in Norfolk) has demonstrated that ‘green’ building does not have to mean increased build costs. The practice has designed ten, two-storey industrial units based on Fillcrete EVT Breathing Technology for the equivalent cost of traditional units.
- Flax fibre loft Insulation made by Textinap is another example of how novel and renewable natural building products are becoming more widely accepted.

#### Coatings Resins and Plastics

- Topac ‘s NaturePac CD tray is made from potato starch. in a similar way to Cargill/Dow’s joint venture “Natureworks”, which is a 100% bio-degradable plastic from cornstarch.

#### Composites

- Wood plastic composites such as CorrectDeck, made from sawdust (60%) and Polypropylene, are becoming particularly popular in the USA.
- The EcoCar is a demonstration platform produced by Splendid engineering utilising natural-origin fibres and polymers developed by Warwick University, to replace mineral-origin fibres and fossil-origin polymers
- The Flaxcat is a racing catamaran developed by Natural Powered Speed Products of the Netherlands utilising flax fibre as the strength giving reinforcement in the hulls composite matrix.

#### Chemical

- The Naturoil product range made by Biochem Wales Ltd includes BioDiesel, Concrete Mold release agents, bicycle chain oil and other lubricants.

## Appendix II - Questionnaire

### Section 1: Your Business Profile

P \_\_\_\_\_

**1.1 Which one of the following BEST describes your MAIN business activity?**

- Composites
- Construction
- Pharmaceuticals
- Coatings, Resins & Plastics
- Chemical
- Other (please specify) \_\_\_\_\_

**1.2 Which of the following role(s) does your business undertake?**

- |                                    |                                       |
|------------------------------------|---------------------------------------|
| Research <input type="checkbox"/>  | Manufacturer <input type="checkbox"/> |
| Design <input type="checkbox"/>    | Retailer <input type="checkbox"/>     |
| Specifier <input type="checkbox"/> | End user <input type="checkbox"/>     |
| Supplier <input type="checkbox"/>  | Other (please specify) _____          |

**1.3 What is the size of your business?**

- | Employees                       | Turnover (£)                             |
|---------------------------------|--|
| 0-9 <input type="checkbox"/>    | up to 500,000 <input type="checkbox"/>   |
| 10-49 <input type="checkbox"/>  | 500,000 – 2.8 m <input type="checkbox"/> |
| 50-249 <input type="checkbox"/> | 2.8 m – 11.2 m <input type="checkbox"/>  |
| 250+ <input type="checkbox"/>   | 11.2 m + <input type="checkbox"/>        |

### Section 2: General Level of Awareness

In this section, we would like to ask you about your views on sustainable development in general and in particular how it relates to your business.

**2.1 Is sustainable development currently part of your business plan? Yes  No**

**If it is NOT currently part of your business plan (whether formally or not) is it going to be? Yes  No**

**2.2 How is your business involved in sustainable development?**

**Does it (please tick as many boxes as appropriate)**

- Use sustainable and renewable materials
- Save energy
- Cut down transportation
- Support the policy of sustainable development
- Undertake research
- Other, please specify \_\_\_\_\_

**2.3 Do you consider that the raw materials and processes that your company uses are sustainable?** Yes

No

**If 'YES', is this because they are (please tick as many boxes as appropriate)**

- Recyclable
- Bioderived
- Biodegradable
- Uses less energy in process
- Reduced material consumption
- Local (less transportation)
- Other, please specify \_\_\_\_\_

**Section 3: Current Use of Renewable and Sustainable Materials**

In this section, we would like to ask you about the raw materials that you use in your business. In certain circumstances, it may be possible to replace materials derived from non-renewable and unsustainable resources with those which are renewable and which could be produced sustainably. For example, in certain instances mineral oil lubricants can be replaced with lubricants derived from industrial crops.

**3.1 Do you currently use renewable and sustainable materials in ANY aspect of your business activities?** Yes

No

**If 'YES', what are your reasons for using sustainable and renewable materials? (please tick as many boxes as appropriate)**

- Easily available
- Legislation
- Customer demand
- New market opportunity
- Environmental issues (cleaner environment)
- Cost
- Competition
- Good reputation
- Greener product
- Easily available raw materials
- Characteristics (performance) of the raw materials
- Characteristics of the products
- Energy efficient products
- Other, please specify \_\_\_\_\_

**3.2 I would like to increase the use of sustainable and renewable materials**

I am **happy with the current use** of sustainable and renewable materials within my business

I would like to **decrease** the use of sustainable and renewable materials

**3.3 Have you noticed any increase in customer demand for sustainable and renewable products?**

Yes

No

## Section 4: Reasons for Change

### 4.1 What barriers have you encountered or would you perceive you may encounter in using sustainable and renewable materials?

	Very much	A lot	Somewhat	A little	Not at all
Lack of support from authorities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lack of technical information	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lack of proof of environmental benefits	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lack of access to adequate R and D funding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lack of easily available materials	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Change too difficult	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Need to reinvest	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Product standard certification	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Disparity between national legislation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Difficult to substitute into existing processes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Raw material logistics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Supply chain relationships	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other, please specify _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### 4.2 What would help/has helped you?

	Very much	A lot	Somewhat	A little	Not at all
More information	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
More support from regional/national/ international authorities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Similar policy for all	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Help with approvals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tax refunds	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cheaper materials	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Expert help	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Materials and machinery easier to access	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reputation/acknowledgement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Certification	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Better control system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Help with approvals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Grants	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other, please specify _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Section 5: Opportunities for the future

**5.1 If you had the choice of producing your products more sustainably, would you do so?**

Yes   
 No

**If 'NO', is it because** (please tick as many boxes as appropriate)

not willing to change   
 cannot see enough benefits   
 not enough customer demand   
 do not know how   
 it is just a fad   
 too expensive

**5.2 Please indicate how much you agree/disagree with the following statements**

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Using sustainable and renewable materials is complicated.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
There is enough information available about sustainable development.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sustainable and renewable materials are too expensive for my business.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Benefits of using sustainable and renewable materials outweigh the difficulties.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sustainable development only works if all sectors of industry take part.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I am in favour of sustainable development.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I would like to use sustainable and renewable materials but do not know how.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sustainable and renewable materials are easy to find and get.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sustainable development is simply a current fad and will not last.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The use of sustainable and renewable materials will be essential in most businesses in the future.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

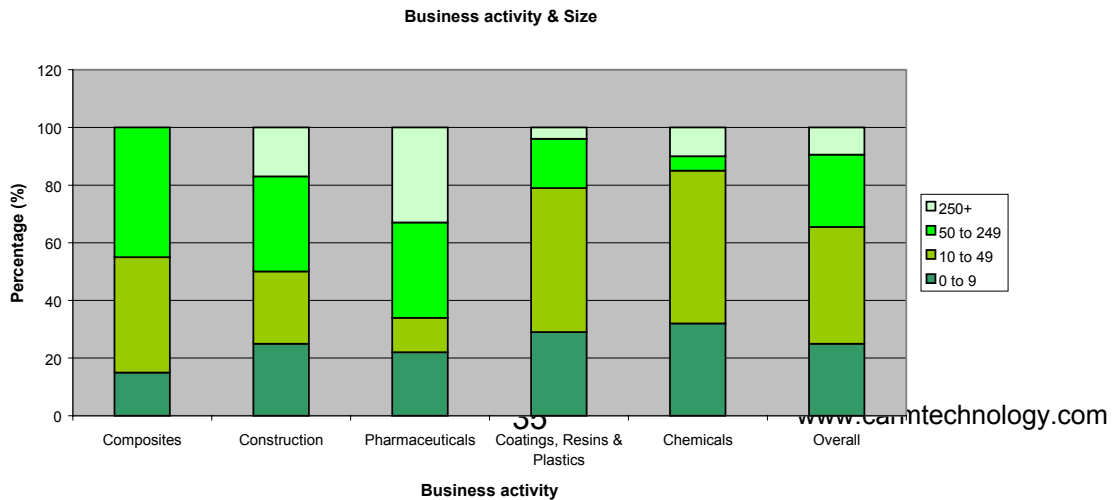
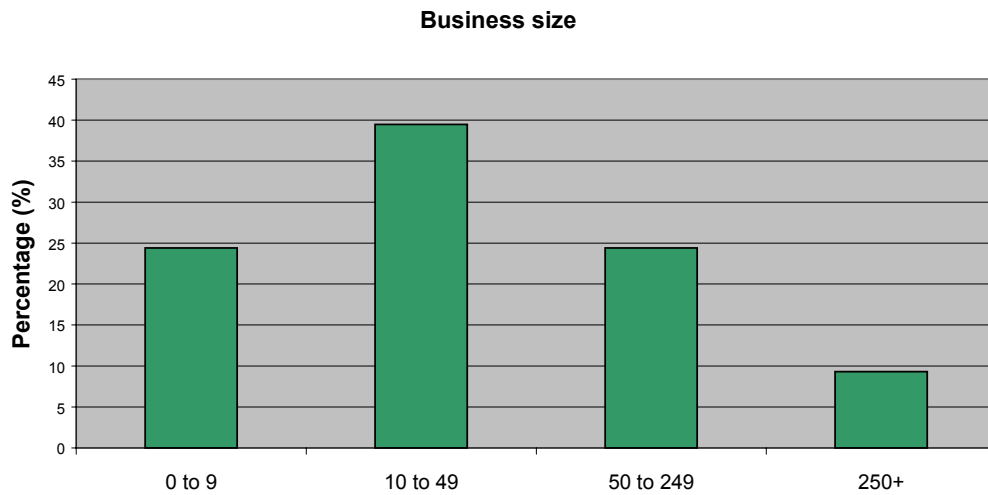
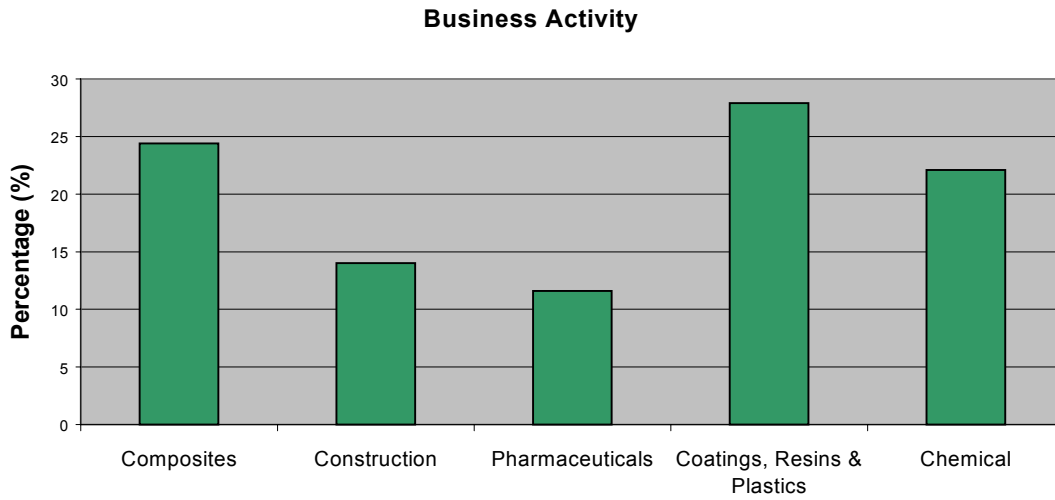
My business is doing well and I am not willing to make any changes.

The real benefits of using sustainable and renewable materials are not clear.

