Department of Trade and Industry

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UK Polymer Composites Sector

Foresight Study and Competitive Analysis

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Foreword

It is refreshing to introduce this new look at the Composites industry and its associated research community as the pioneering studies and groundbreaking applications of the 20th century look increasingly historical. During the last three decades of that century composites shifted from unaffordable, space-programme curiosities to familiar, everyday items ranging from construction panels to consumer goods. Unsurprisingly, markets over this period have seen some spectacular growth, benefiting from investment in research from both defence and civilian agencies. Attempting to project forwards from this point is difficult. Currently, the industry faces a bewildering combination of pressures and opportunities. New material forms and novel processes open up new application areas whilst conflicting environmental concerns appear on the one hand to support this growth and on the other to jeopardise existing markets.

Upheaval and uncertainty are not unique to the composites industry and bring both threats and opportunities. Pressure on VOC emissions has impacted on manufacture throughout Western Europe and, since open-mould applications represent a large fraction of our markets, managing a transition to closed mould techniques is critical to survival. End-user groups are also subject to pressures, which echo along the supply chain. Drives to reduce costs in aerospace manufacture may threaten the stability of the prepreg market, while the EU end-of-life vehicle directive questions the entire sustainability of thermosets in European automobiles. Additional drivers, such as the potential consequences of Kyoto and increasing pressure on occupant and pedestrian safety may mean that composites become the default solution for certain classes of vehicle structure.

One fact is clear; global competition means that new applications for composites will be hard won and parallel developments from competing materials means that no market is completely secure unless materials, processes and products remain cost-effective. Complacency will have its inevitable reward and the need for innovation continues. Historically, UK has provided a global lead with pioneering developments in e.g. fibre science although our current manufacturing output per capita remains only average. The opportunity to benchmark our activities in this field and to prioritise areas for R&D support is an essential first step to improving on that position.

C D Rudd
Chair, IoM Composites Foresight Steering Panel
Nottingham, 27 June 2001

Executive Summary

This study of the UK polymer composites industry, undertaken from April to June 2001, shows how it interacts with a wide range of user and supply industries, how it competes internationally and how it considers its prospects for the future.

The industry is a diverse collection of companies and markets, with many obstacles limiting the faster growth of the industry and broader use of composites. The UK performs well in a few highly specialist sectors, such as aircraft wings, motor sport and leisure/large marine vessels, but unfortunately does not excel in many areas and the overall performance of the industry is average when measured against European competitors. The dispersed nature of the industry means that there is not normally a coordinated approach to threats and opportunities, but examples of good practice are reassuringly common. Importantly, the industry is positive in its attitude towards the challenges that face it and is generally progressing to overcome them, albeit at a slower pace than ideal.

Amongst the changes in evidence are signs of consolidation of the industry through restructuring and globalisation, with market trends towards mass transit and construction. In parallel, environmental issues are having a significant effect on the industry, with strong interest in recycling and significant movement towards cleaner, cheaper production technologies. Strong materials trends are therefore towards thermoplastics and stitched fabrics, whilst processing trends are away from hand lay-up towards resin transfer moulding, resin infusion and thermoforming techniques. The main factors affecting the future competitiveness of the industry are seen to be:

- The changing nature of skills in the UK, away from manufacturing
- A high level of scientific knowledge in the UK
- Likely future developments in technologies
- The strength of Sterling, making UK industry less competitive
- Environmental factors such as recycling, landfill and emissions
- Poor understanding of composites by potential customers

In response to these, the UK industry sees its main strengths in a good level of fundamental understanding and academic research, innovative ideas and manufacturing processes. Its main weaknesses include a shortage of trained staff, a lack of customer awareness, a shortage of design guides, high labour costs, unclear recycling routes and little applied development. Opportunities for exploiting future trends include new markets in infrastructure, transport, offshore, lightweight products and renewable energy.

Additionally, opportunities were seen in stronger company/university links, improved transfer of knowledge from academia and the use of new processes and new materials. The threats to the UK composites industry have been identified as low cost imports from cheaper countries, environmental regulations, reduced development funding for new ideas and the development of competitive technologies, such as titanium and high-strength steel.

Recommendations

1. Lower the cost of supply

The area of highest priority should be on the development, dissemination and commercialisation of low-cost processing methods. This should be achieved through rolling, coordinated dissemination and best practice programmes to ensure that composites companies have the full picture of the benefits and limitations of new process technologies. This would best be achieved through Government and industry partnerships.

2. Lower the barriers that restrict demand

The industry should further strengthen its ability to negotiate collectively and centrally with regulators, as undertaken successfully for styrene registration, and to provide input into European bodies such as GPRMC on regulatory aspects. The industry should develop a primary reference point on recycling issues and should publish validated information on the opportunities for end-of life re-use and disposal of composites. The BPF is best placed to represent the industry on regulatory matters, as shown by its recent actions on styrene registrations and planned seminars.

3. Stimulate sustainable market demand

Additionally, the industry should explore opportunities for composites that arise from environmental pressures to reduce weight, increase service lives or reduce maintenance. The dialogue with new and existing end-users should be through trade and professional bodies, including industry-sector networks.

4. Invest in education and training

To encourage improved levels of skills within the industry, composites companies should be encouraged to train their staff and develop relationships with regional or local education and training specialists. The benefits of training should also be highlighted, and it is envisaged that the CPA might best fulfil this role.

5. Bring about a step-change in standards

To demonstrate the increasing availability of standards in a maturing industry, companies should require that suppliers work to international quality and technical standards wherever possible. The industry should also work with end-user groups and standards developers to develop and publicise guidance information, as a faster pre-cursor to standardisation

6. Teach composites in schools and further education

The industry should actively develop initiatives to teach composites in schools, in support of the National Curriculum requirement to teach composites from Key Stage 3 through to A Level (11/12 years to 18). Equally, the industry should support the development of a common module presenting the important aspects of polymer composites technology in a variety of engineering and materials courses. This is best undertaken by professional bodies facilitating discussion between industry and DfES.

7. Sponsor applications-led research and disseminate results widely

It is recommended that the application process for government development funds should be suitable for SMEs, that research funds should focus more on applied work and that future funds should be targeted according to the impact of completed research. Additionally, the results of work involving significant (>30%) government funding should be disseminated widely, after the appropriate confidentiality periods, in practical and easily understood formats such as seminars and case studies. The correct identification of research needs should be through industry consultations with end-users and researchers.

8. Set up an industry forum

Finally, there is a need to provide an over-arching forum for composites industry, to allow the trade federations to interact more effectively, for the output of research programmes to be more effectively disseminated and for the current state-of art to be more effectively presented to potential customers and regulatory bodies. One possible method of creating this Forum would be through a Faraday style partnership to bring together the leading players in the industry. The steering group for this current study, being made up of a cross-section of industry and professional leaders, have agreed to consider this need.

Background

The Material Foresight Panel's Report 'Shaping our Society' recognised that the composites industry is extremely scattered, composed of a wide range of materials suppliers, fabricators, major OEMs and end users. Companies vary from having a total dependence on composites to those where it forms a small, but often critical part of their operations. A wide range of technology levels is also present in the industry.

This report contains quantified input information both on the current status of the UK composites industry and its position in the world market. It outlines the competitiveness of the UK composites industry and highlights trends in the UK and elsewhere, as well as giving the reasons for those trends and their likely effect on the competitiveness of the UK composites industry.

The report also details the other factors impacting the competitiveness of the UK composites industry and the future scenarios faced by the industry. An analysis of the strengths, weakness, opportunities and threats faced by the industry is followed by recommendations on the roles of industry, academia and government, in future research and business, to maintain and improve the competitiveness of the composites industry.

Methodology

The report has been prepared based on a series of specific information-gathering exercises relevant to a competitiveness and foresight exercise, including:

- Consultations with sector-specific Research and Technology Organisations, Trade Bodies, SMEs and pivotal industrial organizations
- Reviews of published data, overseas embassy inputs and technical journal information
- A industry survey to provide quantified data on the industry and evidence of the issues facing it, resulting in 80 responses, 75% of which were from SMEs.
- An industry workshop to validate the findings of the survey and to achieve a consensual view on the future of the industry
- SWOT analysis of the industry, undertaken through the survey and the workshop
- STEEP analysis of the issues facing the industry, together with prioritisation of those issues and the building of future scenarios, undertaken through the workshop

The report captures a snap-shot of the industry during the period of the study (April to June 2001), generating a full evaluation of the industry, its current competitive position and the longer-term Foresight requirements.

This report has been prepared for the UK Department of Trade and Industry by NPL Materials Centre and NetComposites, in conjunction with the Institute of Materials (IoM), Composites Division Board. This study has also had wide support from other bodies including the Composites Processing Association and British Plastics Federation, ensuring the cooperation and representation of the composites industry.[i]

[i] Composites are defined in the Glossary in Annex 1

1 Introduction

1.1 Industry Characteristics

It is recognised that the composites industry is extremely scattered, as composed of a wide range of materials suppliers (eg fibre and resin manufacturers, compound suppliers), fabricators, major OEMs and end users. Involvement in composites varies can mean total dependence or just a small part of a company's operations. A wide range of technology levels is also present in the industry from hand lay-up GRP to autoclaved cured aerospace materials.

There is therefore a diverse range of complex, varied materials, processes and products, serving a large number of application sectors including:

- Aircraft/Aerospace/Defence
- Industrial
- Construction
- Consumer
- Corrosion
- Electrical/Electronic
- Marine
- Transportation

Each of the application sectors are often associated with particular materials and process combinations for the manufacture of composite components, to give them the performance and cost characteristics that they are looking for. The requirements of the Aerospace sector are, for example, vastly different to those of the Construction sector. This has led to an industry made up of many small companies, each with fairly unique skills and market orientations.

The low cost of entry to basic composites processing has also fuelled the creation of new companies, and the composites industry is therefore highly fragmented, disparate and dominated by SMEs.

Whilst this gives an industry that can be flexible in its approach, the dispersed nature of the composites industry has meant that it cannot easily generate enough critical mass to present itself well to potential customers, stifling faster growth. This problem is common to most national composites industries, especially compared to alternative materials industries (steel for instance) which tend to be dominated by larger players.

In addition, because of the diversity of the composites industry, estimates of market size and numbers of companies can vary significantly. In preparing this report we have attempted to compare figures from different market studies, each of which showed significant variations.

1.2 Restructuring and Ownership

There have been many ownership changes and restructuring activities in the composites industry over the last 2-3 years, and these look set to continue. The reasons behind these activities appear to fall into a number of categories:

- Product Complementarity
- Economies of Scale
- Management buy-outs

Additionally, companies associated with low value or low margin commodity products are acquiring smaller companies with added value products and integrating them into their portfolio. Examples include the purchase of AFX by Hexcel and the purchase of BTI by Saint Gobain and the acquisitions last year of the Zoltek group.

These acquisitions are allowing them to sell higher value-added products as part of their portfolio, often also allowing them to move downstream in the supply chain.

Groups of companies are also being formed that offer complementarity in process technologies, allowing the group to offer the OEM a portfolio of material or process technologies rather than a single process. An example of this is Integral Composites, which recently acquired Hampton Mouldings (SMC/DMC/RTM) and Pulley Brothers (SRIM).

A final feature has been the management buy-out of a number of companies from their corporate parents, examples being SP Systems and Ex-Press Plastics, where the company has not fitted into the portfolio of the parent group and the management has seen their own opportunities for the company.

1.3 Globalisation

Mergers and acquisitions to reach more global markets are generally being seen in larger companies at the supply end (resins and fibres) or the demand end (transport) of the industry. The companies in these areas are of sufficient size that major acquisitions can be used to give global branding, simplify product ranges, streamline distribution and gain economies of scale. Additionally, many of the transactions taking place have been between companies with complementary product ranges or complementary global presence. Examples include the recent purchase of Neste by Ashland or integration of Adtranz into Bombardier.

There is a strong trend towards global supply of materials and components from lower labour-rate countries. In particular, glass fibre supply from China and other far-east countries is increasing, although the cost benefits of importing are reducing year on year. The export of glass fiber from China went up 11.5 percent in volume and 97 percent in value in 2000.

Additionally, there is a gradual trend for companies in the UK to subcontract composite moulding work (especially hand lay-up) to lower labour rate countries, and proactive approaches are being

Case Study

NGCC

Increasing the Awareness of Composites

One of the main difficulties faced by the composites industry is the lack of awareness of composites by potential clients. Whilst it is difficult for any one SME to educate and convince potential customers, there are a small number of groups that have been established by the industry to carry out this task. One such group is the Network Group for Composites in Construction (NGCC), set up with initial funding from DETR to bring together the composites and construction industries.

The network is effective in encouraging the use of composites in construction, raising the profile of the industry and allowing the gradual creation of new market opportunities in the construction industry. This group can be used as one example of the way that the UK industry is now starting to work together to face potential client sectors, rather than talking to itself, and as a reference to stimulate the potential creation of other groups.

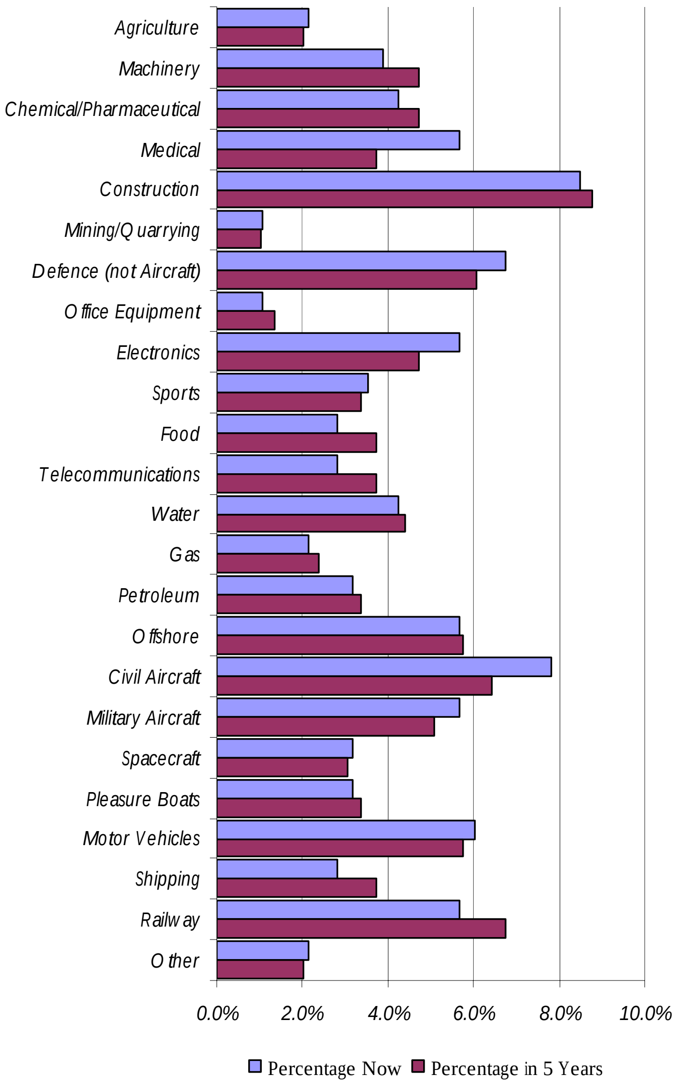
On the web: **www.ngcc.org.uk**

made to UK companies from the former Eastern Bloc, the Middle East and the Far East. Scott Bader, for instance, now has operations in the United Arab Emirates and the Czech Republic. UK companies are then able to concentrate of processes and products with higher levels of technical skill, a higher degree of automation or a lower labour content.

1.4 Trends in Markets

This section explores some of the trends seen by the worldwide composites industry, from a business, market and technological perspective, to build a picture of the current direction of composites and the potential impact on the UK composites industry.

Figure 1.1: Sectoral Involvement of UK Composites Companies (%)[1]



Thermoset composites still take the lion's share of the market and these are used in all areas of application from traditional semi-industrial processes (short production runs) to open moulding techniques and automated methods such as filament winding and pultrusion. However, thermoplastic composites are experiencing a growth rate approximately twice that of thermosets, with the automotive industry acting as the major pull, in particular for under-the-hood parts, interior parts, front and rear face and body parts.

Outside of the automotive sector, the trend towards thermoplastics is also evident due to their cleaner and faster processing. This is in addition to some improved physical properties over thermoset composites, and the use of thermoplastics for low-volume processes is one of the areas where the UK is a major player. The other trend to cleaner processing is a move towards closed-mould processes and low styrene resins, and the industry is now starting to see this shift happening.

In the fibres markets, carbon fibre is forecast to exhibit the highest growth, especially in lower performance applications, and there is also an increase trend to natural fibres due to their perceived lower environmental impact.

There is also resurgent interest in recycling, partly due to European Commission directives on vehicles and electronic equipment (Annex 7) and continued interest in improved process and product modelling.

The results of the UK industry survey are shown in Figure 1.1, showing the percentage of companies that are involved in particular sectors. Results are shown for the industry's position now and where the industry sees itself in 5 years' time.

As part of the review, industry identified their involvement in different technologies, materials and sectors. To minimise the time needed to complete the form, replies were limited to whether a company was involved or not, rather than indicating increased or decreased involvement. Hence, the changes shown although major are within the general growth rates reported later.

It is worth noting that the industry sectors chosen for this survey are related to standard industry codes (SIC). Notably, there are no codes for the

Case Study

Engineered Composites/Clark Steel

Developing New Standards for Construction

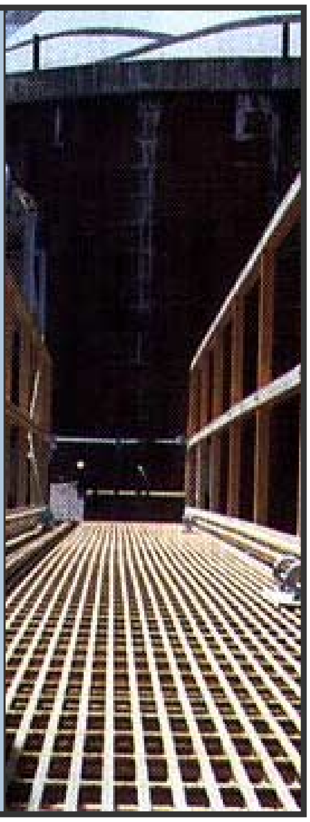
Pultrusion offers unique advantages for standard profiles and represents one of the largest areas of untapped potential for composites, but it was difficult for potential customers to specify a pultruded product as there was no standard.

This restricted the ability of the SMEs, such as Engineered Composites, to sell their product, so they worked together to develop a standard product specification that paralleled the standard specifications of traditional materials. As a result of this a new standard is being published in 2001 and is already appearing in manufacturer's literature, releasing new opportunities and sales.

In other applications a standard can exist that prevents composites being used. Manhole covers are one example of this, and Clark Steel has been working hard to allow composites to be used in this high-tonnage application.

Through the work of companies such as these, composites standards are being created for new products and to allow composites to move into applications currently dominated by traditional materials.

On the web: **www.engineered-composites.co.uk**
www.clark-steel.com



composites industry, although 12% ticked this option as being applicable to their business. There is also no code for the offshore industry, but uses are related to oil or gas extraction. It would appear that the proposed review of the SIC codes is timely, and that the industry should make representations for a sub-code under Plastics code covering the "Composites/Reinforced Plastics" industry.

Key features of this chart are the marked decreases in companies that do not see themselves operating in the electronics, medical and civil aircraft markets in 5 years. Equally notable are the increases in the number of companies that see themselves in mass-transit (shipping and trains) in 5 years.

There is no increase in construction where one might be expected, although this may be because companies outside the construction industry see it as difficult to break into.

Aircraft/Aerospace/Defence

The trend in aerospace is to use composites for more structural components in civil and military aircraft. Whilst military aircraft are now using composites primary airframe structures on aircraft such as the Joint Strike Fighter, the civil sector in Europe and the US is developing composite wings for next-generation aircraft.

There is also a move towards lower cost manufacturing processes such as resin transfer moulding, and this cost drive is evident in the potential broader uptake of composites within commercial aircraft in particular.

Weight alone is no longer the primary driver in this sector and the use of composites in new components such as wings depends on the ability to make the components at a cost competitive to the traditional material and manufacturing process.

Additionally, there is a trend towards the manufacture of all-composite small aircraft, either pressurised or un-pressurised, for executive and business travel. The US leads this with a number of small aircraft manufacturers currently going through certification. There is also some activity of this type in the UK, although to a far lesser extent.

Construction

Composites are expected to grow at a rate of at least 35% in Infrastructure Applications, according to a market survey report just completed in the US[2], with the strongest growth in FRP bridges and repair/strengthening of reinforced concrete structures. The deterioration of the infrastructure is leading to increased opportunities for new materials and structures and composites now are recognised as offering the possibility of displacing other materials. Despite this, the pultrusion industry (which is allied very closely to construction) has seen minimal or flat growth over the last 2-3 years.

One area, allied to construction, that is seeing massive growth and investment is wind energy, and the inherent growth in the wind energy market is expected to be overlaid with increasing use of composites for turbine blades, in particular.

Consumer

Composites of wood and PE, PP, or PVC are growing fast in North America and are widely expected to follow suit in Europe, particularly for decks, railing systems, and related outdoor structures. The market for polymer-wood composites has reached 318,000 tonnes in North America and is projected to more than double by 2005. Decking applications represent over 60% of the market demand[3].

In addition, the use of composites continues to grow in the leisure industry, as the leisure industry itself grows. For example, specific opportunities for growth have been identified in youth leisure goods such as snowboards.

Transportation

Transportation is one of the largest markets for composites, although not the highest growth area.

The sector is significant in that the primary European market drivers – recyclability and weight – are not seen in the US due to lighter environmental legislation and lower fuel prices. The trend is towards fewer vehicle platforms and therefore higher production volumes, necessitating greater investment in process technology for the supplier of composite components.

In the US the use of reinforced thermoset composites by car manufacturers has nearly doubled in the last decade, largely because composites have increasingly been chosen by OEMs to replace steel for body panels and structural components. High profile examples include pick-up truck boxes made from a range of composite materials and processes.

In Europe the trend is towards thermoplastics, almost to the exclusion of thermosets. The End-of-Life Vehicle Directive (Annex 7) places strong emphasis on recyclability (even at the expense of through-life environmental impact), and it is likely that this will significantly affect the use of thermoset composite components on vehicles.

1.5 Trends in Technologies

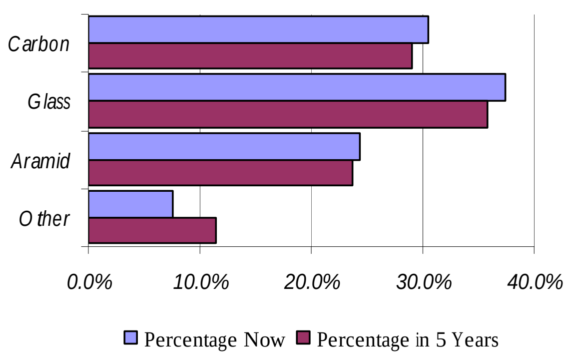
In parallel with the trends in markets, significant trends in technologies have emerged in recent years and are continuing.

These trends revolve around the materials and process technologies used to meet the market demands detailed in the previous sections, or to meet other requirements such as legislation.

Materials

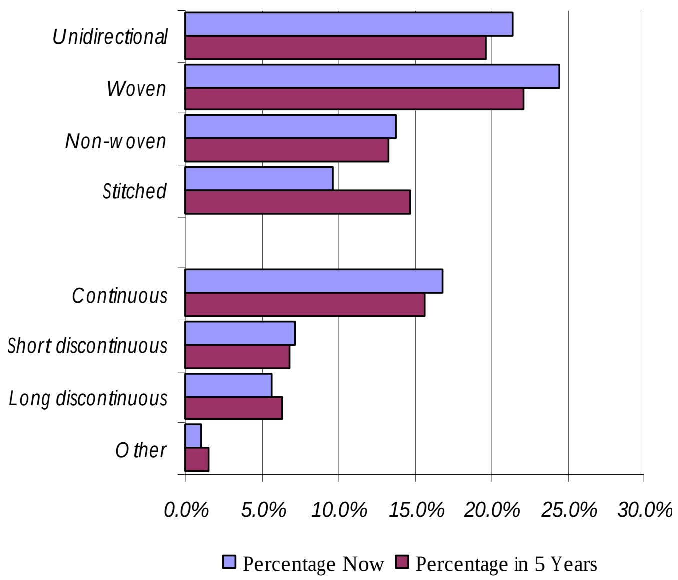
Based on the companies that responded to the industry survey carried out for this study, Figure 1.2 shows the percentage of companies using particular fibre types whilst Figure 1.3 shows the percentage of companies using particular fibre formats. In each case results are given for the position now and in 5 years.

Figure 1.2: Fibres Used by UK Composites Companies (%)[1]



Although overall volumes of fibre use are expected to grow, these figures show some consolidation in the number of companies using each of the main three reinforcements (glass, carbon and aramid), with a corresponding increase seen in the use of other fibres. It is expected that these other fibres will predominantly be natural fibres such as jute, hemp, sisal and flax, although there is also likely to be an increase in the use of polymeric fibres such as polypropylene and polyethylene. Future decreases in the cost of carbon fibre are also likely to influence the choice of fibre in coming years.

Figure 1.3: Fibre Formats Used by UK Composites Companies (%)[1]

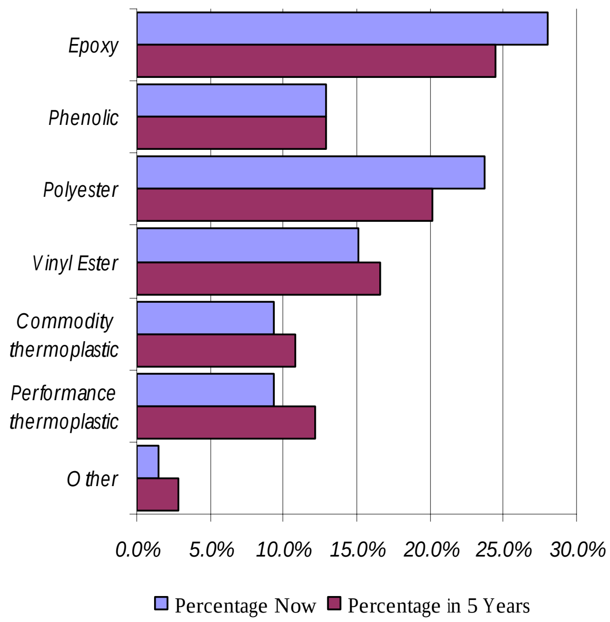


The trend in fibre formats shows a marked increase in the number of companies that expect to be using stitched fabrics in 5 years, at the expense of traditional unidirectional and woven formats. This is primarily because stitched fabrics allow higher deposition rates of material, hence faster cycle times and lower costs. Additionally, there is expected to be an increase in the number of companies using long discontinuous fibres.

Figure 1.4 shows the percentages of companies using particular matrix materials now, and those that they envisage they will be using in 5 years.

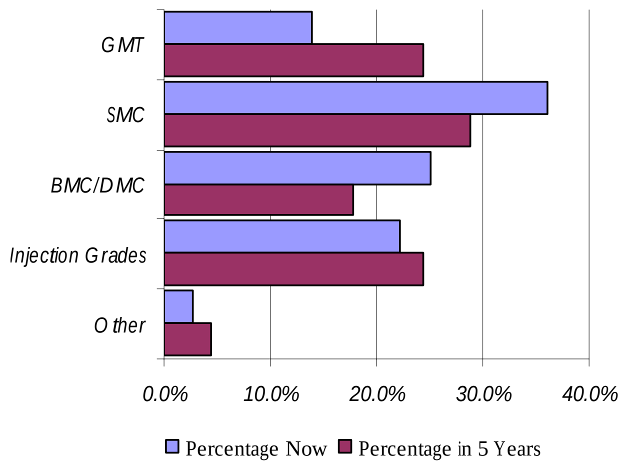
The notable trend in this chart is the increased use of thermoplastics (high performance and commodity grades) at the expense of a decrease in the number of companies using polyester and epoxy systems. However, within thermosets, an increased number of companies are forecast to use vinylesters and the number of companies using phenolics stays the same. This could point to a retention of thermoset dominance in applications where, for example, fire performance is an issue.

Figure 1.4: Matrix Materials Used by UK Composites Companies (%)[1]



A similar trend is seen in the compounds being used. Figure 1.5 shows the number of companies using particular compounds, both now and forecast in 5 years.

Figure 1.5: Compounds Used by UK Composites Companies (%)[1]



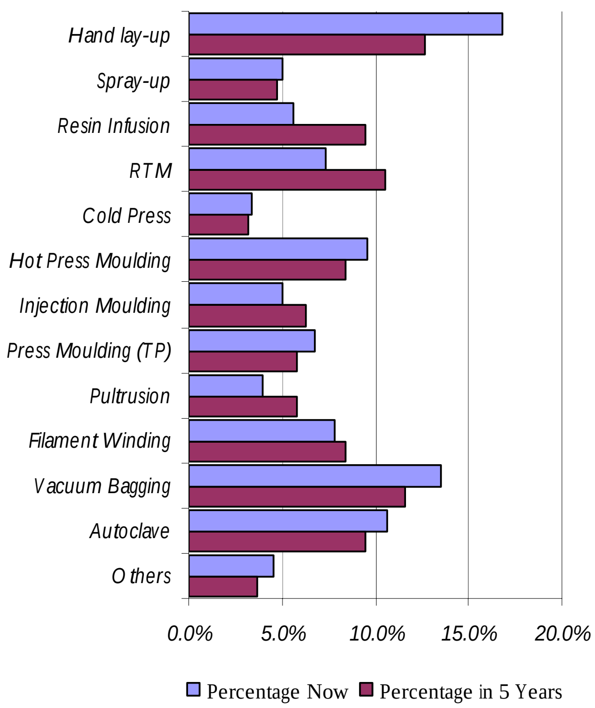
There is forecast to be a dramatic increase in the number of companies using GMT (glass mat thermoplastic) materials as opposed to SMC (sheet moulding compound) and BMC/DMC (bulk/dough moulding compound). This reflects the emergence of recycling as an issue for the automotive industry, the major customer for these high-volume processes.