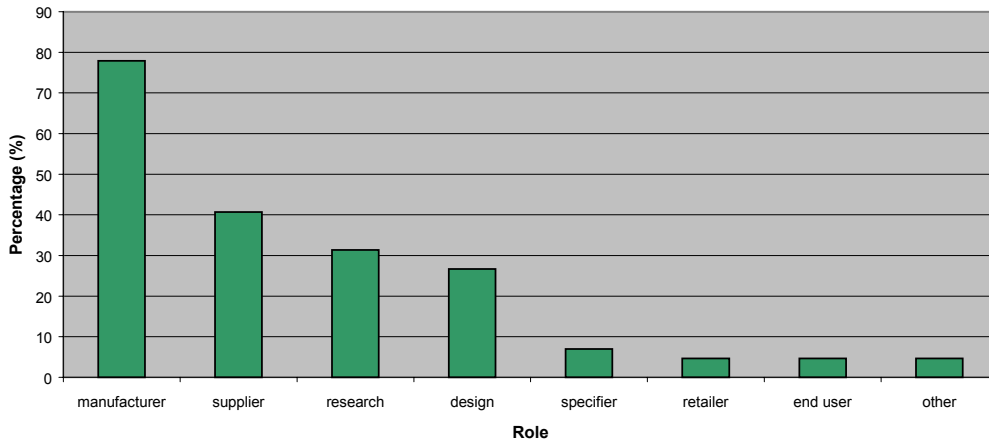
## Appendix III – Full graphical analysis

Please note: The following graphical representations should be considered in the context of the above questionnaire (Appendix II)

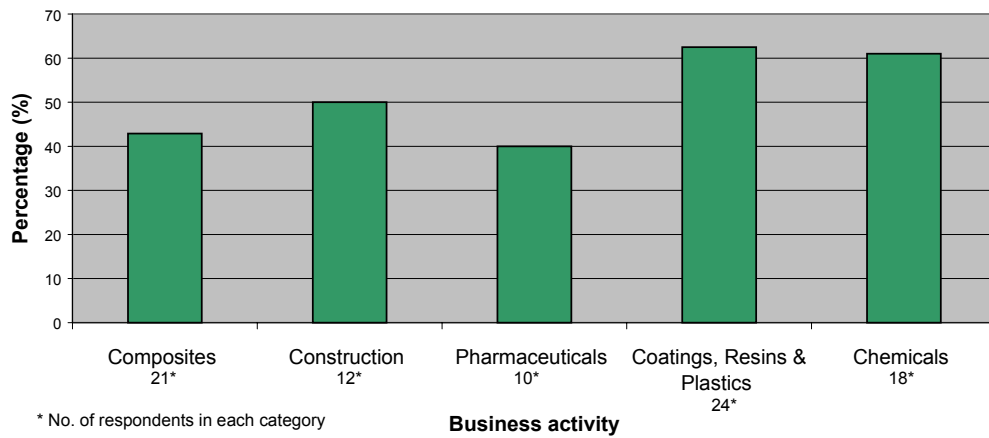


# BIOPRODUCTS Renewable Feedstock for Sustainable Materials

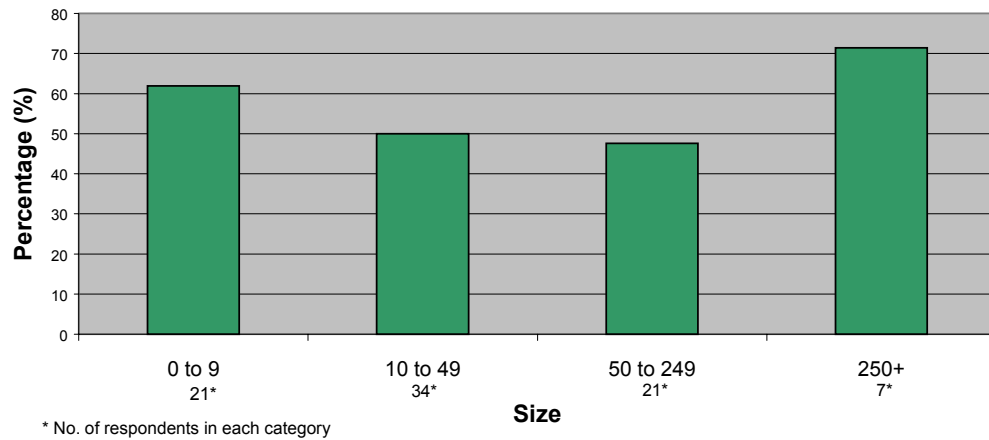
**Business roles**



**Sustainable development as part of the current business plan**

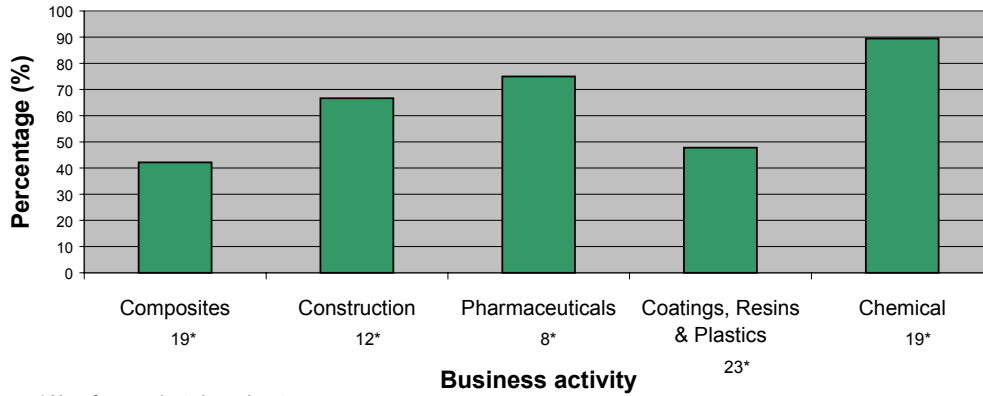


**Sustainable development part of the business plan**



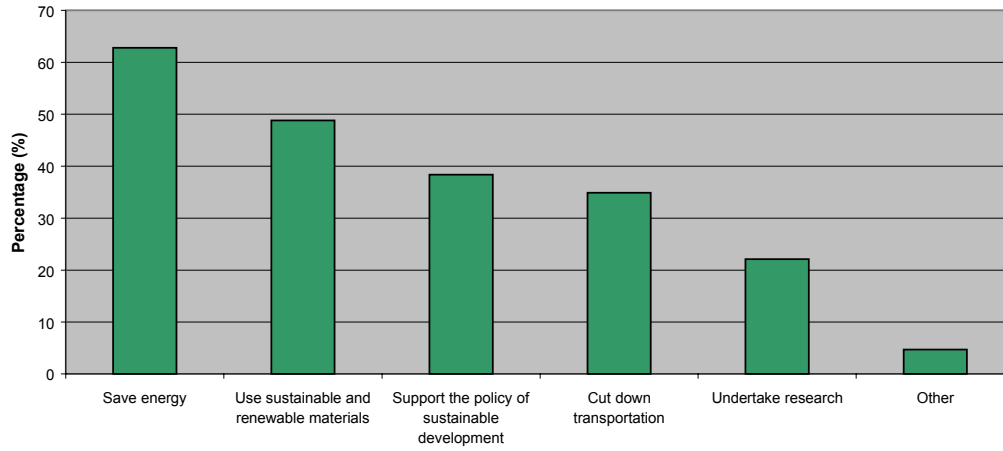
**BIOPRODUCTS Renewable Feedstock for Sustainable Materials**

**Do you consider that the raw materials and processes that your company uses are sustainable**

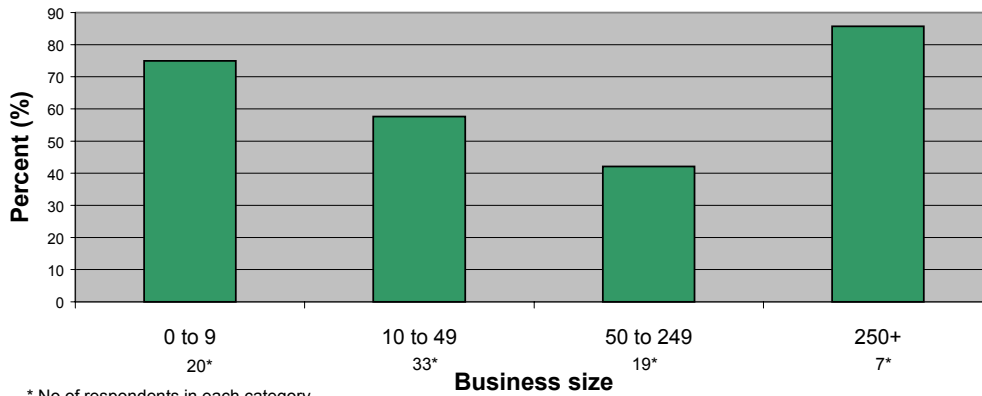


\* No. of respondents in each category

**How is your business involved in sustainable development?**

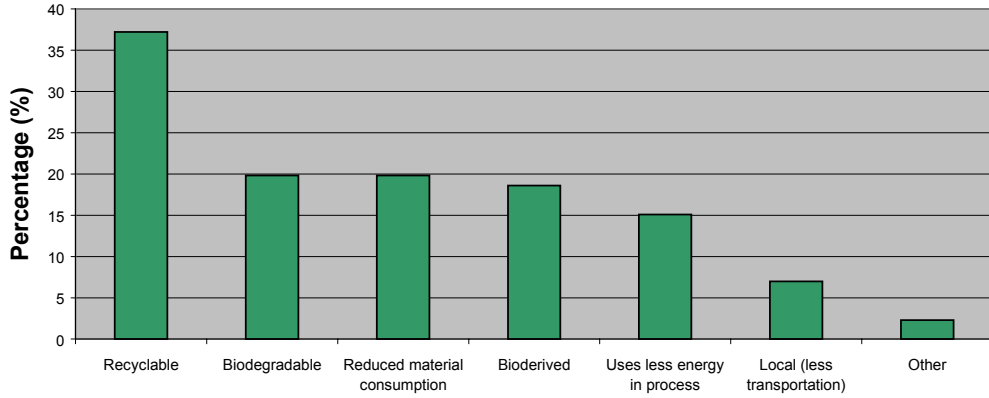


**Do you consider that the raw materials and processes that your company uses are sustainable**

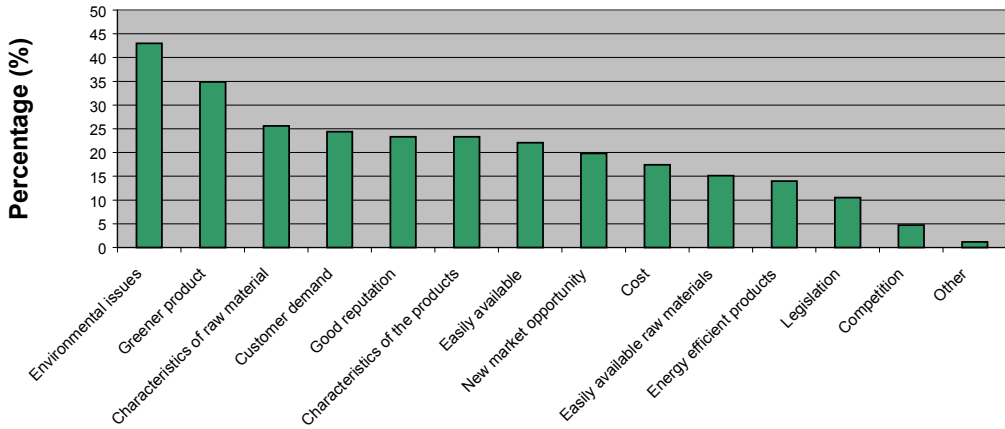


\* No of respondents in each category

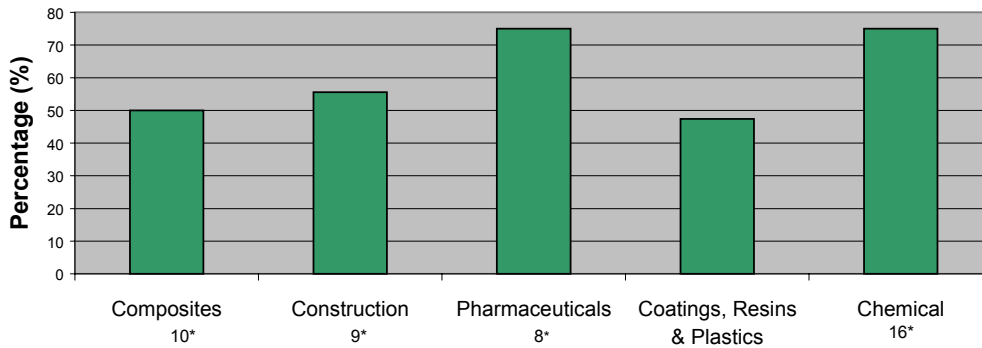
**Sustainable raw materials and processes  
(claims for sustainability)**



**If you currently use renewable and sustainable materials in ANY aspect of your business activities, what are your reasons for it?**



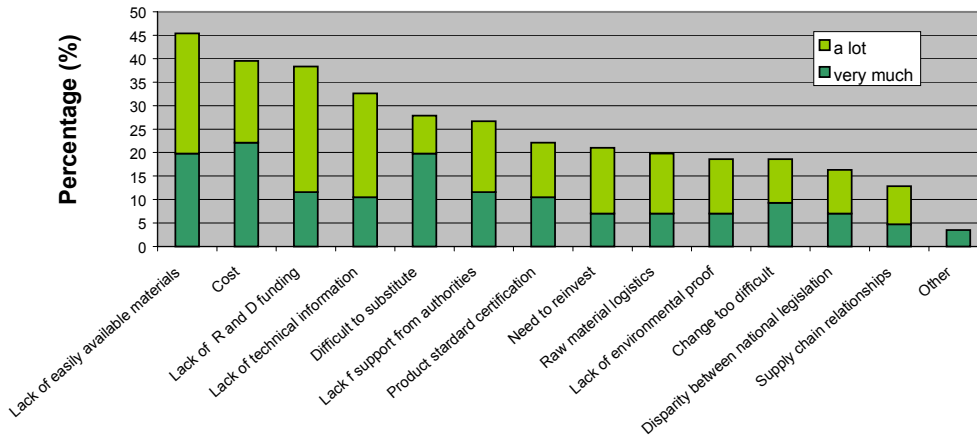
**Environmental issue as a reason for using renewable and sustainable materials**



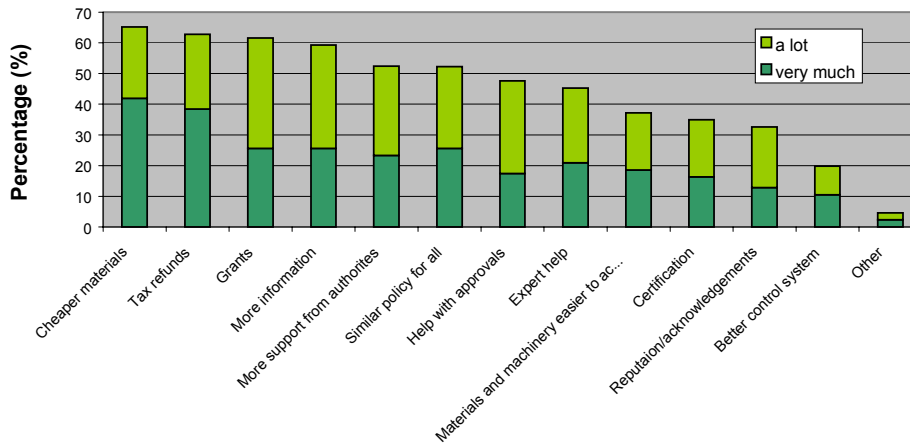
\* No. of respondents in each category

**Business activity**

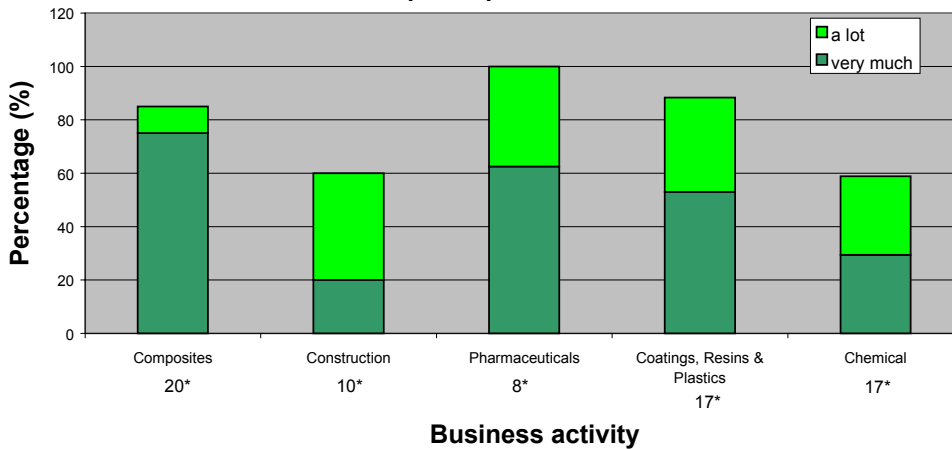
**Barriers to using sustainable and renewable materials**



**What would help/has helped**

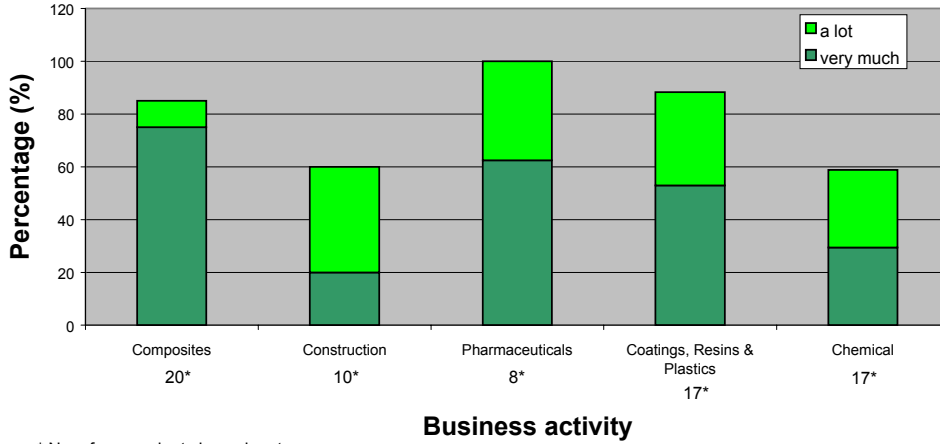


**Help/cheaper materials**



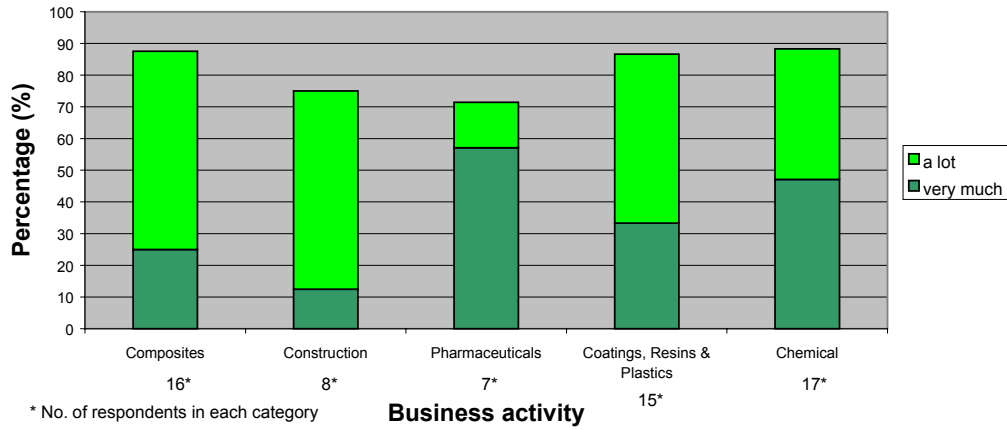
\* No. of respondents in each category

**Help/cheaper materials**



\* No. of respondents in each category

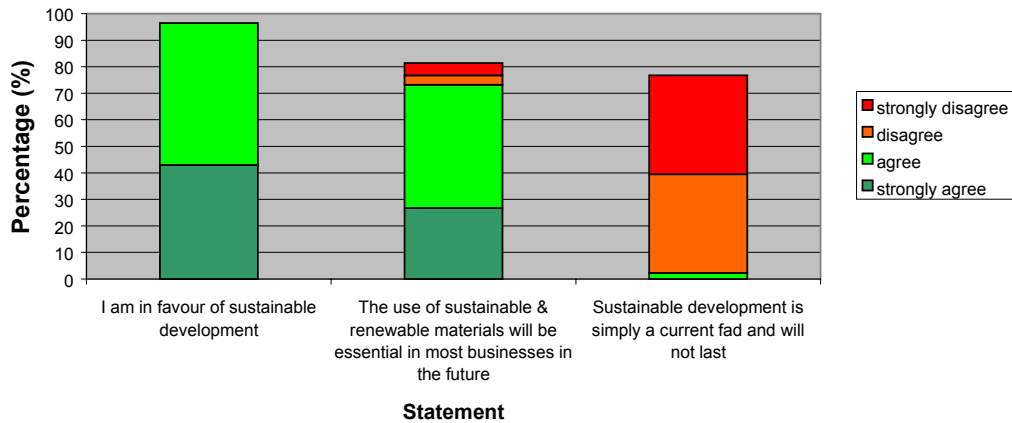
**Help/grants**



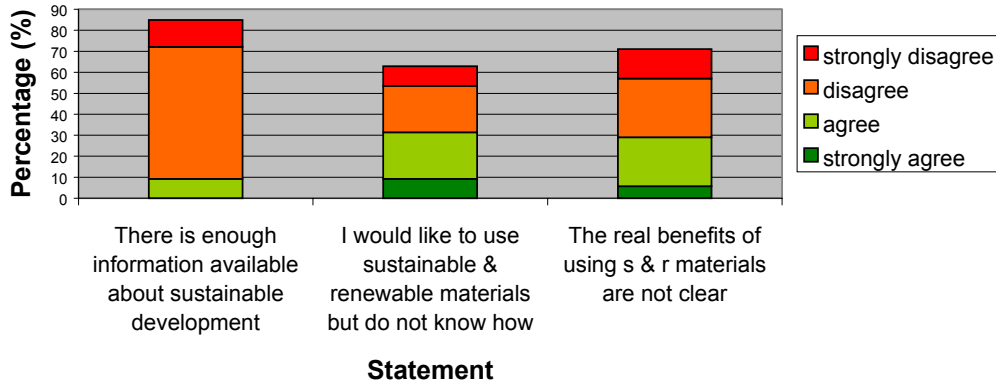
\* No. of respondents in each category

**Statements: Group 1**

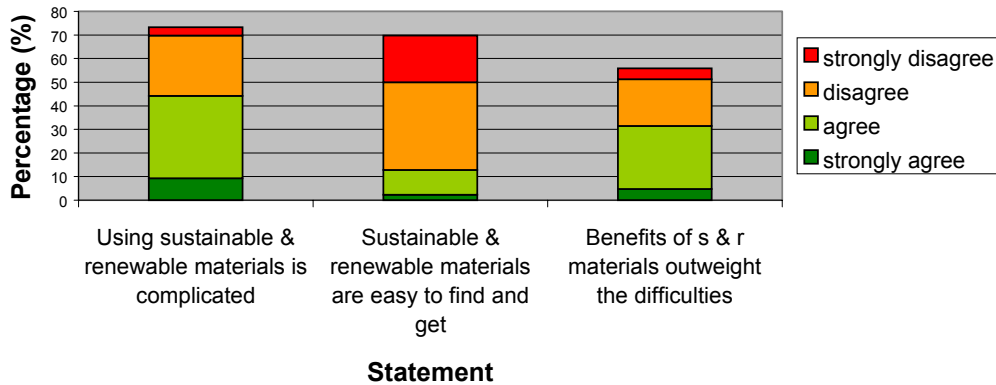
**General attitude towards sustainable development and future visions**