Outside of the UK though, there is a further trend towards Long-Fiber Reinforced Thermoplastics (LFTs) due to their combination of cost, processability and recyclability. Most of the work in this area is being carried out in Germany and France, and there is little in the UK as yet.

Manufacturing Processes

Figure 1.6 shows the trends in manufacturing processes, with the percentage of companies using particular processes now and the percentages using those processes in 5 years.

Figure 1.6: Manufacturing Processes Used by UK Composites Companies (%)[1]



This chart shows a clear trend in the reduction of hand lay-up and the uptake of higher-skill, more capital intensive processes such as resin infusion and resin transfer moulding (RTM). Perhaps surprisingly, there is no reduction forecast in the number of companies using spray-up techniques, where a major reduction might be expected due to the open nature of the process. As well as an increase in the number of companies using RTM for lower performance parts, some of the increase in RTM is also attributable to higher-performance parts, with a balancing reduction in the use of vacuum bagging and autoclave techniques.

Other increases in processes such as pultrusion, injection moulding and filament winding reinforce the trend towards higher levels of sophistication, cleanliness and automation.

These changes in the nature of composites processing in the UK also impact significantly on the way the composites industry is funded. Higher levels of automation necessitate higher levels of capital investment and make it more difficult for start-up companies with very low levels of capital to enter the industry.

1.6 Competitor Countries

The main competition to the UK composites industry currently comes from other western European countries. This competitive situation exists mainly in transport markets (aerospace, mass transit, marine and automotive) where there are only a few worldwide customers, although it can arise in other sectors, for example in the supply of components to major construction/infrastructure projects.

Secondary competition comes from countries with a lower labour rate than the UK, where the manufacture of low-tech/high labour components can be undertaken more cost-effectively.

Broad views on the competitive position of main competitor countries to the UK will be provided in this section. North America is provided as a comparison.

Western Europe

Western Europe is the second largest composites market after the USA, with most of the countries having a bias towards a particular market sector[4]. Within Western Europe, France, Germany and Italy are the dominant countries.

The composites market in France, for example, is one of the strongest in Europe, largely due to demand from transportation applications, the automotive market making up a strong component of this. Electricity and electronics are also significant markets, followed by construction and public works[4].

Germany's composites industry is strongly reliant on its automotive industry. It therefore dominates the use of high volume production technologies such as SMC/GMT materials. The industry is active in transferring expertise to the mass transit sector to reduce reliance on the automotive industry[4].

Italy's composites industry is regarded as being one of the strongest in Europe, being well established with a full range of technologies and markets served. It is still ranked above the UK[4].

Spain is an increasingly important centre for composite materials, with high levels of recent growth and revitalised automotive and construction/infrastructure industries, all creating markets for composites[4].

In other areas of Europe, Austria and Switzerland produce considerable amounts of composite for the leisure industry, including the manufacture of ski and similar equipment. The Belgian composites industry, while having strength in breadth, is not well recognised as being especially strong in any particular sector or technology. Holland is in a similar position, but has a strong history in polymer development and supply and is currently undertaking significant National investments into polymers and composites.

In Scandinavia, Norway and Finland have strong material suppliers and infrastructural markets such as pipe and profiles. Danish industry is dominated by the manufacture of wind-turbine blades, whilst Sweden has strong automotive and shipbuilding industries. Ireland, Portugal and Greece are still to develop their composites industries[4].

The UK performs well in a few highly specialist sectors, such as aircraft wings and large marine vessels. However, although the UK does everything seen in the global industry, it does not excel in many areas and the overall performance of the industry is average when measured against European competitors[4].

Eastern Europe

Although the engineering heritage in Eastern Europe is exceptional, lack of investment over the last few decades means that composites

Case Study

SP Systems/Aerolaminates

Advanced Manufacturing for Turbine Blades

The adoption of advanced manufacturing techniques is seen as important to the future of the UK composites manufacturing industry. SP Systems has moved towards this by forming partnerships with their customers and providing technical support services as well as materials technology.

This philosophy has been used in the development of a close relationship with NEG Micon Aerolaminates, in the production of wind turbine blades.

Aerolaminates chose to build its new production facility adjacent to the SP Systems facility - its main supplier of raw material. This close partnership allowed the adoption of through-the-wall manufacturing supply more commonly seen in the supply of automotive components, allowing both companies to use composites in applications where their environmental performance is second-to-none.

On the web: **www.spsystems.com**
www.neg-micon.com

"There is always a problem of lack of understanding about composite materials."

technology in Eastern Europe is dominated by labour-intensive open-moulding techniques such as hand lay-up and spray-up[4].

Asia-Pacific

The major players in the Asia-Pacific Region are Japan and China. In China, the knowledge and use of composites has come about mainly by technology transfer from the Western World, mostly through joint ventures. There has also been supporting development in raw materials manufacturing capability to allow a fully integrated industry. Compared to its size, the Chinese composites industry receives marked support from government and a number of well-funded and staffed research institutes[4].

The Japanese market is large for its population, with most of the market being in bathtubs. India is also notable for its relatively high level of sophistication in process technologies, and relatively high levels of composites exports (20%). Other areas of Asia-Pacific are undergoing significant investments in composites technology in a drive to develop competitive industries, including Malaysia and Taiwan[4].

Even in a relatively low cost product, such as modular water tanks, two of the four Japanese manufacturers import into the UK.

Africa

The South African composites industry has a greater reliance on lower technology processes than most Western European countries, although there is some manufacture of high-tech products[4].

In the remaining African countries, there is widespread thermoset composites products, mainly based on open mould techniques but with some exceptions[4]. High-profile products include piping and water tanks.

Middle East

In this region, there are a growing number of high quality fabricators and moulders exporting to a global market, practising most fabrication techniques. The highest level of composites activity is seen in Bahrain, Kuwait, Saudi Arabia, Qatar and UAE, with some specialised aerospace work being carried out in Israel[4].

South America

The most important markets for composites are the automotive industry, water tanks/pipes, telecommunications, electrical and construction/infrastructure. Contact moulding is the major fabrication technique, with spray-up common and a definite interest in resin transfer moulding.

There is also increasing aerospace composites strength through Enaer (Chile) and Embraer (Brazil), with both organisations manufacturing advanced composites for their aircraft.

Russia

Unfortunately there is little accurate data on the state of the composites industry in Russia and surrounding states. However, it is worth mentioning the region for completeness because, although the area is still in confusion, there is undoubtedly some significant expertise, especially in advanced composites for aerospace and military applications[4]. Russia is therefore a potential competitor in these areas of activity.

North America

North America is seeing continued strength in infrastructure and construction applications, as well as in automotive, where there has been a number of recent large high profile, high-volume components. North America is generally thought to be several years ahead of Europe in technology and markets, although this is not the case in the application and understanding of structural thermoplastic composites.

2 Competitive Performance

2.1 Market Size and Share

This report carries out three broad market comparisons. The first compares the position of the UK in relation to its economic counterparts in Europe. This comparison is relevant to current technologies and markets, especially where the requirements of European market sectors may differ from their US counterparts.

The second comparison gives the position of the European composites industry relative to that of the United States. Although there are differences between the two regions in technology and markets requirements (these have been outlined previously), this comparison is useful as the US is generally thought to be several years ahead of Europe in technology and markets. This comparison therefore allows some broad views to be made on the potential direction of the industry, providing allowances are made for the regional differences in markets.

The third comparison is broader, showing the position of other world regions to provide a measure of the competitiveness of the UK in a world market, especially with regard to emerging competition to the UK from the Middle East and Asia-Pacific.

All figures in this section are estimates for 2000, unless otherwise highlighted.

United Kingdom

The overall revenue of the UK composites industry is estimated to be £510Million, against shipments of 240,000 tonnes[5]. The UK industry is forecast to grow at an average of 3.7% per annum to 2005[4].

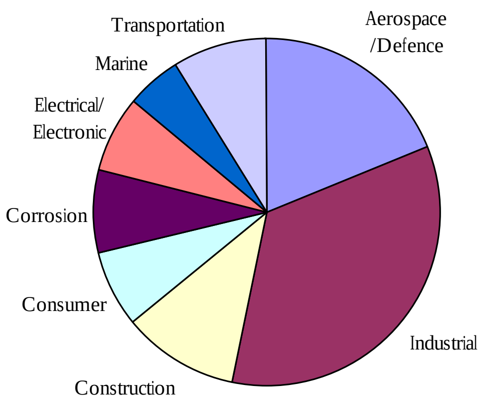
Estimates of the number of UK composites companies vary widely, but a common consensus is that there are approximately 1000 companies directly engaged in the manufacture of composite products or precursors. They are supported by an additional 1500 companies for whom composites represents a significant proportion of their business, either as secondary suppliers to the industry or as manufacturers of components.

The results of the industry survey give the breakdown of sectors served by the UK composites industry (Table 2.1 and Figure 2.1).

Table 2.1: UK Composites
Finished Product Tonnage by Sector[1]

	%
Aerospace/Defence	19%
Industrial	34%
Construction	11%
Consumer	7%
Corrosion	8%
Electrical/Electronic	7%
Marine	5%
Transportation	9%

Figure 2.1: UK Composites Finished Product Tonnage by Sector[1]



In this chart it is worth noting the relatively high level of defence and industrial activity in the UK when compared to later charts of Europe and North America, although some care should be exercised in interpreting these results due to the relatively small size of the sample taken.

Figure 2.2: Proportion of UK Companies' Businesses Related to Composites[1]

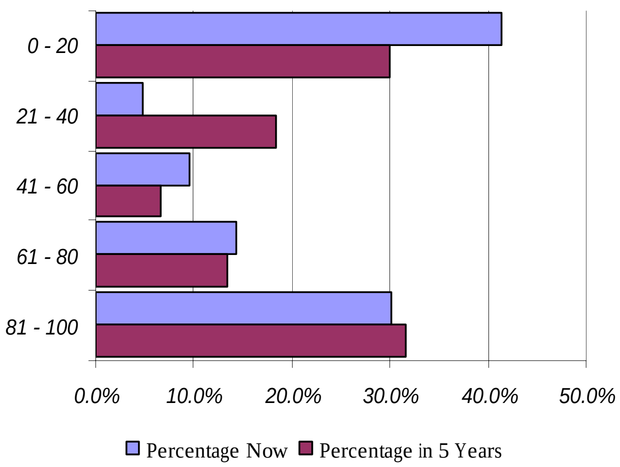


Figure 2.2 shows the proportion of companies' businesses that are related to composites (against the percentage of companies responding to the survey). The key feature here is the marked increase at the lower levels, with a drop in the number of companies for whom composites is related to 20% of the business, and a corresponding increase in the number of companies for whom composites is related to 40% of their business.

One additional aspect of the survey was that the industry predicts a 25% increase in output of the weight of composites being produced in 5 years time, alongside a respective 40% increase in their value. Additionally, it foresees an increase in exports, rising from 37% to 47% of output.

Western Europe

The overall revenue of the European composites industry is estimated to be £3300Million[5]. The European industry has shipments of 1,540,000 tonnes and is forecast to grow at an average of 3.8% per annum to 2005[4].

Of this, the European market can be broken down by country as shown in Table 2.2 and Figure 2.3, illustrating the UK's 14% share of the market, behind Germany, France and Italy.

Table 2.2: Western European Composites Finished Product Tonnage by Country[4]

	k tonnes	%
UK	209.8	13.6%
Austria	36.0	2.3%
Belgium	49.4	3.2%
Denmark	28.3	1.8%
Finland	27.7	1.8%
France	282.4	18.3%
Germany	261.2	17.0%
Greece	21.6	1.4%
Ireland	11.3	0.7%
Italy	271.3	17.6%
Luxembourg	2.6	0.2%
Netherlands	73.7	4.8%
Portugal	29.3	1.9%
Spain	193.8	12.6%
Sweden	41.5	2.7%
	1540	

Figure 2.3: Western European Composites Finished Product Tonnage by Country[4]

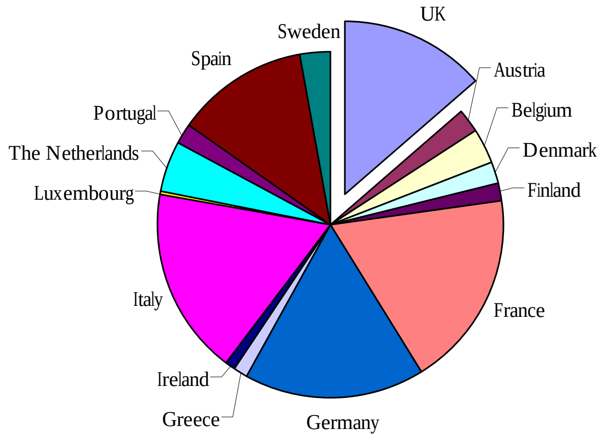


Table 2.3 shows the forecast growth for composites output of the five largest European composites-producing countries – France, Germany, Italy, Spain and the UK. From this it can be seen that, although the UK is forecast to enjoy faster growth than Germany, higher growths are shown by France, Italy and Spain.

Table 2.3: Western European Growth Rates Finished Product Tonnage by Country[4]

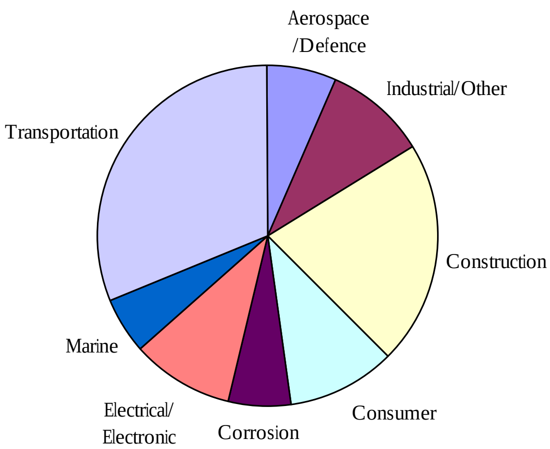
	%
UK	3.7%
France	4.0%
Germany	3.2%
Italy	4.4%
Spain	4.4%

It is also possible to breakdown the European market according to the application sector supplied, shown in Table 2.4 and Figure 2.4: European Composites Finished Product Tonnage by Sector.

Table 2.4: Western European Composites Finished Product Tonnage by Sector[4]

	k tonnes	%
Aerospace/Defence	104	6.8%
Industrial	150	9.7%
Construction	324	21.0%
Consumer	157	10.2%
Corrosion	90	5.8%
Electrical/Electronic	150	9.7%
Marine	80	5.2%
Transportation	485	31.5%
	1540	

Figure 2.4: Western European Composites Finished Product Tonnage by Sector[4]



Asia-Pacific

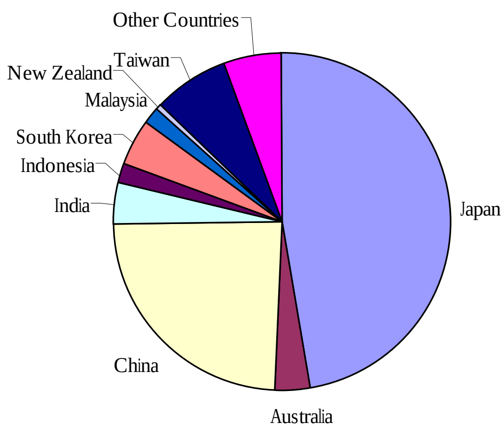
The Asia-Pacific region showed a total shipment of finished products of 1,448,000 tonnes, broken down in Table 2.5 and Figure 2.5 below.

The composites industry in the Asia-Pacific region is forecast to grow at an average of 6.2% per annum to 2005[4], a high rate relative to the UK.

Table 2.5: Asia-Pacific Composites Finished Product Tonnage by Country[4]

	k tonnes	%
Australia	49	3.3%
China	350	24.2%
India	53	3.7%
Indonesia	29	2.0%
Japan	686	47.3%
South Korea	67	4.6%
Malaysia	23	1.6%
New Zealand	8	0.5%
Taiwan	105	7.2%
Others	80	5.5%
	1448	

Figure 2.5: Asia-Pacific Composites Finished Product Tonnage by Country[4]



North America

The overall revenue of the US composites industry is approximately £3930Million, against shipments of 1,775,000 tonnes[6].

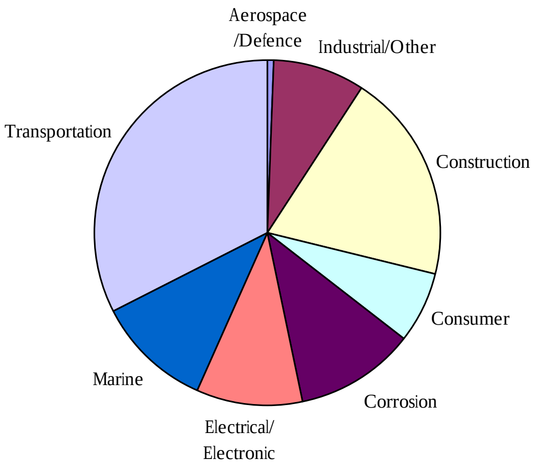
The US composites industry is forecast to grow at an average of 2.8% per annum to 2005[4], a lower figure than that of Europe.

As with the European market, it is possible to breakdown the US market according to the application sector, and this is shown in Table 2.6 and Figure 2.6: US Composites Finished Product Tonnage by Sector.

Table 2.6: US Composites Finished Product Tonnage by Sector[6]

	k tonnes	%
Aerospace/Defence	11	1%
Industrial	152	9%
Construction	352	20%
Consumer	115	6%
Corrosion	201	11%
Electrical/Electronic	177	10%
Marine	192	11%
Transportation	576	32%
	1775	

Figure 2.6: US Composites Finished Product Tonnage by Sector[6]



2.2 Comparative Performance

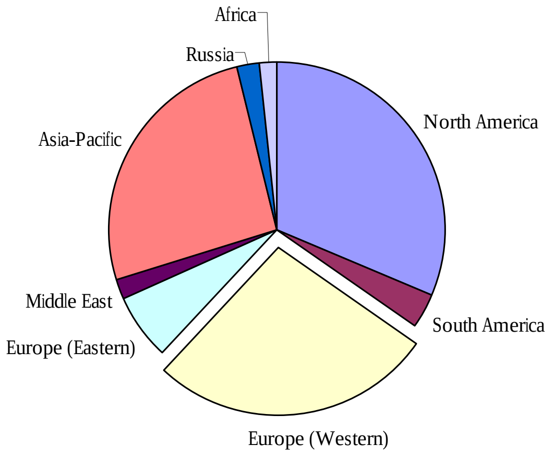
Comparison of Global Regions

Table 2.7 and Figure 2.7 shows the market size for each of the main global regions, expressed as finished product tonnage, with figures for Eastern Europe, Africa, Middle East, South America and Russia as well as those detailed in previous sections.

Table 2.7: World Composites Finished Product Tonnage by Region

	k tonnes	%
North America	1775	31%
South America	176	3%
W. Europe	1540	27%
E. Europe	357	6%
Middle East	119	2%
Asia-Pacific	1448	26%
Russia	126	2%
Africa	96	2%

Figure 2.7: World Composites Finished Product Tonnage by Region



Total Output

The product output figures can be used to provide a direct assessment of the position of the UK composites industry in direct relation to its European counterparts. Figure 2.8 shows the tonnage output for EU countries and clearly shows the relative position of the UK. However, these figures do not make allowance for the sizes of countries, so an assessment of Output Per Capita is also useful in judging the comparative performance of the UK industry.

Table 2.8 below shows the regional output of composites per capita for each of the main composite-producing regions. Using the measure of Output per Capita, the position of the UK relative to its European Competitors can be seen in Figure 2.9. These figures show a relatively poor performance by the UK in relation to the majority of its European neighbours.

Figure 2.8: European Output of Composites – Relative Position of UK (k tonnes)[5]

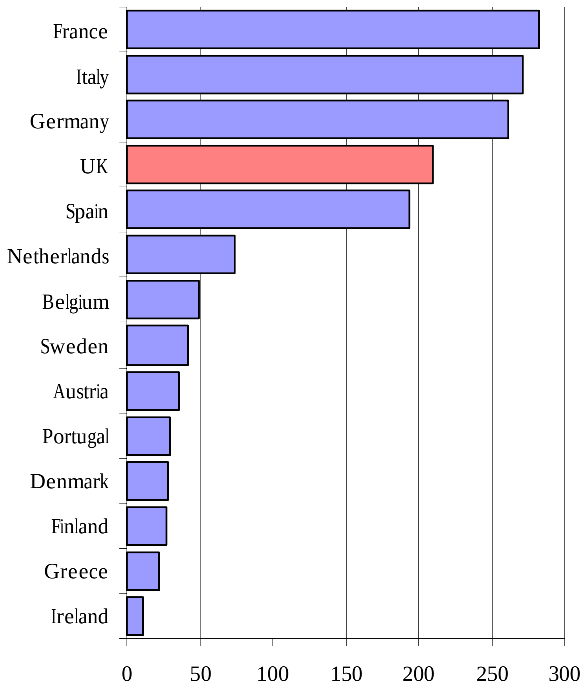


Figure 2.9: European Output of Composites per Capita – Relative Position of UK (kg per capita)[4]

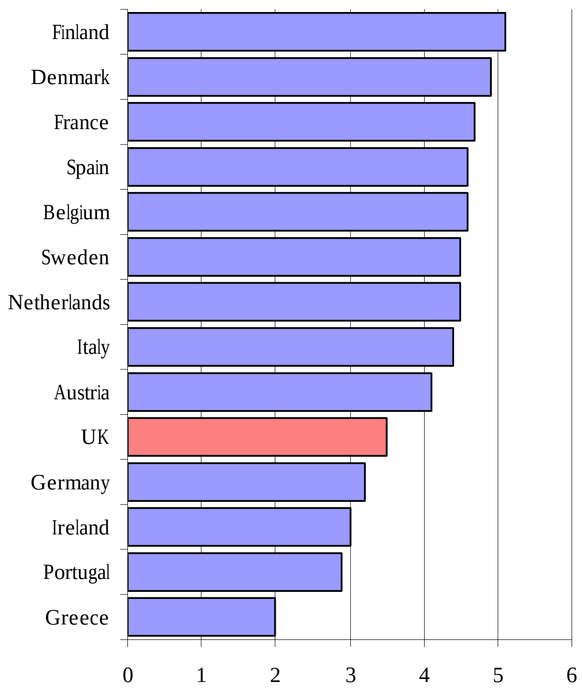


Table 2.8: Regional Output of Composites per Capita[4]
(1998 Figures)

		kg per capita			kg per capita
Western Europe	UK	3.50	**South America**	Argentina	0.97
	Austria	4.10		Brazil	0.64
	Belgium	4.60		Chile	0.48
	Denmark	4.90		Colombia	0.22
	Finland	5.10		Venezuela	0.65
	France	4.70		Others	0.18
	Germany	3.20			
	Greece	2.00	**Middle East**	Bahrain/Saudi Arabia/ Qatar/Kuwait/UAE	2.40
	Ireland	3.00			
	Italy	4.40		Egypt/Israel	0.60
	Luxembourg	6.40		Others	0.30
	Netherlands	4.50			
	Portugal	2.90	**Asia-Pacific**	Australia	2.40
	Spain	4.60		China	0.22
	Sweden	4.50		India	0.05
				Indonesia	0.16
Eastern Europe	Czech Republic	1.75		Japan	5.29
	Others	1.25		South Korea	1.52
				Malaysia	1.10
North America	Canada	2.90		New Zealand	2.00
	United States	6.50		Taiwan	4.30
	Mexico	0.71		Others	0.15
Africa	South Africa	1.06	**Russia**	All regions	0.82
	Others	0.16			

3 Factors Impacting Competitiveness

This section details the drivers that affect the composites industry, some of these particularly relevant to the UK while others are more general issues impacting the worldwide industry.

These factors are broken into two groups. The first is a classical STEEP analysis that looks at the external factors that are likely to have an impact on the UK composites industry, based on the industry survey and the workshop session.

The second group looks in outline at 6 specific issues that are known to affect the industry and which were therefore highlighted in the industry survey.

3.1 STEEP Analysis

A useful technique for identifying and categorising these factors is the STEEP analysis, where external factors are grouped into 5 areas:

- Sociological factors
- Technological factors
- Environmental factors
- Economic factors
- Political factors

The STEEP analysis enables identification of the key factors likely to influence the future competitiveness of the composites industry. Section 4: Foresight highlights the opportunities and threats identified by the STEEP analysis, alongside the industry's strengths and weaknesses in responding to the opportunities and threats.

Sociological Factors

The main sociological factor lies with the changing nature of skills in the UK, with more emphasis on service provision and less on manufacture. The general decline in the popularity of engineering in the UK has had an impact on the awareness of composites and on the level of skills.

The general skills shortage within the UK composites industry applies at all levels, but there is a particular shortage of qualified engineers and supervisors that understand composite materials, and in skilled laminators. Recruiting researchers & students with appropriate skills has also become more difficult, with an increasing number coming from outside the UK, many of whom return to their own countries as practising engineers and scientists.

The pace of technological development in the composites industry has not been matched by a corresponding shift in education. As well as leading to a lack of direct skills in the industry, it widely recognised that there is a general lack of knowledge about composite materials amongst potential specifiers.

Allied to this is potential customers' discomfort with new technology, and a fear of critical components failing if composites are used over more traditional materials.

On the positive side, the increase in the ageing population is expected to stimulate greater demand for lightweight products, an opportunity for composites. Additionally, the greater degree of disposable income through all levels of the population will lead to a corresponding increase in higher value products, especially in the youth markets and for sporting/leisure goods.

Technological Factors

It is generally regarded that the UK has a fairly strong scientific and technical knowledge base in composites, especially in relation to innovative future technologies, and that future advances in composite materials and process development will be a major factor in the industry. It is also expected that the development of applied technology, rather than theoretical studies, will have most effect.

Equally, developments in competitive materials are expected to have an impact on the uptake of composite materials. Materials where recent advances have been made include titanium, nanocomposites, foamed aluminium and ultra-high strength steels.

In parallel with this, processing advances have been made in surface engineering technologies and aluminium welding, for example. It is also likely that further opportunities for synergy exist between composites and competitive materials building on materials such as the Glare aluminium/composites laminate.

Other external technological factors are potentially of equal importance to the competitiveness of the composites industry, especially the adoption of appropriate technologies, such as automation and information technology, that have already been embraced by other industries and sectors.

Economic Factors

Th major economic factor affecting the composites industry, as with all UK manufacturing, is the strength (and variation) of the pound against other currencies.

This leads to the inability to offer stable prices for export customers due to the variation of the pound against other currencies, in particular the Euro and US Dollar. This difficulty in winning export contracts is exacerbated by the fact that general decline in UK manufacturing industry also means that there are fewer domestic customers.

In addition, the close link between composites manufacturing and the general economic climate means that there is the potential for a dip in demand if the pattern of the US economic climate continues and is followed elsewhere in the world.

Consolidation and globalisation is also a factor affecting the industry. Whilst there has been some consolidation in recent years, the industry is still fragmented and finds it difficult to present a common face. The corresponding lack of co-ordinated financial resources reduces the opportunity for the industry to invest in long term campaigns to influence specifiers in the same way that aluminium or steel material suppliers have.

The move towards globalisation on the part of customers, coupled with the relatively low labour rate of developing countries, means that companies are increasing subcontracting work that involves high labour content, such as hand lay-up, outside the UK.

Although the low capital investment required for composites processing allows cost-effective expansion of businesses engaged in low-cost processes, these companies are increasingly finding competition from overseas.

Environmental Factors

The environmental issue is probably the most critical external factor affecting the industry.

Environmental factors offer unsurpassed opportunities for composites, as life-cycle thinking means that the through-life costs and

“Design engineers are now reluctant to specify thermoset composites for component parts, due to the negative effect on vehicle recyclability.”

Case Study

Ex-Press Plastics

Improving Environmental Performance

One of the biggest problems facing SME moulders is the need to improve environmental performance whilst maintaining business performance.

Ex-Press Plastics' approach to this issue has been to develop alternative thermoplastic moulding techniques to allow them to meet the future requirements, for higher recyclability by vehicle manufacturers, their main customers. The use of thermoplastics is also allowing them to reduce emissions and improve the local environment, a key issue for them.

The developed technology is based around Twintex glass/PP fibre developed by Vetrotex and the access to this technology was greatly assisted by the DTI Carrier Programme. Building on this background knowledge, Ex-Press worked to overcome any remaining practical problems with the process and committed the investment needed to take it to production.

As well as improving their environmental performance, this new technology is allowing Ex-Press to compete much more favourably in the supply of parts to low volume and niche vehicle manufacturers.

On the web: **www.ex-pressplastics.co.uk**

environmental impacts of components are being more thoroughly considered.

Renewable energy is seen as a major growth opportunity for composite products, and the EU has set a target for 12% of primary energy to come from renewable sources by the year 2010. Biocomposites are also likely to have a positive impact on the industry.

On the other hand, implications on processing, emissions and recyclability mean that the industry has to look hard at addressing these issues. The issue of recycling is likely to have the greatest impact on the composites industry. This leads from the lack of clear, developed recycling routes (logistics, infrastructure and recycling technologies) relative to other materials industries, and the lack of clear end products for recycled composite materials.