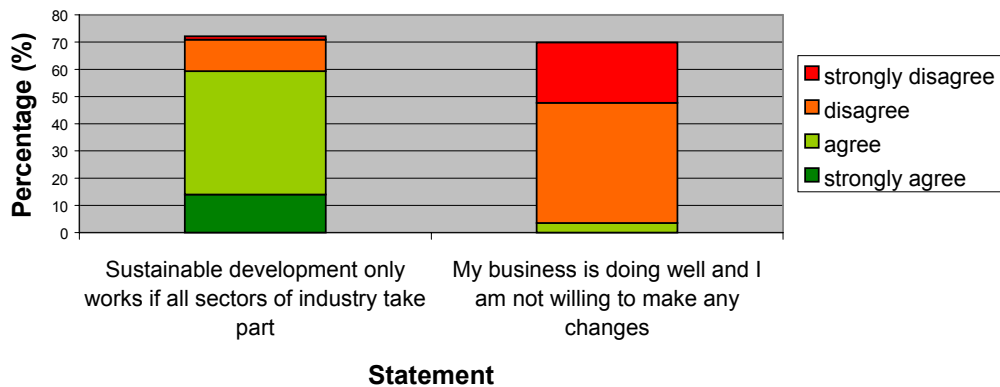
**Statements: Group 2**  
**Information about sustainable development & materials**



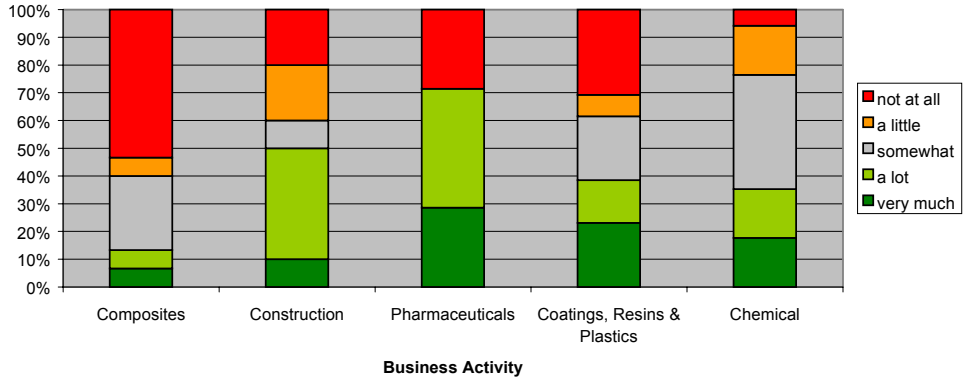
**Statements : Group3**  
**Supply and manufacture**



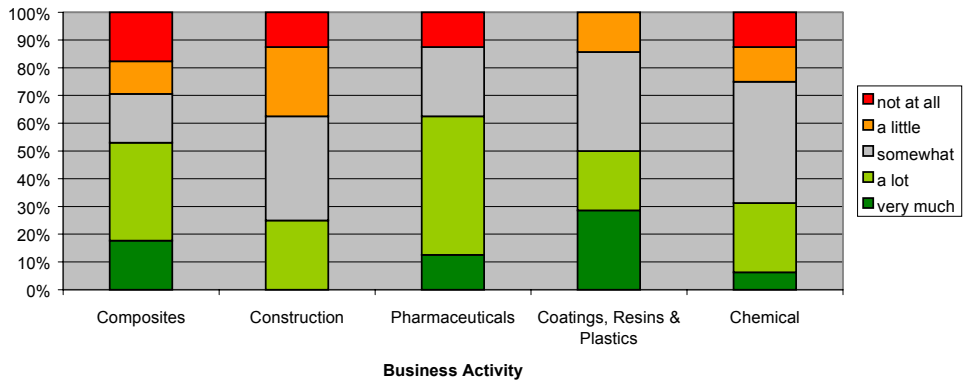
**Statements: Group 4**  
**Sustainable development - Common effort**



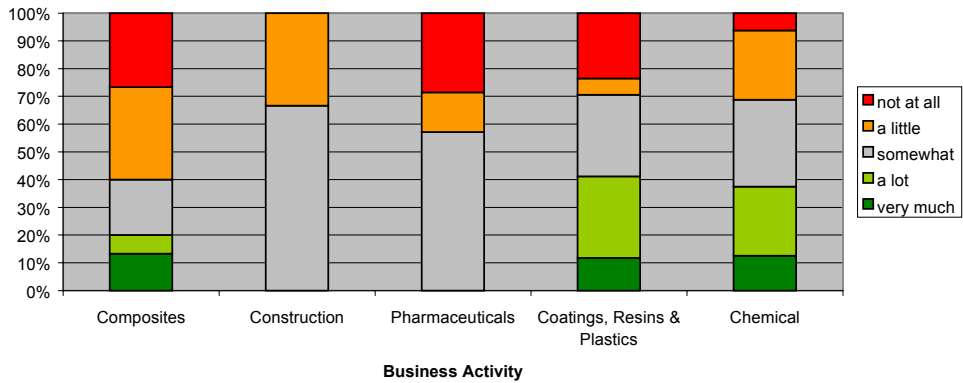
**Barrier - Lack of Support from Authorities**



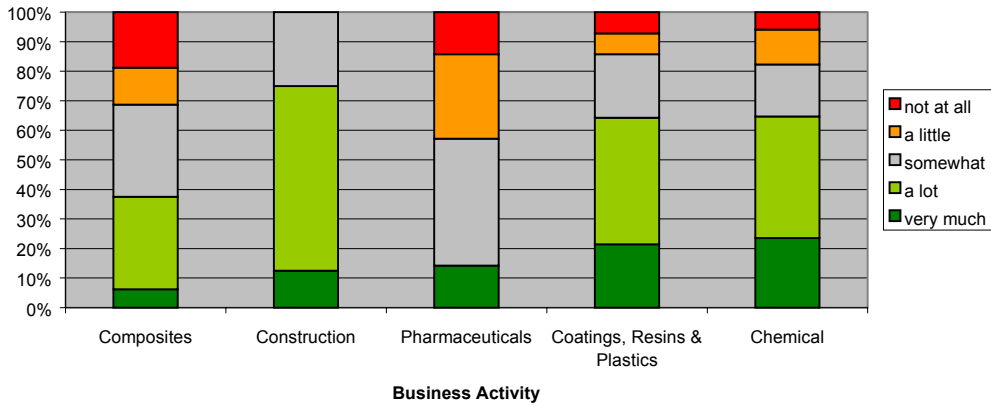
**Barrier - Lack of Technical Information**



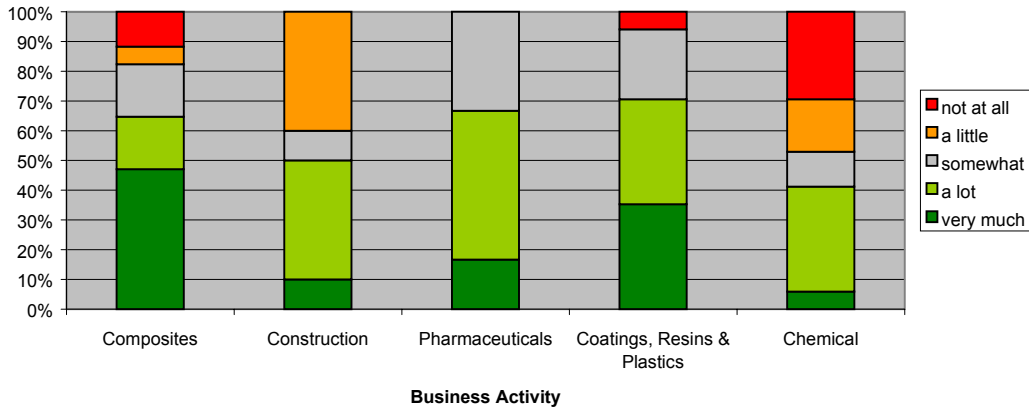
**Barrier - Lack of Proof of Environmental Benefits**



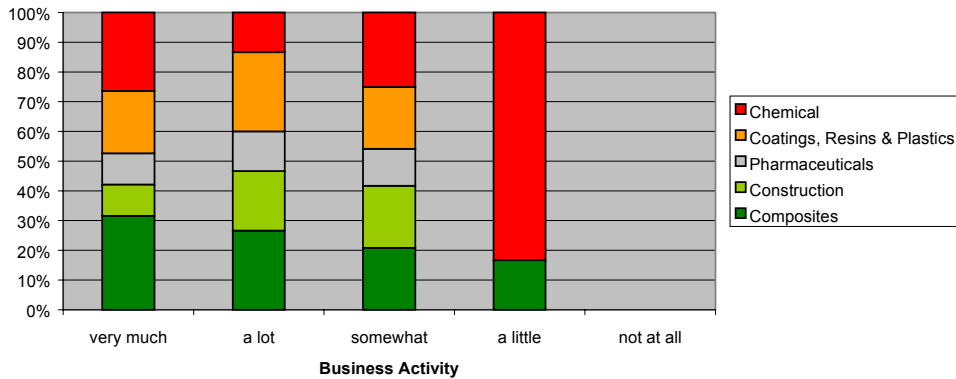
**Barrier - Lack of Access to Adequate R and D Funding**