Legislation on this subject will have a major effect on the use of composites, and in some cases may suppress their use in favour of more easily recyclable materials. Relevant environmental legislation affecting the industry includes:

- EU end-of-life vehicle directive
- EU directives on landfill and incineration
- EU waste electronic equipment directive

This effect also extends into the aircraft industry, where the aircraft operators are exerting pressure on OEMs to minimise the use of composites on aircraft structure due to limitations in disposal. More details on the EU directives can be found in Annex 7.

Political Factors

Political factors and policies that affect the UK composites industry come from UK and EU government. Much of the policy that affects the industry is environmentally driven and is covered above, although there are other political issues that affect the industry.

Health and Safety (H&S) is one of these areas, and H&S legislation is expected to have an impact on the composites industry. Whilst much of the impact will be in the improvement of working conditions for those in the composites industry, there is also a move towards lower levels of manual handling, especially in construction, which may create an opportunity for lightweight materials such as composites.

Standards are another constant issue for composites. On the one hand there is difficulty in competing against traditional materials, around which existing standards have been written, whilst on the other hand there is a need for new standards that allow composites to be specified. Each of these aspects of standards legislation will continue to affect the composites industry.

Finally, the level of R&D spend on composites generally reflects the UK's low R&D spend relative to GDP, compared to other nations. In addition, the continued move towards privatisation of major composites research capabilities will further affect the industry.

3.2 Specific Issues

The review of specific issues was based on six pre-selected broad topics that are known to affect the UK composites industry, and which were highlighted in the industry survey. The responses to the survey has allowed the detailed issues to be understood, as well as gauging the importance of the issues and the actions that are needed. The six issues are:

- Environmental and regulatory issues
- Cost-effective manufacturing
- Skills shortages
- Awareness and education
- Standards and design codes
- Business issues

Environmental/Regulatory Issues

The environmental issue is seen both as an opportunity and a threat. Environmental impact legislation can open the door for composites in new applications where life-cycle costing and analysis is carried out, although these applications are limited by the lack of a clear recycling route for composites.

"We are reviewing our manufacturing and will move soon to RTM."

Additionally, the industry itself is affected by environmental concerns, especially those relating to emissions in the workplace, and these are now causing a move towards alternative materials and processes. Coordination on regulatory issues is already being undertaken, principally by the British Plastics Federation (BPF), for example through coordination of industry response to the requirement to be registered for styrene use. The BPF organised seminars for dissemination and coordinated the response to HMIP (Her Majesty's Inspectorate of Pollution) that resulted in a local agreement for styrene use that could be undertaken using a standard agreement.

It is anticipated that this issue will have maximum effect in 4-7 years' time, and the majority of companies have ongoing actions to address environmental issues.

Cost-effective Manufacturing

Cost reduction is seen as important from two main points of view. The first is due to increasing competition in the supply of composite components by companies outside the UK, especially those with lower labour costs. The second is an increasing need to win more business from traditional materials and hence grow the composites market.

Because of the limited control over raw material prices and the high UK labour costs, cost-effective manufacturing processes are seen as the primary way in which companies can reduce their costs and be more competitive.

This issue is more immediate, having the greatest impact on the industry in the next 3 years and reducing only slightly in the following 4 years. It is therefore seen as an immediate priority affecting high proportions of the business of composites companies.

Skills Shortages

The issue of skills shortages is expected to be seen most over the next 3 years, with most companies having the issue high on their priority lists.

However, the industry is widely divided on this subject. Whilst many companies see the lack of skills as a significant problem, a few do not see a lack of skills as a major issue.

Overall there does appear to be a shortage of trained engineers and laminators, perhaps a reflection of the low esteem in which the engineering profession in the UK is held.

However, it is worth noting that in July 2001, £500,000 of funding was secured for the South East, to upgrade skills in the composites and advanced materials sector. The funding will be used to address the shortage of skilled technical staff in the composite sector. Further details of this can be found in Annex 2.

A initiative for on-line learning is also being planned by the Polymer NTO.

Awareness and Education

As with manufacturing, lack of awareness amongst potential clients is expected to have the greatest impact on the industry in the next 3 years and reducing only slightly in the following 4 years. This is especially noted because of concern at the general level of education below degree level.

Rather than being seen predominantly as a threat to the industry, this lack of awareness is seen as an opportunity for the industry to grow through the education of more people, from Key Stage 3 through to Continuing Professional Development.

Standards and Design Codes

"Business is more and more conducted electronically. Internet marketing is important to us."

The issues of standards and design codes are seen as important to the industry. The lack of standards for composites restrict their uptake due to perceptions about the reliability of the materials, whist the pre-existence of some standards precludes the use of composites.

The time taken to put standards in place is seen as a problem by the industry, and the use of best practice guidance as an interim measure was strongly recommended to accelerate the time to market for new composite products.

Business Issues

The main business issues that were brought out by the survey covered the difficulty in trading overseas due to the strong pound, the difficulty in gaining access to research finding and the need for the industry to better adopt ICT (including the Internet).

Overall, the view was that these were less important than the other issues and that (in the case of the strong pound) they could be influenced less. However, the maximum impact of these business issues will still be seen in the next 3 years.

4 Foresight

The STEEP analysis in the previous section identifies the factors likely to influence the future competitive position of the UK composites industry. These factors represent both opportunities and threats to which the industry must respond, the most appropriate response being dependent on the strengths and weaknesses of the industry.

This section therefore contains a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of issues facing the UK composites industry, based directly on industry comments, prioritisation of those issues and an examination of possible future scenarios.

4.1 SWOT Analysis

Strengths

The current factors that place the UK composites industry in a positive position to exploit the trends identified during the STEEP analysis are:

- A good level of fundamental understanding and academic research
- Skill, knowledge and worldwide reputation
- Innovative ideas and manufacturing processes
- Wide-ranging materials that can be used in many applications
- Good capability in specific areas (eg motorsport and marine vessels)
- That fact that small companies have a flexible approach
- A long tradition and a high technological standard
- A strong UK defence customer, leading to new materials and innovations

Weaknesses

The current factors that hinder the industry from exploiting the trends identified in the STEEP analysis include:

- A shortage of trained staff and skilled engineers
- A lack of customer awareness and the fact that decision-makers have limited knowledge of composites
- A shortage of design guides and design data
- The industry Is perceived as fragmented and lagging behind the USA and Europe
- Companies are prepared to work at low margins
- The composites industry has little applied research and development
- Unstable primary material supply and costs, with too few suppliers and much raw material needing to be imported
- Small companies cannot influence specifiers, especially compared to larger metallic materials companies
- The pound is strong and variable
- The recycling routes for composites are not defined or clear.
- The UK has higher labour costs than cheaper foreign competitors

Opportunities

Opportunities for exploiting the trends identified in the STEEP analysis include:

- New markets in infrastructure, air and rail transport, offshore, lightweight products and renewable energy
- The use of composites in new applications due to environmental regulations
- Stronger company/university links and the transfer of knowledge from academia to overcome some of the industry's problems
- The use of natural fibres to address environmental concerns
- The use of low cost carbon materials to improve costs
- The use of new processes and new materials (thermoplastics)
- Improved 2-way relationships with customers

Threats

The following threats to the UK composites industry have been identified. These include the consequences of doing nothing, possible negative results of exploiting opportunities and constraints that may hinder action.

- Low cost imports from cheaper countries
- Lack of design guidance and standards
- Environmental legislation and other regulations
- The lack of a clear recycling route, especially for thermosets
- Reduced research and development funding for new ideas and consequent technical stagnation
- Merging of companies outside the UK, leaving UK companies unable to compete
- Overselling of composites and the risk of high-profile failures
- The development of competitive technologies, such as titanium and high-strength steel

4.2 Future Scenarios

Scenarios are imagined futures, typically a set of short stories describing alternative future business conditions, and can be used to help in the testing of ideas and planned actions for the industry. As the STEEP analysis has already identified major trends affecting the industry, a workshop based scenario-building exercise was used to create 2 imagined futures for the industry – one extremely favourable and the other extremely hostile.

Case Study

Aviation Enterprises

Using Existing Schemes to Enhance Staff Skills

Aviation Enterprises is a small company that uses expertise in high performance composite materials to manufacture a range of three-axis microlight aircraft, as well as a range of non-aerospace products. To extend the skills of their staff, they have obtained a TCS (formerly known as the Teaching Company Scheme) project with NPL's Composites Group, allowing an NPL scientist to become a TCS Associate and to work with them.

For the next two years, the NPL scientist will be seconded to Aviation Enterprises, helping them to improve the company design capability (including a traceable materials database and validation of design predictions) by transferring technology from NPL to the company. The company is working on a range of products including a new 2-seater light aircraft, which uses a significant amount of composite materials in its construction. TCS technical support is fundamental to gaining certification for this aircraft.

On the web: **www.aviationenterprises.co.uk**

Case Study

Crompton Technology Group

Accessing New Markets with Venture Capital

Crompton Plastics was an established SME marketing polyurethane mouldings and some specialised composite material components, principally suspension members for cryogenic applications where composites are the only suitable materials. As with many SMEs, their need was to expand into new markets and applications.

To take the business forward into new high-performance markets such as motorsport, a new management team raised venture capital to finance the purchase of Crompton Plastics. Many venture capitalists look favourably at the composites industry, and in this case the deciding factors in obtaining financial support were the historical performance of the company and the strength of the business plan.

This investment enabled the new management, now Crompton Technical Group, to purchase filament winding equipment and technology to develop the business into markets for high-performance drive shafts and pressure vessels.

On the web: **www.ctgltd.co.uk**

These imagined futures can be used to gauge the extremes of possibilities facing the industry. Whilst there is only a very small likelihood of all of these extreme situations arising, the possibility of them arising helps to focus the direction of thoughts on future directions for the industry. The actual future is likely to lie between these 2 extremes, but it is interesting to note that the Favourable Future outlined below does not seem unachievable.

The following extreme futures are based on the position of the UK composites industry in 10-15 years' time.

A Favourable Future

In a favourable future, composite materials will enjoy significant growth in the construction industry, alongside further rapid growth in renewable energy and distributed power systems such as fuel cells.

Legislation on emissions will emphasise the use of lightweight materials and through-life costing, coinciding with the emergence of clear routes for recycling and re-use of composites. This will mean growth in the automotive sector, with additional increase in use of composites for lightweight ground and air mass transit.

This growth will have been due in part to fact that the industry will organise itself to present a combined front against competitive materials and actively raise the awareness of composite materials amongst specifiers.

A Hostile Future

In a hostile future the end-of-life re-use of components will be a legislated necessity, with landfill no longer an option and incineration of FRP components uneconomic.

Conservative heath and safety legislation will lead to the classification of styrene as a probable or possible carcinogen, and the same classification has been issued to reinforcement fibres broken during cutting or recycling. VOC emissions in the early life of parts is also being considered as hazardous to health

Whilst most of the problems facing the industry will be related to health and safety, economic recession will seriously affect the industry, especially considering the dependency of the composites industry on luxury items such as mass transit (holiday travel etc), leisure and sporting goods.

"Composites are kept out of buildings and bridges because of lack of codes."

4.3 Prioritisation of Issues

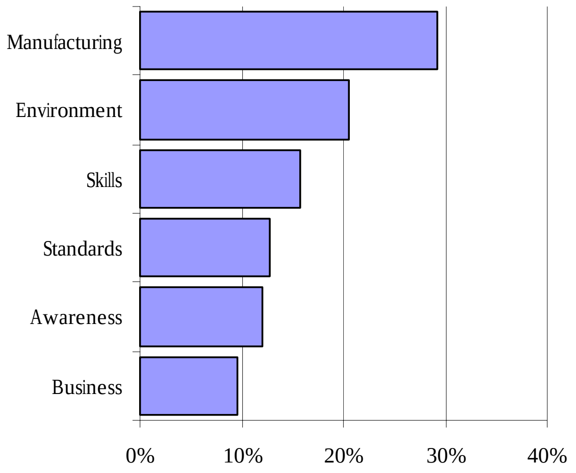
The review of specific issues was based on six pre-selected broad topics that are known to affect the UK composites industry, and which were highlighted in the industry survey.

Prioritisation of the issues facing the industry was undertaken, based on general and detailed ballots by those that contributed to the industry workshop.

The results of this exercise were used to give each subject area a relative ranking according to the overall score that it had received. The relative importance of each of the issues is shown in Figure 4.1, and the priority order is:

1. Cost-effective manufacturing
2. Environmental and regulatory issues
3. Skills shortages
4. Standards and design codes
5. Awareness and education
6. Business issues

Figure 4.1: Relative Importance of Issues facing the UK Composites Industry



Within each of these overall issues, sub-issues on the potential way forward, identified from the survey, were prioritised using the same method to give an indication of the issues that should be focussed on in the near future.

The areas of priority were therefore considered as:

Cost-effective Manufacturing

- Development and commercialisation of low-cost methods
- Increasing the involvement of moulder with customer
- Research and demonstrator programmes

Environmental/Regulatory Issues

- Negotiation collectively and centrally with regulators
- Development of waste agreements and new end of life uses
- Increased effort to show whole life cost savings

Skills Shortages

- Recognised design codes need to be used in training engineers
- Training of new staff in-house and use internal seminars
- Improvement of the esteem of engineering in UK

Standards and Design Codes

- Concentration on working with suppliers meeting standards
- Coordination of standards activities in different countries
- Improved general guidance and codes until standards arrive

Awareness and Education

- Concentration on teaching composites in core modules of engineering courses
- Development of design codes
- Support for the Trade Associations

Business Issues

- Improvement of the ease of access to development funds for SMEs
- Government support for training engineers
- Improvement in the targeting of research funds.

5 Conclusions

Industry Trends

The UK composites industry is a diverse collection of companies and markets, with many obstacles limiting the faster growth of the industry and broader use of composites. However, the industry is positive in its attitude towards these obstacles and is generally progressing to overcome them, albeit at a slower pace than ideal.

Amongst the changes in evidence are signs of consolidation of the industry through restructuring and globalisation, as well as increased activities in networks, each giving the industry greater presence when dealing with potential clients. Market trends are towards mass transit and construction, industries that are slowly coming to appreciate composites as competitive materials, and away from the more niche electronics, civil aircraft and medical markets.

In parallel, environmental issues are having a significant effect on the industry, with strong interest in recycling and significant movement towards cleaner, cheaper production technologies. Strong materials trends are therefore towards thermoplastics and stitched fabrics, whilst processing trends are away from hand lay-up towards resin transfer moulding and resin infusion techniques.

Competitive Performance

The overall revenue of the UK composites industry is estimated to be £510Million, against shipments of 240,000 tonnes, forecast to grow at an average of 3.7% per annum to 2005. This places the UK fourth in size within the European composites industry, estimated at £3300Million, against shipments of 1,540,000 tonnes. The European industry is forecast to grow at an average of 3.8% over the same period.

The UK performs well in a few highly specialist sectors, such as aircraft wings and large marine vessels. However, although the UK does everything seen in the global industry, it does not excel in many areas and the overall performance of the industry is average when measured against European competitors.

Factors Impacting Competitiveness

The main factors affecting the current and future competitiveness of the industry are:

- The changing nature of skills in the UK, away from manufacturing, affecting the level of skills in the industry and the potential clients' awareness of the benefits of composites
- The high level of scientific knowledge in the UK
- Likely future developments in technologies
- The position of the UK economy, particularly the strength of Sterling which makes UK industry less competitive
- Environmental factors such as recycling, landfill and emissions
- Poor understanding of advantages of composites by potential customers and restrictive standards

Broad SWOT Analysis

The UK industry sees its main strengths in a good level of fundamental understanding and academic research, innovative ideas and manufacturing processes. Its main weaknesses include a shortage of trained staff, a lack of customer awareness, a shortage of design guides, high labour costs, unclear recycling routes and little applied development.

Opportunities for exploiting future trends include new markets in infrastructure, transport, offshore, lightweight products and renewable energy. Additionally, opportunities were seen in stronger company/university links, the transfer of knowledge from academia and the use of new processes and new materials.

The threats to the UK composites industry have been identified as low cost imports from cheaper countries, environmental regulations, reduced development funding for new ideas and the development of competitive technologies, such as titanium and high-strength steel.

Prioritisation of Issues

The results of this work have classified the factors affecting the industry and prioritised them according to their relative importance and the industry's ability to change the current situation. This gives the following priority order:

1. Cost-effective manufacturing
2. Environmental and regulatory issues
3. Skills shortages
4. Standards and design codes
5. Awareness and education
6. Business issues

Recommendations on the potential way forward for each of these issues is given in the next section.

6 Recommendations

6.1 Overall Recommendations

This study has resulted in a prioritisation, by the industry, of the factors affecting them, according to their relative importance and the industry's ability to affect them. This gives a prioritised action list of:

1. Cost-effective manufacturing
2. Environmental and regulatory issues
3. Skills shortages
4. Standards and design codes
5. Awareness and education
6. Business issues

In conjunction with industry representatives, recommendations have been developed in the areas in which value-added action might be taken in the UK, by industry and government (and the wider public sector) to improve competitive performance, as the basis for a strategic action plan. These are detailed below.

Cost-effective Manufacturing

Concentration in this area of highest priority should be on the development, dissemination and commercialisation of low-cost clean processing methods. This should be achieved through rolling, coordinated dissemination and best practice programmes to ensure that composites companies have the full picture of the benefits and limitations of new process technologies.

It is envisaged that this programme should build on the dissemination exercise carried out for the LINK Structural Composites programme, broadening it to include a comprehensive range of project results funded from other public sources (eg CARAD, EPSRC). Such an exercise should have a strong hands-on, practical bias to ensure the widest possible uptake.

In parallel with this, best practice in composite processing should be highlighted and companies actively supported in making the transfer to cleaner cost-effective processes, through workshops, guidance information and demonstrators.

This should be supplemented with dissemination of best practice in management and production tools to further support and encourage concepts such as supply chain management and lean manufacturing.

It is felt that industry trade federations should have a role in the coordination of activities such as these, and that this role might best be suited to the CPA. The CPA has already started this activity through 4 regional road shows on closed-mould techniques, starting in November 2001 and aimed at SME moulders.

Environmental/Regulatory Issues

The industry should further strengthen its ability to negotiate collectively and centrally with regulators, as undertaken successfully for styrene registration, and to provide input into European bodies such as GPRMC (via the BPF) on regulatory aspects. As part of this the industry should develop a primary reference point on recycling issues and should publish validated information on the opportunities for end-of life re-use and disposal of composites.

It is envisaged that these activities fall most easily within the remit and current role of the BPF Composites Group.

The industry should also increase its efforts in life-cycle analysis, so that suppliers are able to provide clear life-cycle costs to potential customers. Additionally, the industry should explore opportunities for composites that arise from environmental pressures to save energy or costs through reduced weight, longer service lives or reduced maintenance.

To stimulate this, future UK programme priorities should be focussed on life-cycle aspects of composites, including design costs, material/manufacturing costs, through-life costs and end-of-life costs.

Skills Shortages

To encourage improved levels of skills within the industry, composites companies should be encouraged to train their own staff and develop relationships with regional or local education and training specialists. The benefits of training should also be highlighted, and the CPA is willing to be involved in the organisation and coordination of training.

As part of this, discussions with the BPTA (British Polymer Training Association) or similar organisation should be resumed with a view to providing recognised courses and qualifications for laminators. CPA has already initiated the first stage of this, potentially with Southampton University, to be rolled out so that it is available around the country to local manufacturers. The CPA has suitably experienced people from its membership to train the trainers.

Depending on the success of the recently announced SEEDA training fund for composites in the South East, an extension of this programme on a National basis should be considered.

Additionally TCD, responsible for the TCS (formerly the Teaching Company Scheme), should provide publicity throughout the industry to encourage a greater take-up of the scheme to allow training of professional staff. Specialised courses, such as the MSc course at Imperial College, should also be developed and maintained in order to provide graduates with the detailed practical understanding of polymer composites needed by industry.

In addition, a guide to current Continuous Professional Development (CPD) courses should be developed to aid industry choose the right level and content from those that are currently offered by institutions and private companies. This could be produced by the Institute of Materials.

It is important in all these training courses that recognised design codes and standards, where available, are used in the training process.

Finally, it is important for the industry to be able to attract sufficient numbers of staff, and recommendations to achieve this are detailed below under “Awareness and Education”.

Standards and Design Codes

To demonstrate the increasing availability of standards in a maturing industry, companies should require that suppliers work to international quality and technical standards wherever possible.

The industry, in conjunction with end-users and standards development organisations (eg British Standards Institution, NPL and BPF) should further develop design codes to facilitate greater use of composites. These codes will also provide the information needed in engineering training.

Additionally, the industry should also work with end-user groups to develop and publicise guidance information, as a faster pre-cursor to standardisation. The future conversion of these guides to standards should then be proactively undertaken with DTI materials measurement and innovation budget support.

International coordination of standards should also be targeted by the industry, to enhance the UK’s ability to export.

The CPA and BPF could develop their industry guidance documentation by collating and disseminating information relating to composites. They could further develop guidelines to encourage users to make use of accredited suppliers that comply with industry standards.

Awareness and Education

The industry should actively develop initiatives to teach composites in schools, especially in training teachers and in the provision of education materials, in support of the National Curriculum requirement to teach composites from Key Stage 3 through to A Level (11/12 years to 18). As well as creating general awareness, this will encourage students to further develop skills and knowledge in composites.

Equally, the industry should support, through their expertise, the development of a common module presenting the important aspects of polymer composites technology in a variety of engineering and materials courses. This initiative could be headed by the IoM Composites Division.

Trade Associations and other organisations should also concentrate on securing additional funds, ideally from new member companies, specifically earmarked for creating awareness on composites within target customer sectors.

Business Issues

The main business issue, over which there is some possibility of control, is public spend in the sector. It is recommended that access to government development funds should be simplified, that research funds should focus more on applied work and that future funds should be targeted according to the impact of completed research.

Additionally, the results of work involving significant (>30%) government funding should be disseminated widely, after the appropriate confidentiality periods, in a practical and easily understood format such as seminars and case studies.

The industry should itself strive to use available regional, national and international funding for its own development. The BPF and the CPA could take on such a role, to make their members aware of available schemes.

General Recommendations

Many of the recommendations above naturally fall into the responsibility of one of the trade or professional bodies that represents the industry. In particular there appears to be good synergy between the activities of the BPF, CPA and IoM.

However, there appears to be a need to provide an over-arching forum for composites industry. This could allow the trade federations to interact more effectively, for the output of research programmes to be more effectively disseminated and for the current state-of art to be more effectively presented to potential customers and regulatory bodies.

The creation of such a coordinating forum depends on the cooperation of all the bodies concerned, but the Steering Committee for this study may well provide the basis for such a group. A preferred method of creating this Forum would be through a Faraday style partnership to bring together the leading players in the industry, funded either from the Faraday scheme or from other sources.

Finally, the proposed review of the SIC codes used in this study is timely, and the industry should make representations for a code for a Composites or Reinforced Plastics industry sector products.

6.2 Recommendations Checklist

The key recommendations of the report can be summarised under 8 major objectives:

1. **Lower the cost of supply**

   Task: Develop, disseminate and commercialise low-cost processing methods to promote the benefits and limitations of new process technologies.

   Action: Government/Industry partnerships to facilitate technology translation.

2. **Lower the barriers that restrict demand**

   Task: Provide coordinated development and advice on end-of-life, re-use and disposal of composites as a means to strengthen negotiations collectively and centrally with regulators.

Action: Industry partnerships for effective representation with Government.

3. **Stimulate sustainable market demand**

   Task: Respond to customers' demands for environmentally friendly products that are lighter, stronger, longer-lasting and use less energy to manufacture.

   Action: Industry dialogue with new and existing end-users.

4. **Invest in education and training**

   Task: Develop relationships between regional and local training specialists to improve the range and quality of skills available to the composites industry.

   Action: Trade associations facilitating dialogue between trainers and staff.

5. **Bring about a step-change in standards for composites**

   Task: Specify and publicise international quality and technical standards to address the general lack of standards and codes for composite materials and products.

   Action: Trade and professional associations facilitating dialogue with regulators.

6. **Teach composites in schools and further education**

   Task: Establish composites as fundamental to future materials engineering and address the lack of understanding about composite materials.

   Action: Trade and professional associations facilitating dialogue with DfEE

7. **Sponsor applications-led research and disseminate results widely**

   Task: Establish a high-level Faraday style partnership in composite materials to provide easier access to knowledge and research, in consultation with DTI and EPSRC.

   Action: Composites industry in consultation with end-user demands.

8. **Set up an industry forum**

   Task: Present a unified front to potential customers and regulatory bodies.

   Action: Trade and professional associations with key industry leaders.

6.3 Acknowledgements

The authors are pleased to acknowledge the input and support from Steering Group members, Workshop attendees/observers and support staff. Guidance from DTI Chemicals Directorate is also gratefully acknowledged.

Annex 1: Glossary of Terms

Aramid
Strong aromatic polyamide organic fibre with high strength-to-weight ratio. Often used for applications requiring high impact resistance.

Autoclave
A closed vessel for application of pressure and heat, used for processing composite materials.

Bag Moulding
A process in which the consolidation of the material in the mould is effected by the application of fluid or gas pressure through a flexible membrane.

BPF
British Plastics Federation

Broad Goods
Fibre woven to form fabric up to 1270 mm wide. It may or may not be impregnated with resin and is usually furnished in rolls of 25 to 140 kg.

Bulk Moulding Compound (BMC)
Thermosetting resin mixed with strand reinforcement, fillers, and so on, into a viscous compound for compression or injection moulding. See also *sheet moulding compound*

Carbon Fibre
An important reinforcing fibre known for its light weight, high strength, and high stiffness that is commonly produced by pyrolysis of an organic precursor fibre (often polyacrylonitrile (PAN) or rayon) in an inert atmosphere.

CFA
Composites Fabricators Association, the US trade body for the composites industry.

CFRP
Carbon fibre-reinforced plastic

Chopped Strand
Continuous roving that is chopped into short lengths for use in mats, spray-up or compounds.

Composite
A homogeneous material created by the synthetic assembly of two or more materials (a selected filler or reinforcing elements and compatible matrix binder) to obtain specific characteristics and properties. For the purposes of this study, a composites is a long-fibre reinforced polymeric material, where the reinforcement is greater than 7.5mm in length prior to processing (BS EN ISO 10350-2).

Compression Moulding
A technique for moulding thermoset plastics in which a part is shaped by placing the fibre and resin into an open mould cavity, closing the mould, and applying heat and pressure until the material has cured or achieved its final form.

Contact Moulding
A process for moulding reinforced plastics, in which reinforcement and resin are placed on a mould, cure is either at room temperature using a catalyst-promoter system or by heat in an oven and no additional pressure is used.

Continuous Filament
An individual, small-diameter reinforcement that is flexible and indefinite in length.

Continuous Roving
Parallel filaments coated with sizing, gathered together in single or multiple strands and wound into a cylindrical package. It can be used to provide continuous reinforcement in woven roving, filament winding, pultrusion, prepregs or high-strength moulding components. It also can be chopped (see *Chopped Strand*).

Conventional Roving
Roving that is assembled from several forming packages using a creel and a roving winder. Typical characteristics are multiple ends, 3-inch diameter centres, a tube core and some catenary.

CPA
Composites Processing Association of the UK.

E-Glass
A borosilicate glass; the type most used for glass fibres for reinforced plastics; suitable for electrical laminates because of its high resistivity.

Epoxy
A thermoset polymer containing one or more epoxide groups and curable by reaction with amines, alcohols, phenols, carboxylic acids, acid anhydrides, and mercaptans. An important matrix resin in composites and structural adhesive.

Fabric, Nonwoven
A material formed from fibres or yarns without interlacing (e.g., stitched bonded, nonwoven broadgoods).

Fabric, Woven
A material constructed of interlaced yarns, fibres or filaments produced by the weaving process.

Fabrication
The process of making a composite part or tool.

Fibre Content
The amount of fibre present in a composite. This is usually expressed as a percentage volume fraction or weight fraction of the composite.

Filament Winding
A process for fabricating a composite structure in which continuous reinforcements (filament, wire, yarn, tape, or other), either previously impregnated with a matrix material or impregnated during the winding, are placed over a rotating and removable form or mandrel in a prescribed way to meet certain stress conditions. Generally the shape is a surface of revolution and may or may not include end closures. When the required number of layers is applied, the wound form is cured and the mandrel removed.

FRP
Fibre-reinforced plastic or polymer.

Gel Coat
A resin applied to the surface of a mould and gelled prior to lay-up. The gel coat becomes an integral part of the finished laminate, and is usually used to improve surface appearance and protect the laminate from the environment.

GFRP
Glass fibre-reinforced plastic, polymer or polyester.

Glass Fibre
Reinforcing fibre made by drawing molten glass through bushings. The predominant reinforcement for polymer matrix composites, it is known for good strength, processability and low cost.

Graphite Fibres
This term is used interchangeably with carbon fibres throughout the industry.

Glass Mat Thermoplastic (GMT)
A ready-to-mould glass fibre reinforced polypropylene material primarily used in compression moulding.

GPRMC
The European Composites Industry Association

GRP
Glass-reinforced plastic, polymer or polyester.

Hand Lay-Up
A fabrication method in which reinforcement layers are placed in mould by hand, saturated with resin and then cured to the formed shape.

Injection Moulding
Method of forming a plastic to the desired shape by forcibly injecting the polymer into the mould.

IoM
Institute of Materials, UK

Laminate
A product made by bonding together two or more layers of material or materials. Primarily means a composite material system made with layers of fibre reinforcement in a resin. Sometimes used as a general reference for composites, regardless of how made.

Lay-Up
The reinforcing material placed in position in the mould. The process of placing the reinforcing material in position in the mould. The resin-impregnated reinforcement. A description of the component materials, geometry, and so forth, of a laminate.