**Barrier - Lack of Easily Available Materials**

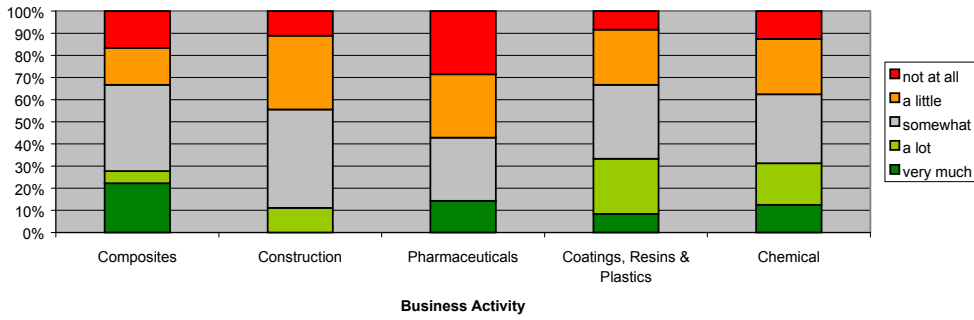


**Barrier - Cost**

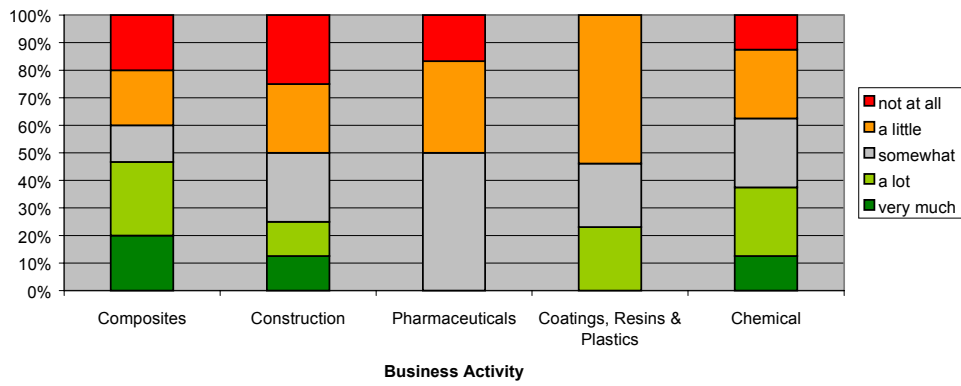


# BIOPRODUCTS Renewable Feedstock for Sustainable Materials

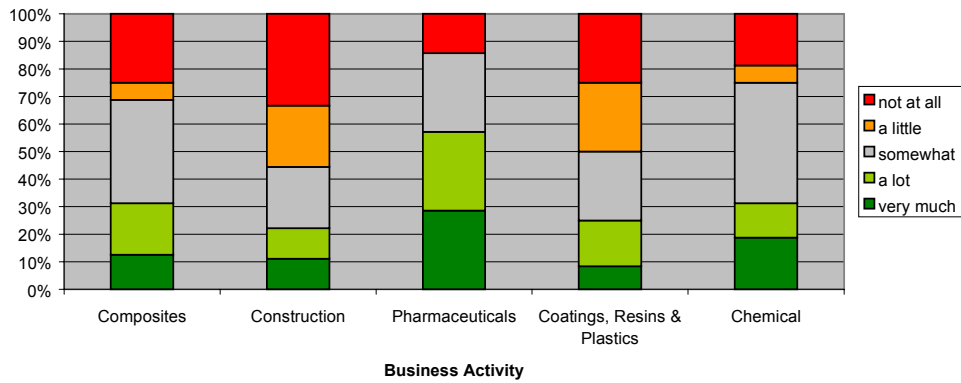
**Barrier - Change Too Difficult**



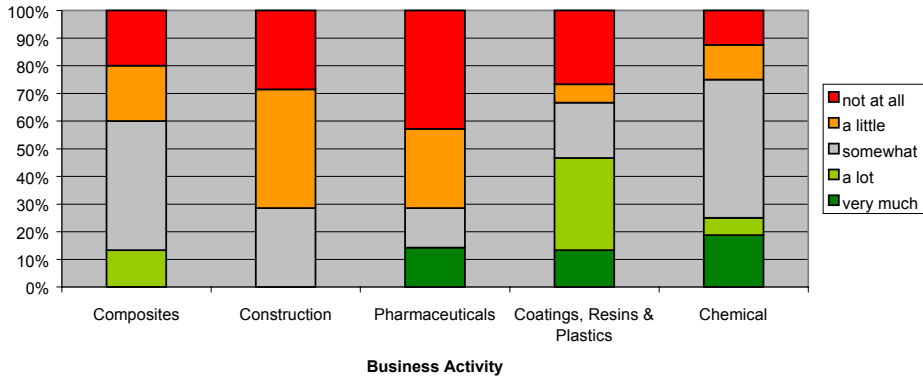
**Barrier - Need to Reinvest**



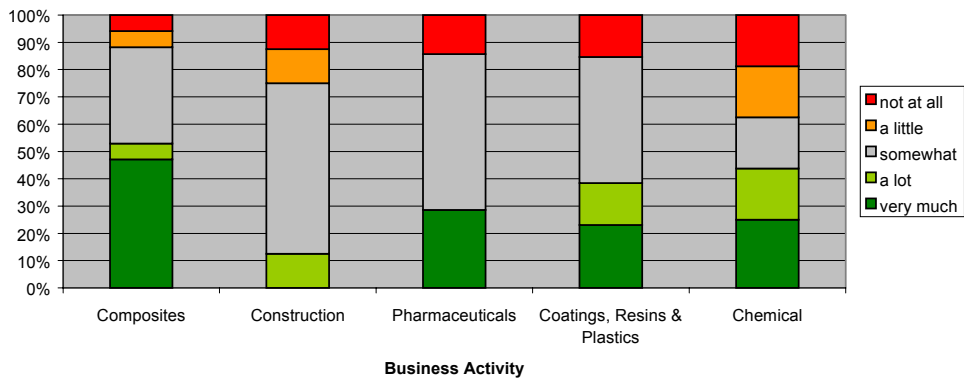
**Barrier - Product Standar Certification**



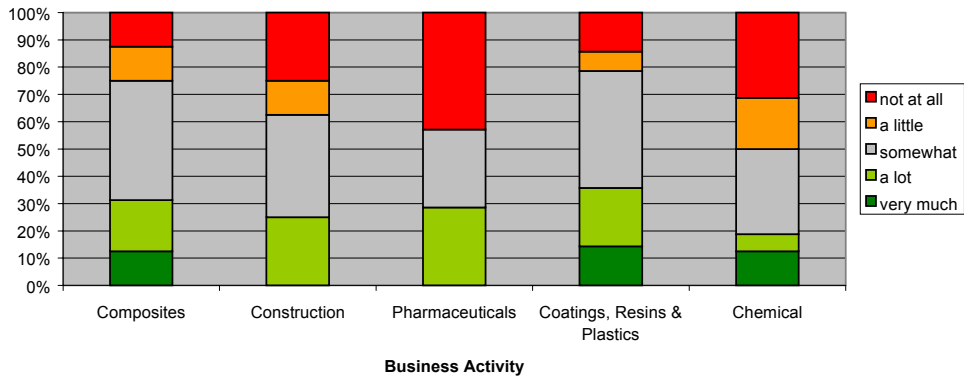
**Barrier - Disparity Between National Legislation**



**Barrier - Difficult to Substitute into Existing Processes**

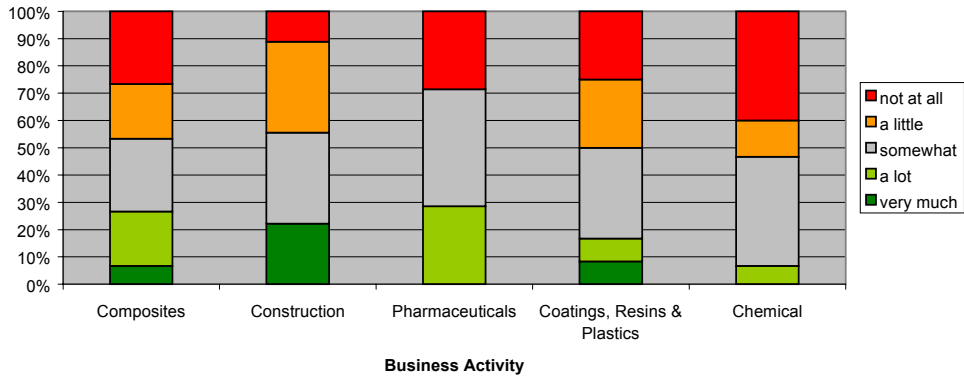


**Barrier - Raw Material Logistics**

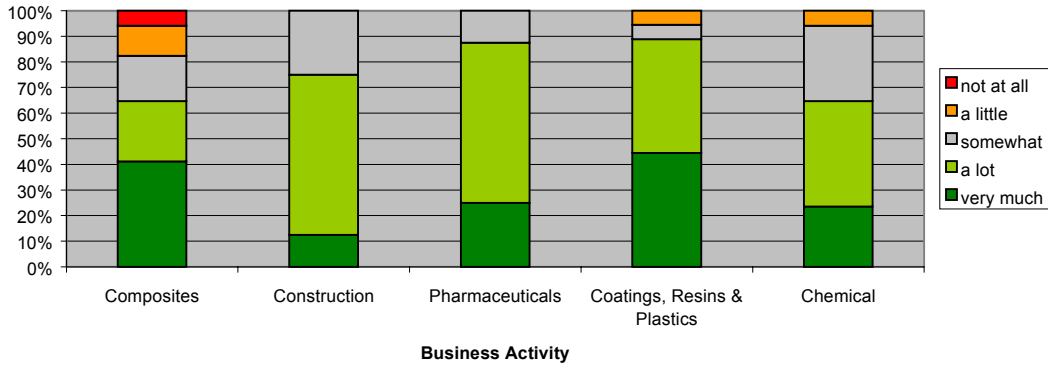


v

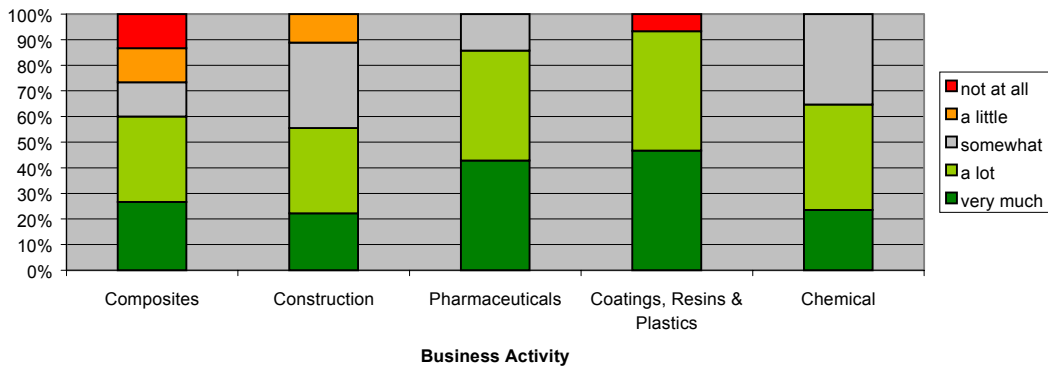
**Barrier - Supply Chain Relationships**



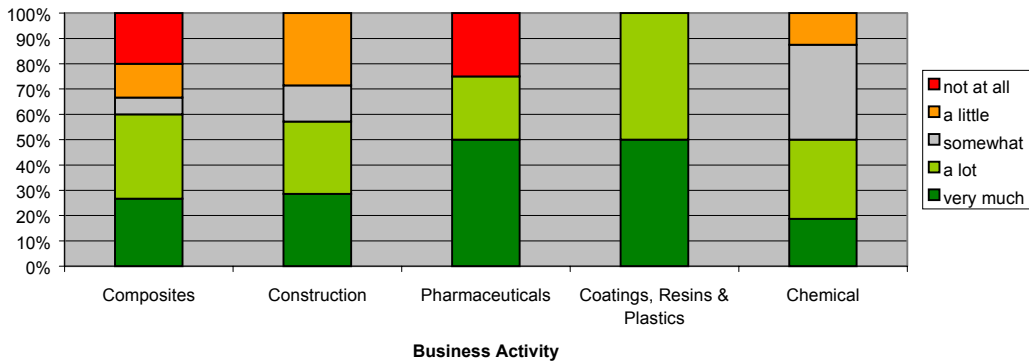
Help - More Information



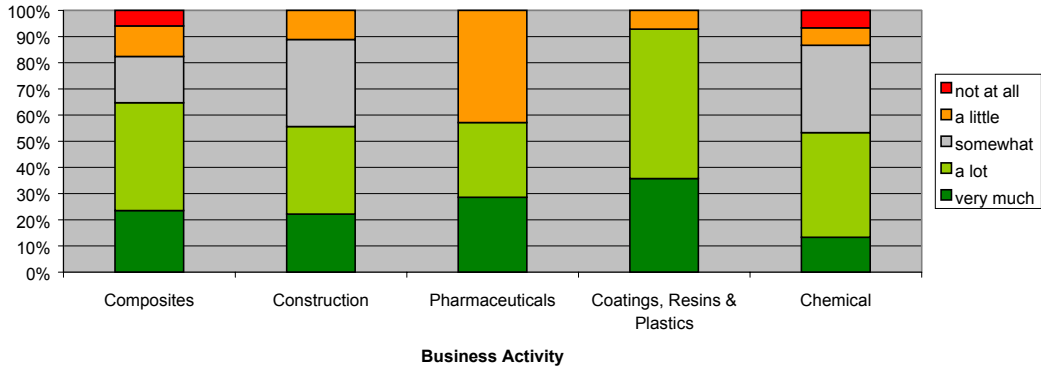
Help - More Support from Regional/National/International Authorities