LFT (Long Fibre Thermoplastic)
A thermoplastic moulding material, characterised by long, discontinuous fibres in a thermoplastic matrix, often compounded at the mould tool and compression moulded to avoid fibre damage.

Low-Pressure Moulding
The distribution of relatively uniform low pressure (200 psi or less) over a resin-bearing fibrous assembly of cellulose, glass, asbestos, or other material, with or without application of heat from external source, to form a structure possessing definite physical properties.

Matched Metal Moulding
A reinforced plastics manufacturing process in which matching male and female metal moulds are used (such as compression moulding) to form the part.

Matrix
The material in which the fibre reinforcements of a composite system are embedded. Thermoplastic and thermoset resin systems can be used, as well as metal and ceramic.

Non-Woven Fabric
A textile structure produced by bonding or interlocking of fibres, or both, accomplished by mechanical, chemical, thermal, or solvent means and combinations thereof.

PET
Polyethylene Terephthalate (Thermoplastic Polyester Resin).

Polyamide
A polymer in which the structural units are linked by amide or thioamide groupings. Commonly called Nylon.

Polyesters
Thermosetting resins, produced by dissolving unsaturated, generally linear, alkyd resins in a vinyl-type active monomer such as styrene, methyl styrene, and diallyl phthalate. Cure is effected through vinyl polymerisation using peroxide catalysts and promoters, or heat, to accelerate the reaction. The resins are usually furnished in solution form, but powdered solids are also available.

Polymer
A very large molecule formed by combining a large number of smaller molecules, called monomers, in a regular pattern.

Polymerisation
A chemical reaction in which the molecules of monomers are linked together to form polymers.

Post-Cure
Additional elevated temperature cure, usually without pressure, to improve final properties and/or complete the cure. In certain resins, complete cure and ultimate mechanical properties are attained only by exposure of the cured resin to higher temperatures than those of curing.

PPO
Polyphenylene Oxide (Thermoplastic Resin).

PPS
Polyphenylene Sulfide (Thermoplastic Resin).

Preform
A preshaped fibrous reinforcement formed by distribution of chopped fibres by air, water flotation, or vacuum over the surface of a perforated screen to the approximate contour and thickness desired in the finished part. Also, a preshaped fibrous reinforcement of mat or cloth formed to desired shape on a mandrel or mock-up prior to being placed in a mould press. Also, a compact "pill" formed by compressing premixed material to facilitate handling and control of uniformity of charges for mould loading.

Prepreg
Ready-to-mould material in sheet form which may be cloth, mat, or paper pre-impregnated with resin and stored for use. The resin is partially cured to a 'B' stage and supplied to the fabricator who lays up the finished shape and completes the cure with heat and pressure.

Pressure Bag Moulding
A process for moulding reinforced plastics in which a tailored, flexible bag is placed over the contact lay-up on the mould, sealed, and clamped in place. Fluid pressure, usually provided by compressed air or water, is placed against the bag, and the part is cured.

Pultrusion
An automated, continuous process for manufacturing composite rods, tubes and structural shapes having a constant cross section. Roving and other reinforcements are saturated with resin and continuously pulled through a heated die, where the part is formed and cured. The cured part is then cut to length.

Reinforcement
A material added to the matrix to provide the required properties; ranges from short fibres through complex textile complex textile forms.

Resin
A material, generally a polymer that has an indefinite and often high molecular weight and a softening or melting range and exhibits a tendency to flow when it is subjected to stress. Resins are used as the matrices to bind together the reinforcement material in composites.

Resin-Transfer Moulding (RTM)
A moulding process in which catalyzed resin is transferred into an enclosed mould into which the fibre reinforcement has been placed; cure normally is accomplished without external heat. RTM combines relatively low tooling and equipment costs with the ability to mould large structural parts.

RTP
Sometimes used to distinguish reinforced thermoplastic from reinforced thermoset plastic.

S Glass
A family of magnesium-alumina-silicate glasses with high mechanical strength.

Sheet Moulding Compound (SMC)
A ready-to-mould glass fibre reinforced polyester material primarily used in compression moulding using matched metal tools.

Spray-Up
Technique in which fibrous glass and resin is simultaneously deposited in a mould. Roving is fed through a chopper and ejected into a resin stream, which is directed at the mould by either of a spray system.

Thermoplastic
Capable of being repeatedly softened by an increase of temperature and hardened by a decrease in temperature. Applicable to those materials whose change upon heating is substantially physical rather than chemical and that in the softened stage can be shaped by flow into articles by moulding or extrusion.

Thermoset
A material that will undergo a chemical reaction caused by heat, catalyst, etc., leading to the formation of a solid. Once it becomes a solid, it cannot be reformed.

Vacuum Bag Moulding
A process in which a sheet of flexible transparent material plus bleeder cloth and release film are placed over the lay-up on the mould and sealed at the edges. A vacuum is applied between the sheet and the lay-up. The entrapped air is mechanically worked out of the lay-up and removed by the vacuum, and the part is cured with temperature, pressure, and time. Also called *bag moulding*.

Vacuum-Assisted Resin Transfer Moulding
(VARTM) An infusion process where a vacuum draws resin into a one-sided mould. A cover, either rigid or flexible, is placed over the top to form a vacuum-tight seal.

VOC
Volatile organic chemical

Wet Lay-Up
A method of making a reinforced product by applying a liquid resin system and impregnating the reinforcement as it is placed in an open mould. Normally a manual process.

Annex 2: External Funding

DTI

DTI through the Innovation budget supports the development of composite products, such as through the SMART initiative. Within the DTI Measurement Programme, the composites related programme had a value of about £1.3 million/year over 8 years before 2001, and the forthcoming programme will have a reduced value of approximately £1.0 million/year over 4 years from now. Alongside the Research Councils, the DTI also funds the TCS scheme (formerly the Teaching Company Scheme) aimed at the transfer of technology from academia and research organisations via post-graduate placements and training.

The CARAD (Commercial Aircraft Research and Development) programme is valued at £20 million/year, with 36% on materials and structures. Direct grants for collaborative work carried out in industry comprise 49% of this (eg Airbus Industries' £10 million AMCAPS programme, 50% funded by government and 50% by industry). Additionally QinetiQ/DERA Intramural work (carried out at QinetiQ/DERA) comprises 33% and QinetiQ/DERA Extramural work is decreasing from 7%, as this type of activity is being phased out due to the privatisation of DERA.

DETR

In addition to research funding, DETR is funding BRE for 3 years to organise an industry-led network, Network Group for Composites in Construction, to develop the use of composites in this important sector.

EPSRC

EPSRC current projects total £163 million for materials, with 39 grants on characterisation of composites (£9.1 million) and 24 grants on processing of composites (£7 million). Funding for composites (including particulate and short-fibre reinforced materials) makes up 10% of the Materials budget, and an equal amount is thought to be coded under other topics, such as Engineering.

5 of these networks of excellence are:

- Sustainable Composites Materials Network (SUSCOMPNET)
- Hybrid Materials Network (HYBRIDNET)
- Thermoplastic Matrix Composites (THERMOFORMNET)
- Advanced Polymeric Composites for Structural Applications in Construction (CoSACNet)
- Real Time Cure Monitoring in the Manufacture of Composites Structures (CURENET) -- completed

LINK Structural Composites (1989-1999)

The LINK Structural Composites programme, which ran from 1989 to 1999, aimed to encourage collaborative pre-competitive research between industry and science-based partners in a wide range of structural composites. These were defined as load bearing materials in which particles or fibres are incorporated in polymer, metal or ceramic matrices to obtain improved properties in the composites.

Its primary objective was to encourage British Industry to exploit such composites in a sound and cost effective manner. It focused on innovative applied research - if successful, it was expected to yield useful results, exploitable in the medium term through the development of new products, processes, systems and services. Particular encouragement was given to projects that involved or could be exploited by small and medium sized enterprises (SMEs). Thirty-eight projects were supported by £29.4 million of UK Government funds. The results of an external evaluation will be published at the next International Conference of Fibre Reinforced Composites. FRC2002.

European Commission Framework Programme

Within the Brite-Euram 3 programme, running from 1994-1998, there were a total of 172 composites projects, 105 of which had some UK involvement and 53 of which had UK coordinators.

Ministry of Defence (MoD)

The MoD provides extensive support to both composite materials research and product development, although no detailed figures on the level of support were made available.

SEEDA

In July 2001, £500,000 of funding was secured for the South East Composites Manufacturing Skills Development (SEECOM) from the South East England Development Agency (SEEDA) Fund for Learning & Skills, to upgrade skills in the composites and advanced materials sector. The funding will be used to address the shortage of skilled technical staff in the composite sector.

In the first year this project will develop and deliver training for 250 employees and involve over 50 companies. It also aims to embed an awareness of the industry into the school curriculum and will produce pilot packages based on composite courses at GCSE and GNVQ levels.

Annex 3: References

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Annex 5: Additional Survey Results

A general survey was undertaken to provide additional evidence and validation of the issues facing the composites industry. The survey was completed by nearly 80 organisations, giving an excellent broad view of the issues affecting the composites industry as a whole, and the UK industry in particular.

In this annex we have included some additional graphs and data that support the main findings of the report, but which were not included in the body of the report for reasons of space.

UK Composites Industry Overview

Although the survey was aimed at companies in the polymer composites industry, it is still significant that more than half the correspondents indicated that composites were "critical" to their business, and that this applied even for companies where the composites proportion of their business is less than 20%. The type of respondents covered all categories with the largest representation from fabricators and designers, followed by consultants, processors and researchers. In addition over three-quarters of the companies responding were SMEs, with a half of the replies from companies employing less than 50 persons.

Figure A5.1:
Importance of Composites to the Business of UK Respondents

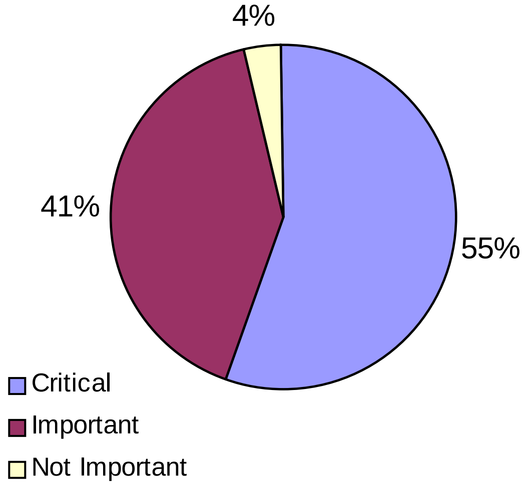
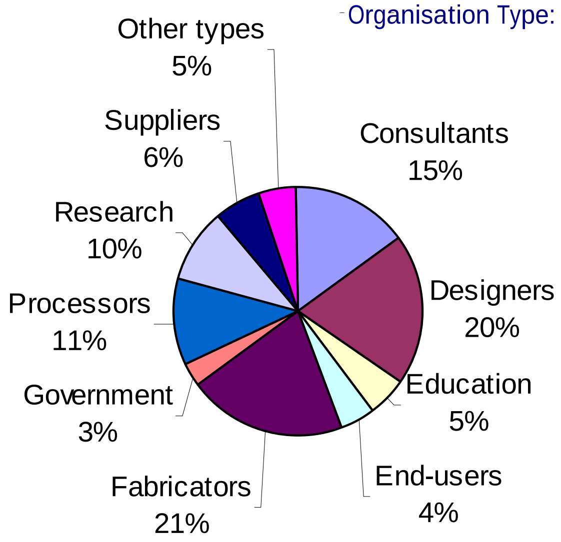


Figure A5.2:
Organisation Type:



UK Composites Industry Size and Location

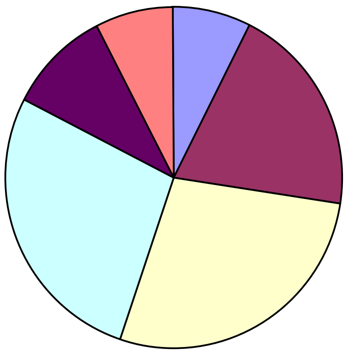


Figure A5.3:
Company Size (Number of Employees) of UK Respondents

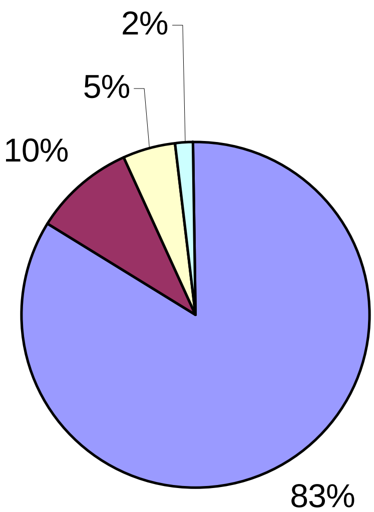


Figure A5.4:
Location of sites of UK Respondents

Headquarters

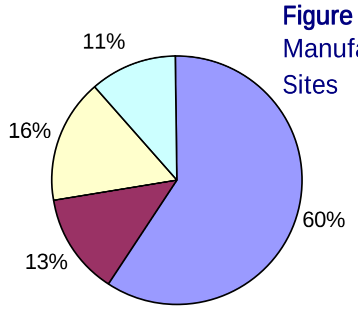


Figure A5.5:
Manufacturing Sites

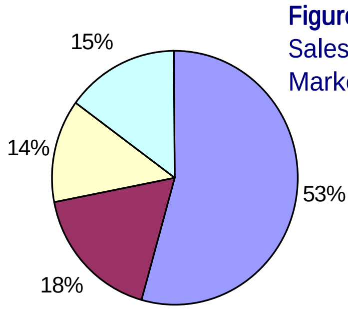


Figure A5.6:
Sales & Marketing Sites

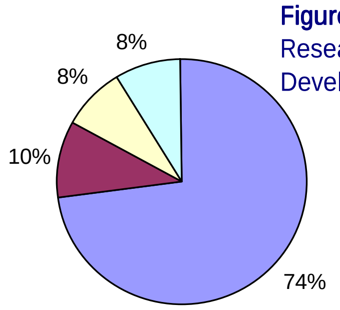


Figure A5.7:
Research & Development Sites

UK based replies had significant proportions of the their operations in the UK (83% headquarters, 60% of manufacturing sites, 53% of sales sites and 74% of research sites) with equal involvement in Europe, USA and elsewhere). For non-UK correspondents (mainly headquartered in USA), approximately 12% of their operations (research, sales and manufacturing) was in the UK with, compared with approximately 20% in the remainder of Europe.