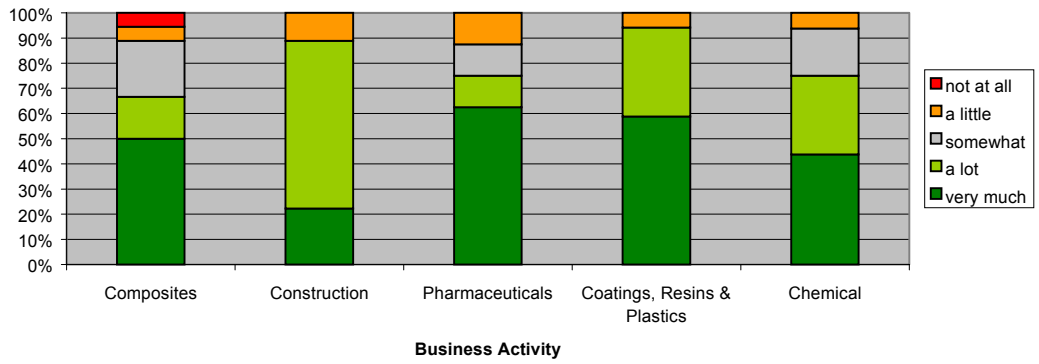
Help - Similar Policy for All



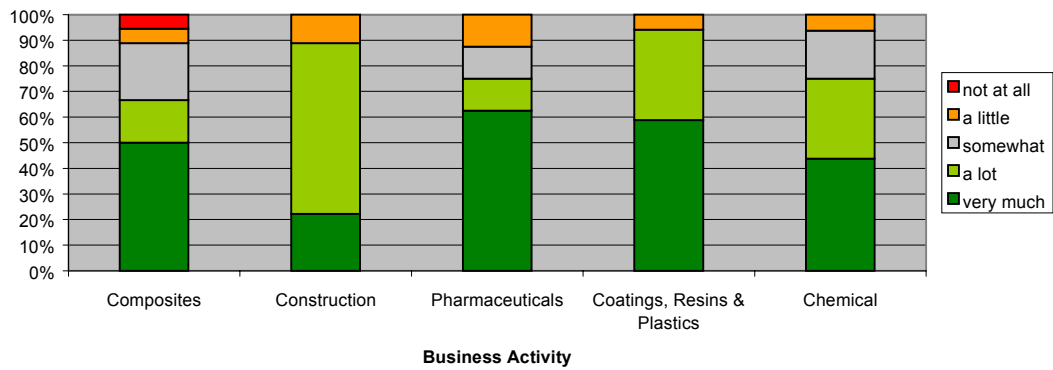
**Help - Help with Approvals**



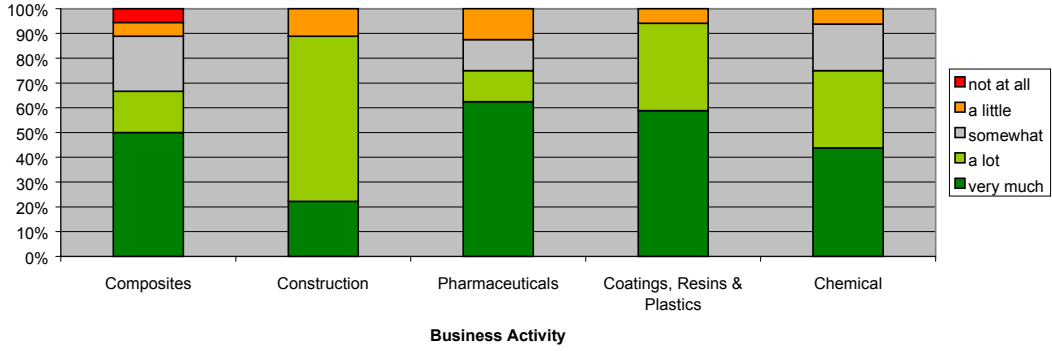
**Help - Tax Refunds**



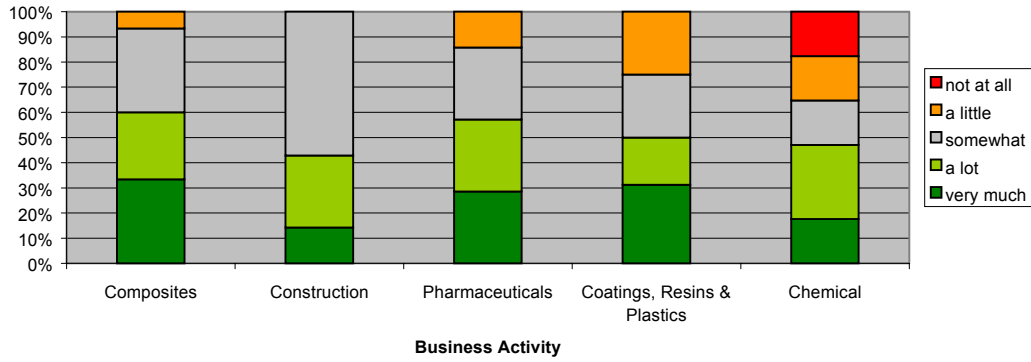
**Help - Cheaper Materials**



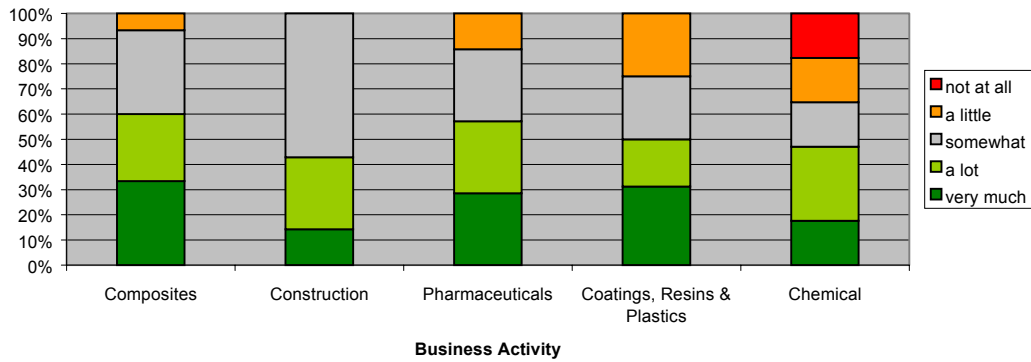
**Help - Cheaper Materials**



**Help - Materials & Machinery Easier to Access**

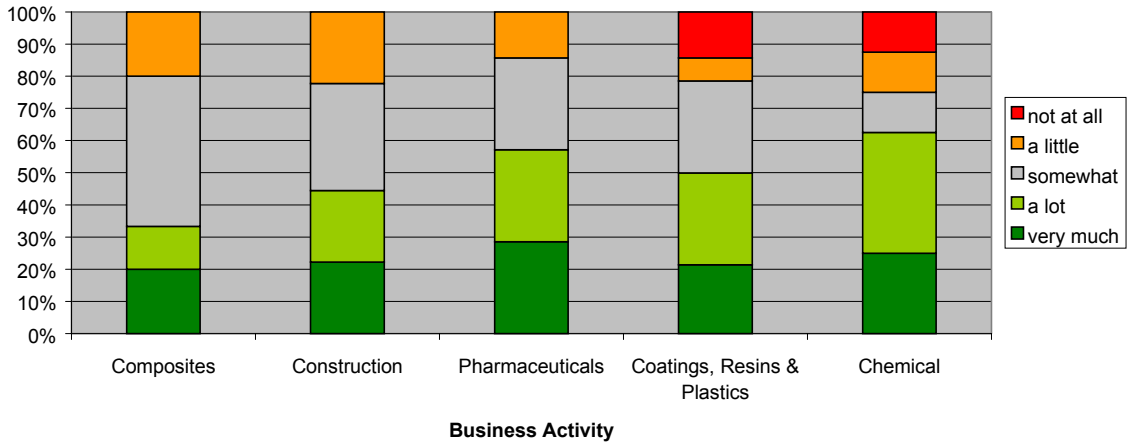


**Help - Reputation & Acknowledgements**

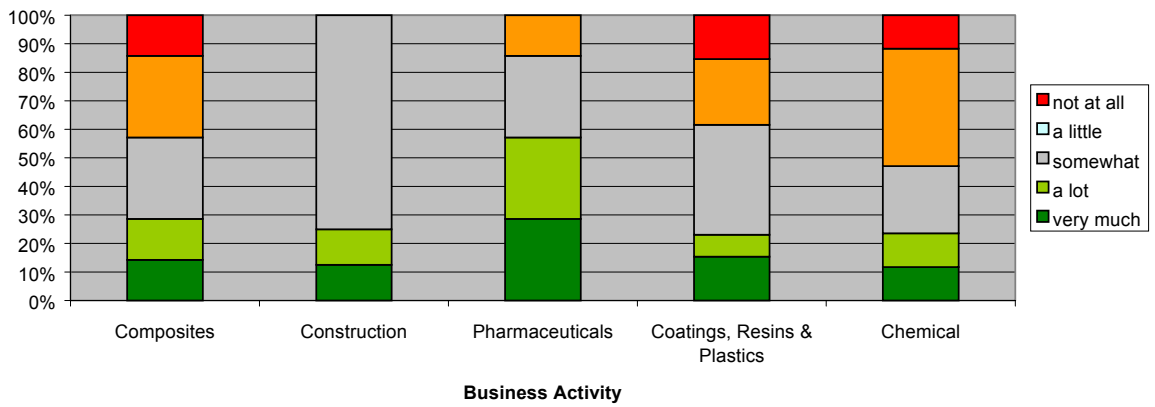


# BIOPRODUCTS Renewable Feedstock for Sustainable Materials

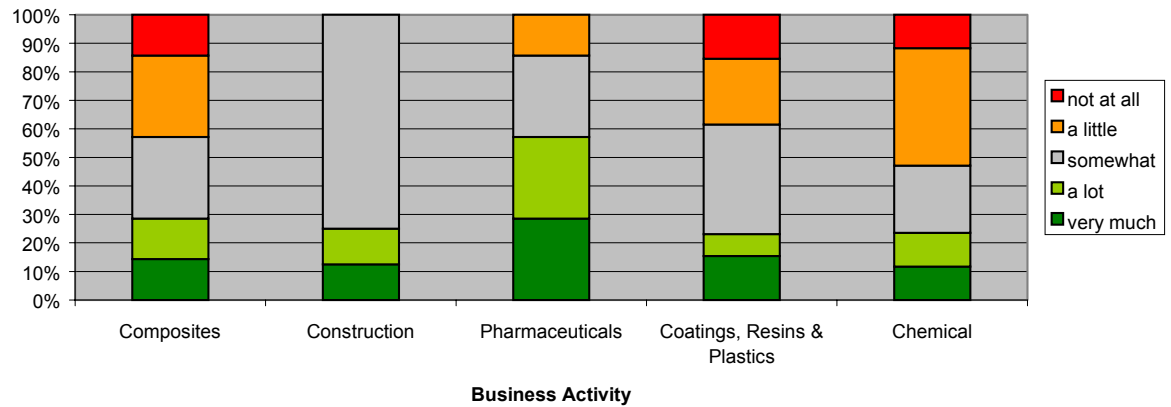
## Help - Certification



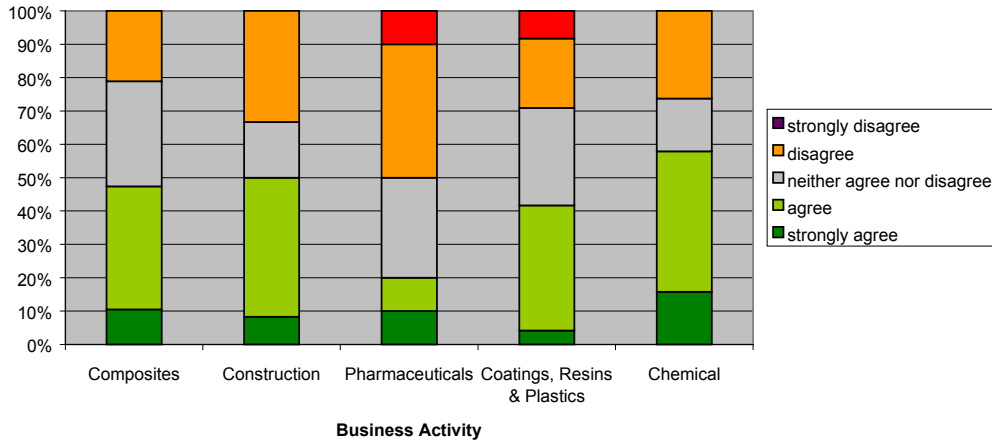
## Help - Better Control System



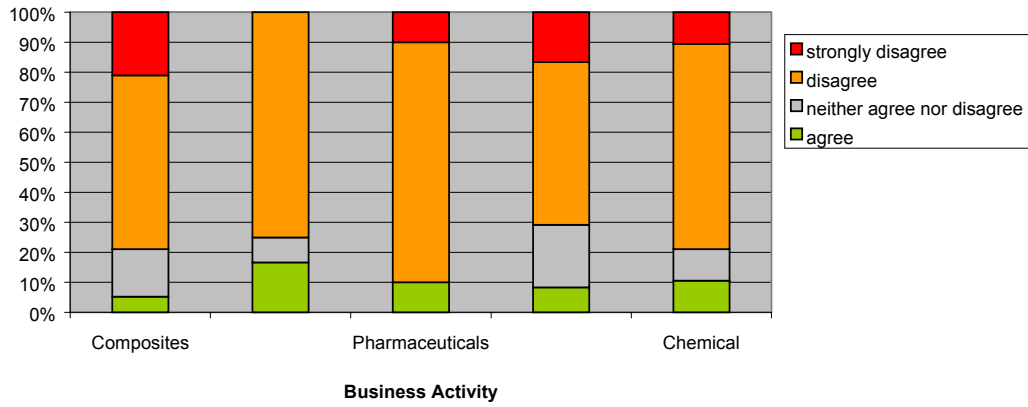
## Help - Grants



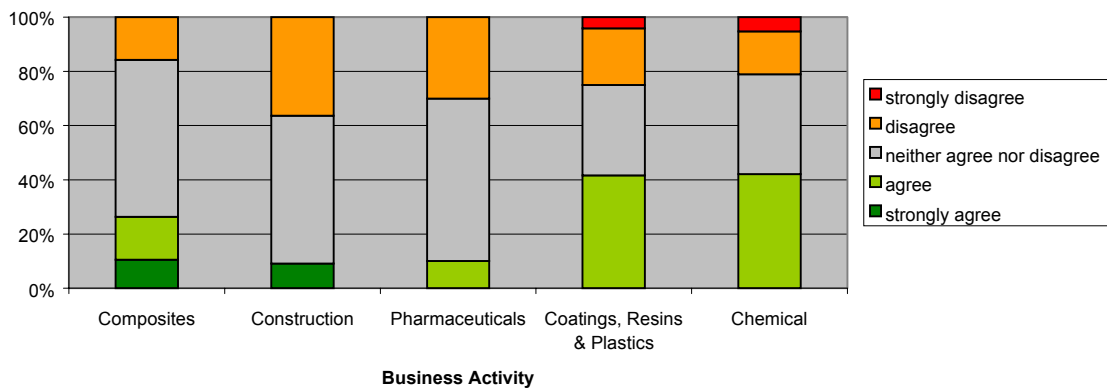
**Statement - Using Sustainable and Renewable Materials is Complicated**



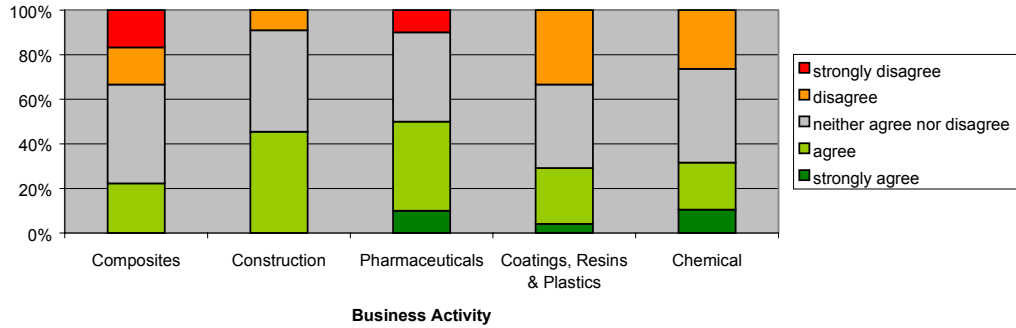
**Statement - There is Enough Information Available about Sustainable Development**



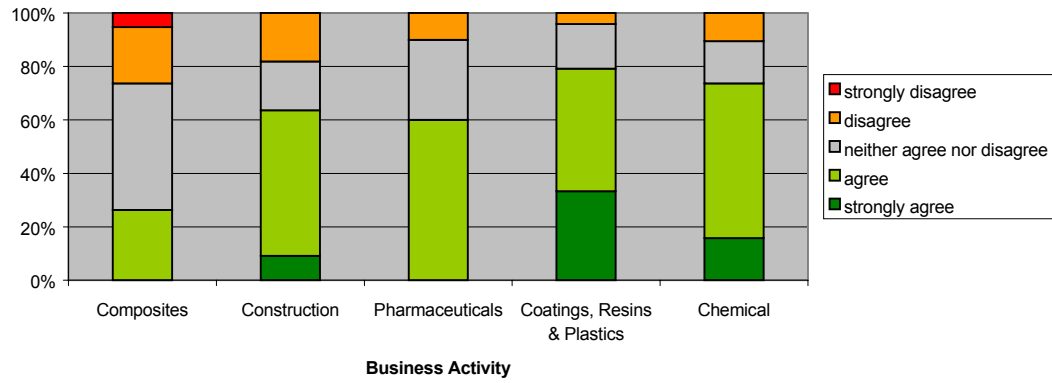
**Statement - Sustainable and Renewable Materials Are Too Expensive to My Business**



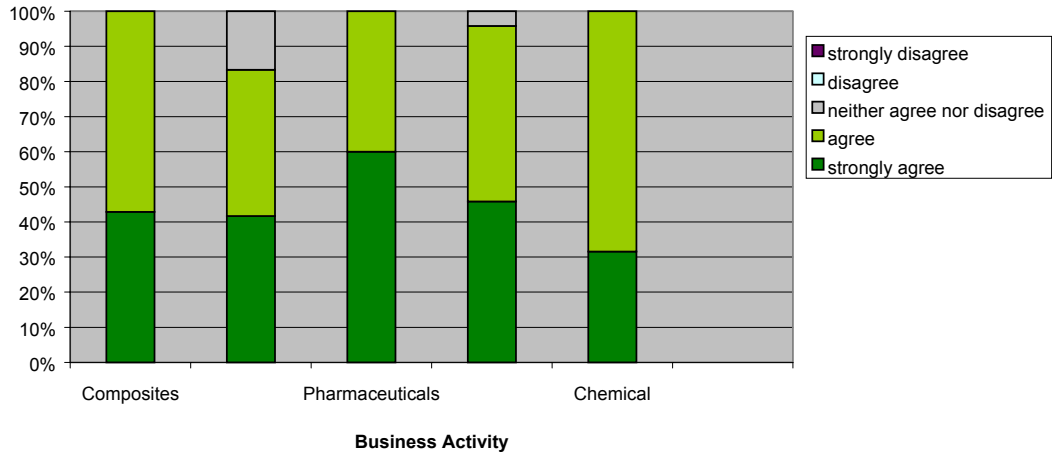
**Statement - Benefits of Using Sustainable and Renewable Materials Outweight the Difficulties**



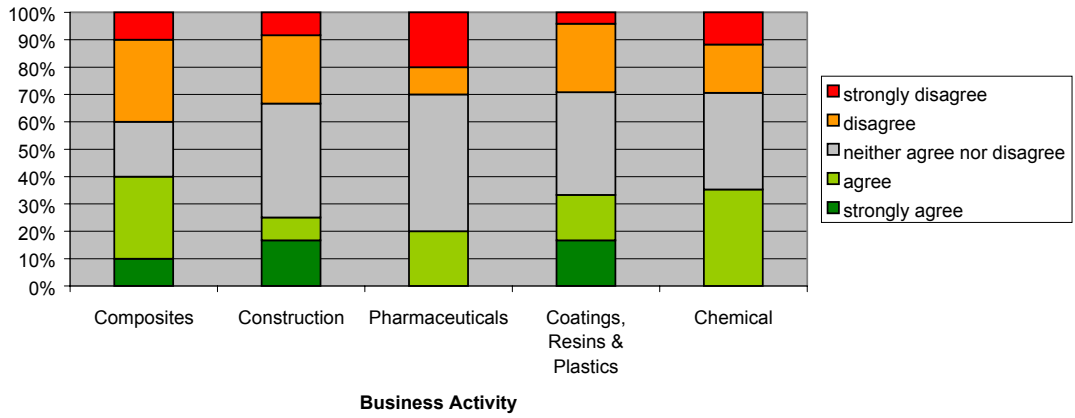
**Statement - Sustainable Development Only Works if All Parts of Industry Took Part**



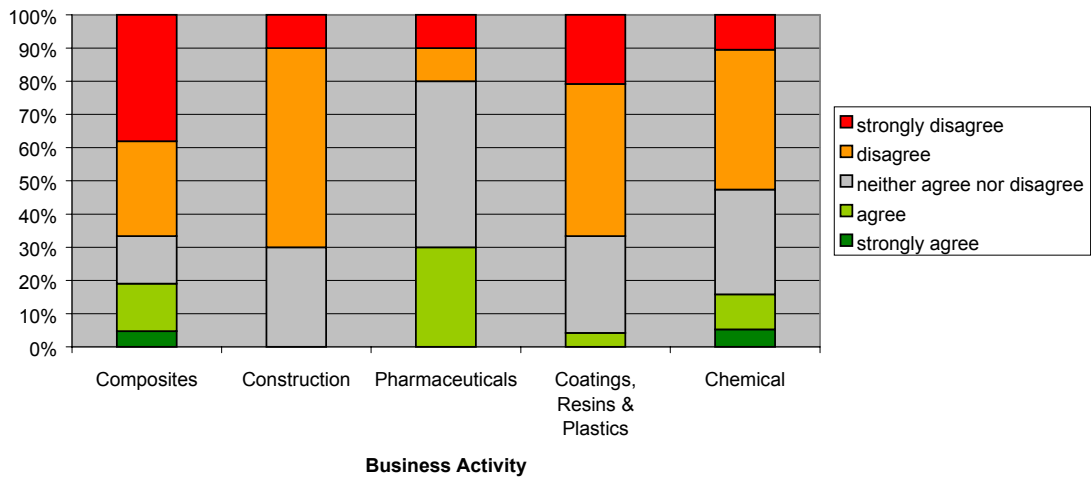
**Statement - I Am in Favour of Sustainable Development**



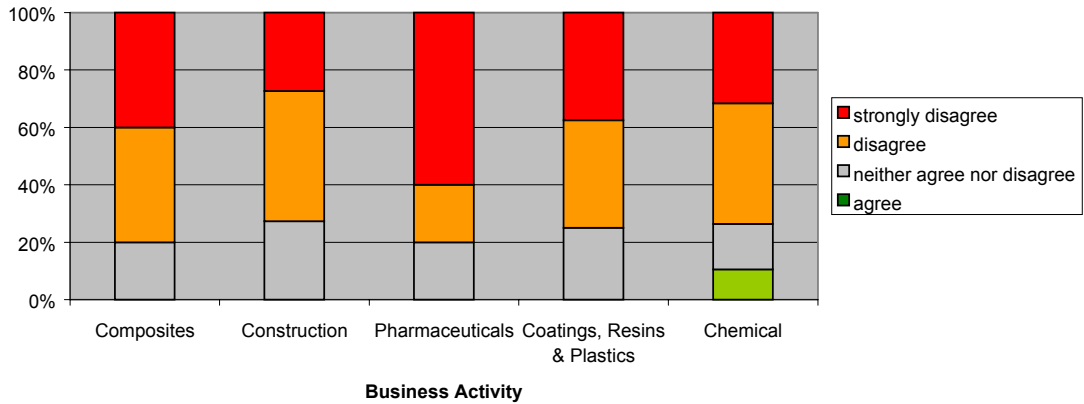
**Statement - I Would Like to Use Sustainable and Renewable Materials but Do Not Know How**



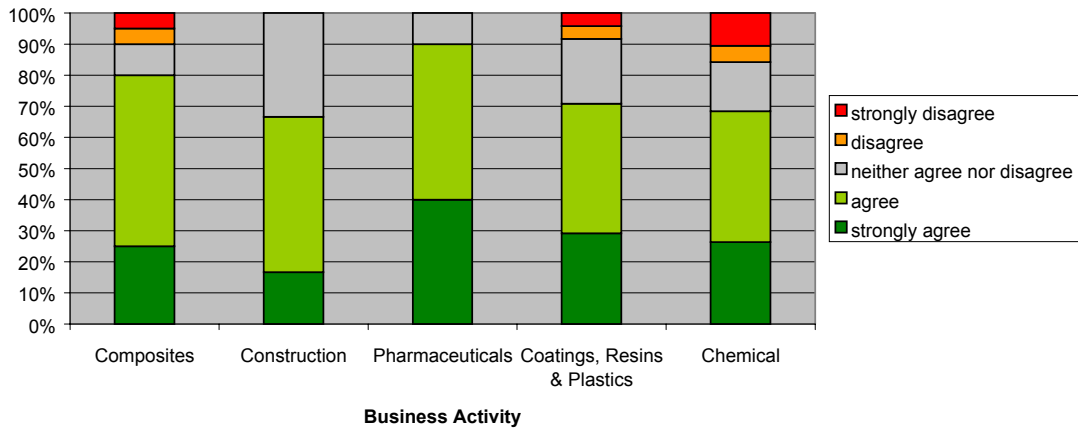
**Statement - Sustainable and Renewable Materials Are Easy to Find and Get**



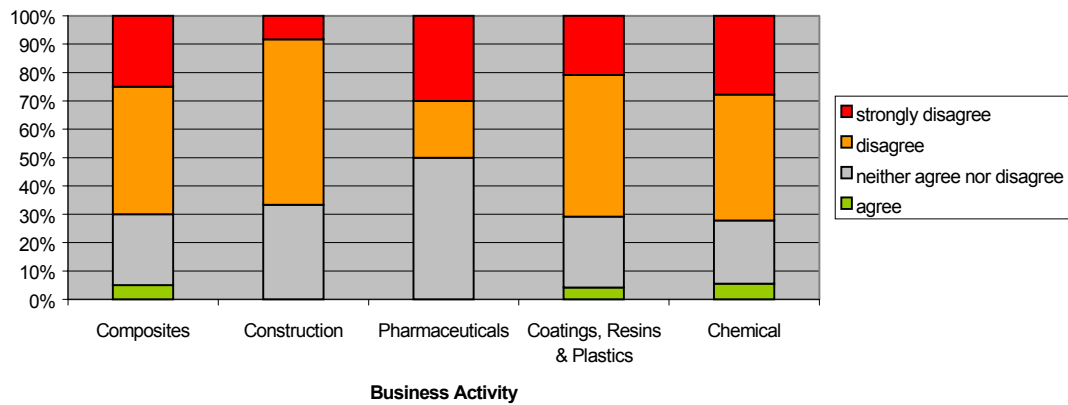
**Statement - Sustainable Development is Simply a Current Fad and Will Not Last**



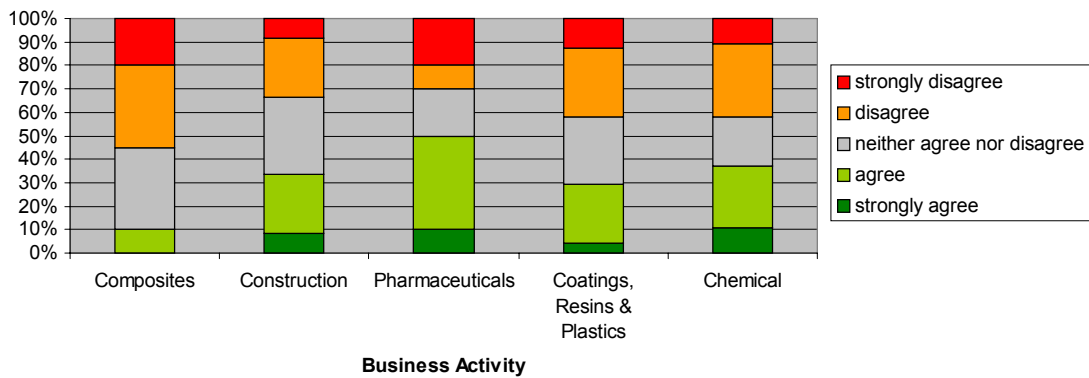
**Statement - The Use of Sustainable and Renewable Materials Will Be Essential in Most Businesses in the Future**



**Statement - My Business is Doing Well and I Am Not Willing to Make Any Changes**



**Statement - The Real Benefits of Using Sustainable and Renewable Materials Are Not Clear**



## Appendix IV – Response frequencies

### Section 1: Your Business Profile

#### 1.2 Which one of the following BEST describes your MAIN business activity?

Composites	24.4%
Construction	14.0%
Pharmaceuticals	11.6%
Coatings, Resins & Plastics	<b>27.9%</b>
Chemical	22.1%

#### 1.2 Which of the following role(s) does your business undertake?

Research	31.4%	Manufacturer	<b>77.9%</b>
Design	26.7%	Retailer	4.7%
Specifier	7.0%	End user	4.7%
Supplier	40.7%	Other (please specify)	4.7%

#### 1.3 What is the size of your business?

Employees		Turnover (£)	
0-9	24.4%	up to 500,000	11.6%
10-49	39.5%	500,000 – 2.8 m	<b>20.9%</b>
50-249	24.4%	2.8 m – 11.2 m	17.4%
250+	9.3%	11.2 m +	14.0%

### Section 2: General Level of Awareness

In this section, we would like to ask you about your views on sustainable development in general and in particular how it relates to your business.

<b>2.1 Is sustainable development currently part of your business plan?</b>	<b>Yes</b>	<b>52.3%</b>
	<b>No</b>	46.5%

<b>If it is NOT currently part of your business plan (whether formally or not) is it going to be?</b>			
<b>Yes</b>	<b>26.7%</b>		
<b>No</b>	17.4%		

#### 2.3 How is your business involved in sustainable development?

**Does it** (please tick as many boxes as appropriate)

Use sustainable and renewable materials	48.8%
Save energy	<b>62.8%</b>
Cut down transportation	34.9%
Support the policy of sustainable development	38.4%
Undertake research	22.1%
Other, please specify _____	4.7%

- 2.3 Do you consider that the raw materials and processes that your company uses are sustainable?
- |     |       |
|-----|-------|
| Yes | 58.1% |
| No  | 36.0% |

If 'YES', is this because they are (please tick as many boxes as appropriate)

Recyclable	37.2%
Bioderived	18.6%
Biodegradable	19.8%
Uses less energy in process	15.1%
Reduced material consumption	19.8%
Local (less transportation)	7.0%
Other, please specify_____	2.3%

### Section 3: Current Use of Renewable and Sustainable Materials

In this section, we would like to ask you about the **raw materials** that you use in your business. In certain circumstances, it may be possible to replace materials derived from non-renewable and unsustainable resources with those which are **renewable** and which could be produced sustainably. For example, in certain instances mineral oil lubricants can be replaced with lubricants derived from industrial crops.

- 3.1 Do you currently use renewable and sustainable materials in ANY aspect of your business activities?
- |     |       |
|-----|-------|
| Yes | 67.4% |
| No  | 25.6% |

If 'YES', what are your reasons for using sustainable and renewable materials? (please tick as many boxes as appropriate)

Easily available	22.1%
Legislation	10.5%
Customer demand	24.4%
New market opportunity	19.8%
Environmental issues (cleaner environment)	43.0%
Cost	17.4%
Competition	4.7%
Good reputation	23.3%
Greener product	34.9%
Easily available raw materials	15.1%
Characteristics (performance) of the raw materials	25.6%
Characteristics of the products	23.3%
Energy efficient products	14.0%
Other, please specify_____	1.2%

- 3.2 I would like to **increase** the use of sustainable and renewable materials **70.9%**  
 I am **happy with the current use** of sustainable and renewable materials within my business **25.6%**  
 I would like to **decrease** the use of sustainable and renewable materials **0%**

- 3.3 Have you noticed any increase in customer demand for sustainable and renewable products?
- |     |       |
|-----|-------|
| Yes | 29.1% |
| No  | 65.1% |

## Section 4: Reasons for Change

### 4.2 What barriers have you encountered or would you perceive you may encounter in using sustainable and renewable materials?

	Very much	A lot	Somewhat	A little	Not at all
Lack of support from authorities	11.6%	15.1%	17.4%	8.1%	<b>19.8%</b>
Lack of technical information	10.5%	22.1%	<b>23.3%</b>	9.3%	8.1%
Lack of proof of environmental benefits	7.0%	11.6%	<b>26.7%</b>	16.3%	12.8%
Lack of access to adequate R and D funding	11.6%	<b>26.7%</b>	18.6%	8.1%	7.0%
Lack of easily available materials	19.8%	<b>25.6%</b>	14.0%	9.3%	9.3%
Cost	22.1%	17.4%	<b>27.9%</b>	10.5%	
Change too difficult	9.3%	9.3%	<b>25.6%</b>	17.4%	10.5%
Need to reinvest	7.0%	14.0%	16.3%	<b>20.9%</b>	9.3%
Product standard certification	10.5%	11.6%	<b>23.3%</b>	8.1%	16.3%
Disparity between national legislation	7.0%	9.3%	<b>24.4%</b>	12.8%	16.3%
Difficult to substitute into existing processes	19.8%	8.1%	<b>27.9%</b>	5.8%	9.3%
Raw material logistics	7.0%	12.8%	<b>26.7%</b>	8.1%	16.3%
Supply chain relationships	4.7%	8.1%	<b>23.3%</b>	12.8%	18.6%
Other, please specify _____	3.5%				1.2%

### 4.3 What would help/has helped you?

	Very much	A lot	Somewhat	A little	Not at all
More information	25.6%	<b>33.7%</b>	14.0%	4.7%	1.2%
More support from regional/national/international authorities	23.3%	<b>29.1%</b>	14.0%	3.5%	3.5%
Similar policy for all	25.6%	<b>26.7%</b>	9.3%	7.0%	5.8%
Help with approvals	17.4%	<b>30.2%</b>	12.8%	9.3%	2.3%
Tax refunds	<b>38.4%</b>	24.4%	9.3%	5.8%	1.2%
Cheaper materials	<b>41.9%</b>	23.3%	11.6%	3.5%	3.5%
Expert help	20.9%	<b>24.4%</b>	18.6%	7.0%	1.2%
Materials and machinery easier to access	18.6%	18.6%	<b>20.9%</b>	10.5%	3.5%
Reputation/acknowledgement	12.8%	<b>19.8%</b>	18.6%	14.0%	3.5%
Certification	16.3%	18.6%	<b>20.9%</b>	10.5%	4.7%
Better control system	10.5%	9.3%	<b>24.4%</b>	17.4%	7.0%
Grants	25.6%	<b>36.0%</b>	5.8%	4.7%	1.2%
Other, please specify _____	2.3%	2.3%			

## Section 5: Opportunities for the future

### 5.3 If you had the choice of producing your products more sustainably, would you do so?

**Yes 93.0%**  
**No 1.2%**

If 'NO', is it because (please tick as many boxes as appropriate)

not willing to change 1.2%  
cannot see enough benefits 1.2%  
not enough customer demand 1.2%  
do not know how  
it is just a fad  
too expensive 1.2%

**5.4 Please indicate how much you agree/disagree with the following statements**

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Using sustainable and renewable materials is complicated.	9.3%	<b>34.9%</b>	24.4%	25.6	3.5%
There is enough information available about sustainable development.		9.3%	12.8%	<b>62.8%</b>	12.8%
Sustainable and renewable materials are too expensive for my business.	3.5%	25.6%	<b>44.2%</b>	20.9%	2.3%
Benefits of using sustainable and renewable materials outweigh the difficulties.	4.7%	26.7%	<b>39.5%</b>	19.8%	4.7%
Sustainable development only works if all sectors of industry take part.	14.0%	<b>45.3%</b>	24.4%	11.6%	1.2%
I am in favour of sustainable development.	43.0%	<b>53.5%</b>	3.5%		
I would like to use sustainable and renewable materials but do not know how.	9.3%	22.1%	<b>33.7%</b>	22.1%	9.3%
Sustainable and renewable materials are easy to find and get.	2.3%	10.5%	27.9%	<b>37.2%</b>	19.8%
Sustainable development is simply a current fad and will not last.		2.3%	20.9%	<b>37.2%</b>	<b>37.2%</b>
The use of sustainable and renewable materials will be essential in most businesses in the future.	26.7%	<b>46.5%</b>	17.4%	3.5%	4.7%
My business is doing well and I am not willing to make any changes.		3.5%	27.9%	<b>44.2%</b>	22.1%
The real benefits of using sustainable and renewable materials are not clear.	5.8%	23.3%	<b>27.9%</b>	<b>27.9%</b>	14.0%