Impact of the Environmental Issue

Figure A5.8: Importance of the Issue to the Business

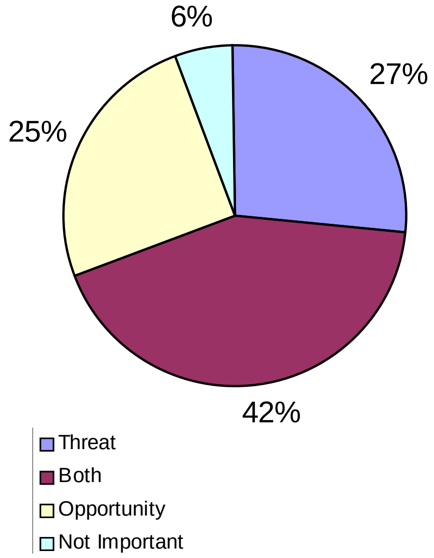


Figure A5.9: Percentage of Business Affected (%)

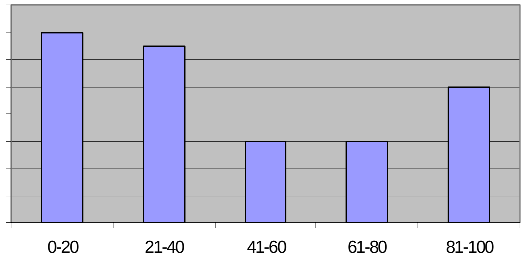


Figure A5.10: Timescale for the Issue to have Maximum Effect (Years)

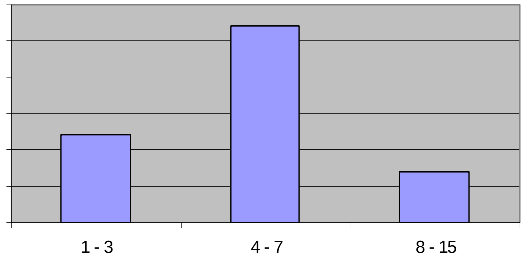
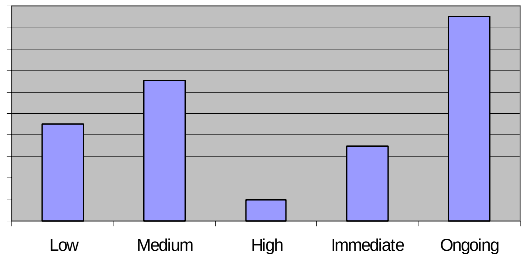


Figure A5.11: Company's Action Priority for the Issue



Impact of Cost-effective Manufacturing

Figure A5.12: Importance of the Issue to the Business

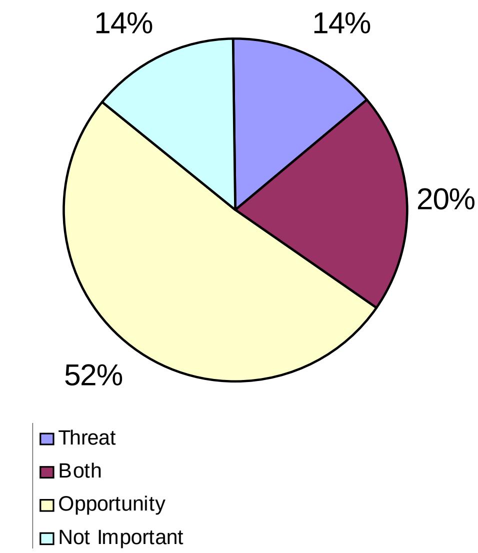


Figure A5.13: Percentage of Business Affected (%)

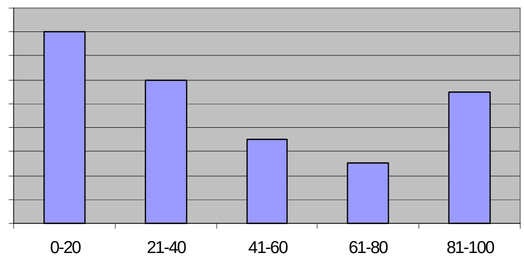


Figure A5.14: Timescale for the Issue to have Maximum Effect (Years)

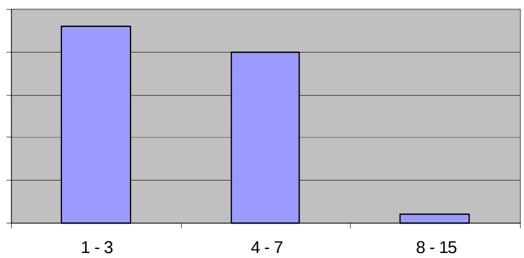
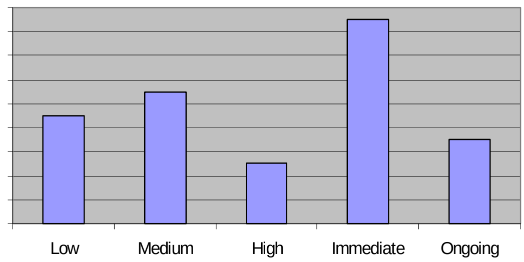


Figure A5.15: Company's Action Priority for the Issue



Impact of Skills Shortages

Figure A5.16: Importance of the Issue to the Business

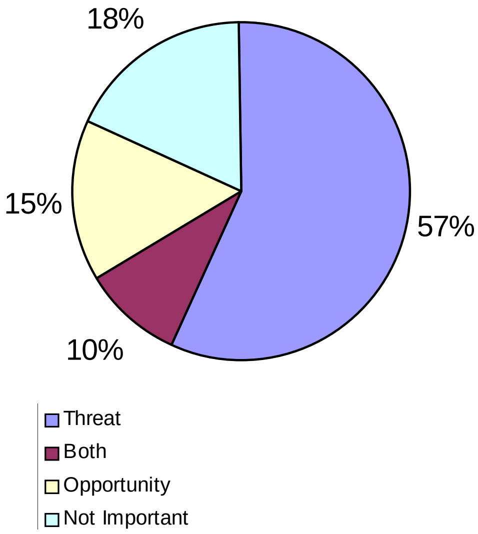


Figure A5.17: Percentage of Business Affected (%)

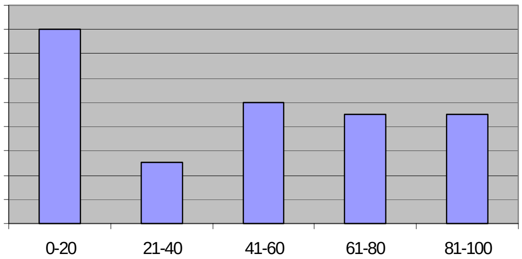


Figure A5.18: Timescale for the Issue to have Maximum Effect (Years)

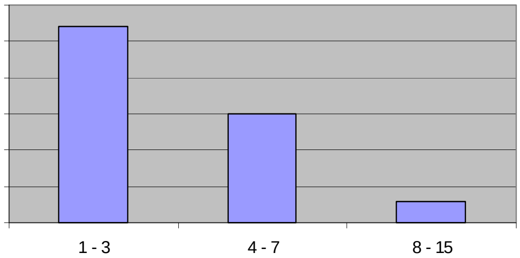
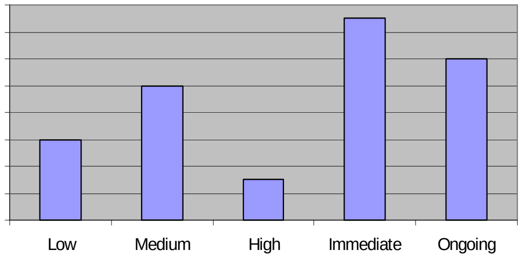


Figure A5.19: Company's Action Priority for the Issue



Impact of Education and Awareness

Figure A5.20: Importance of the Issue to the Business

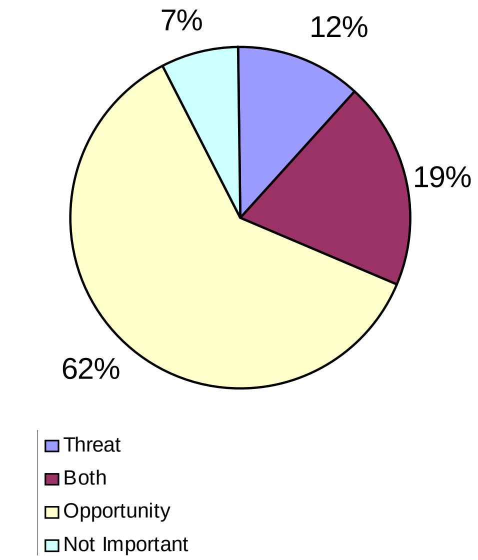


Figure A5.21: Percentage of Business Affected (%)

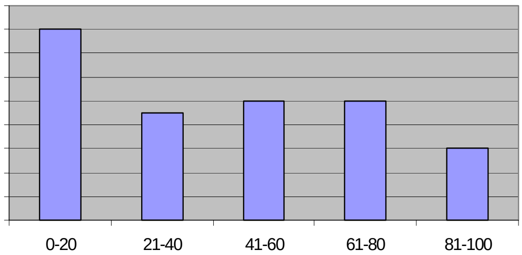


Figure A5.22: Timescale for the Issue to have Maximum Effect (Years)

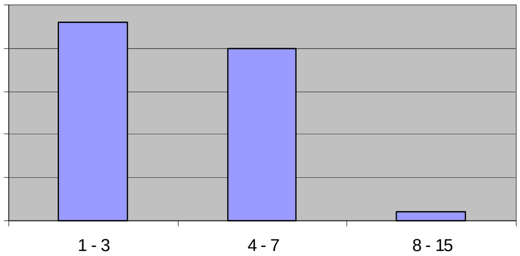
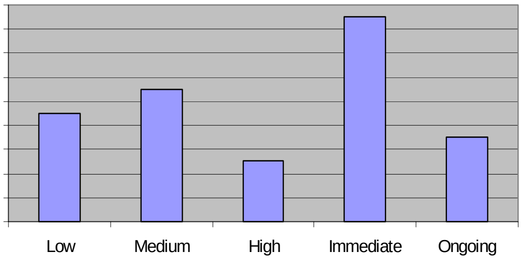


Figure A5.23: Company's Action Priority for the Issue



Impact of Standardisation

Figure A5.24: Importance of the Issue to the Business

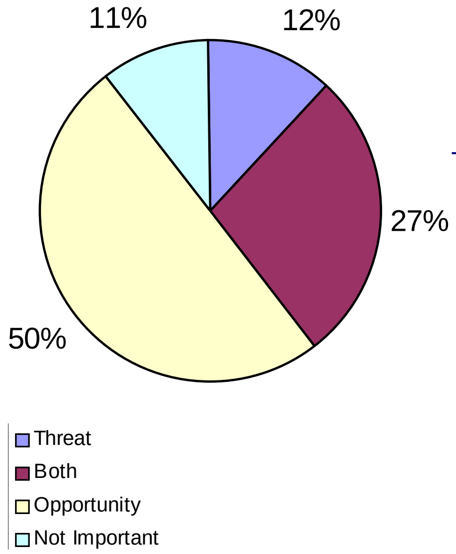


Figure A5.25: Percentage of Business Affected (%)

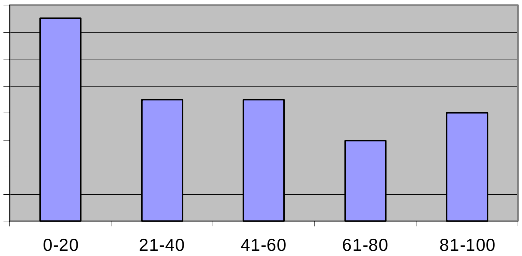


Figure A5.26: Timescale for the Issue to have Maximum Effect (Years)

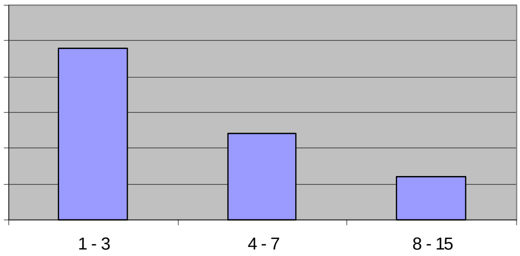
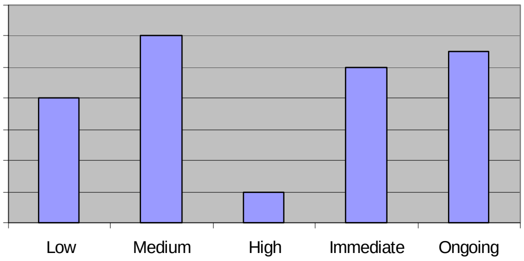


Figure A5.27: Company's Action Priority for the Issue



Impact of other Business Issues

Figure A5.28: Importance of the Issue to the Business

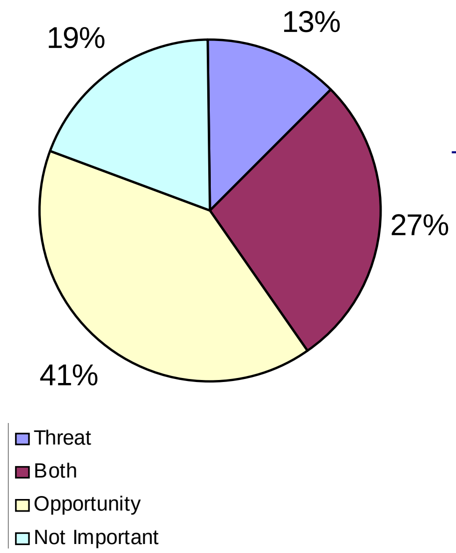


Figure A5.29: Percentage of Business Affected (%)

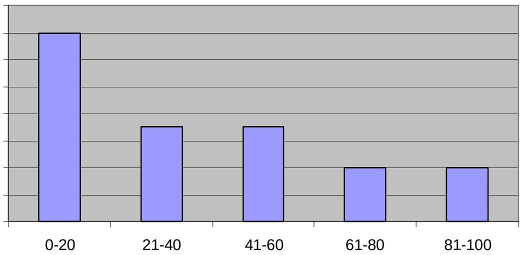


Figure A5.30: Timescale for the Issue to have Maximum Effect (Years)

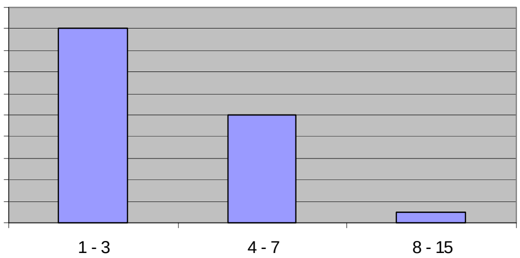
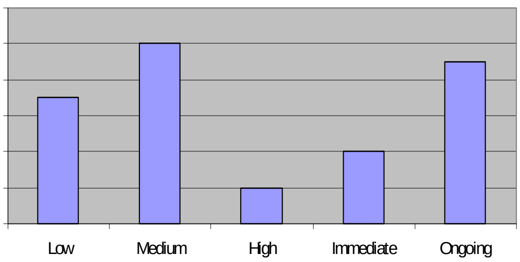


Figure A5.31: Company's Action Priority for the Issue



UK Composites Industry Staffing

The principal manning levels are professional and skilled employees. Skilled workers are predicted to reduce, perhaps in recognition of the trend to more automated production techniques, whilst professional engineers are predicted to increase, further compounding the shortage of qualified engineers.

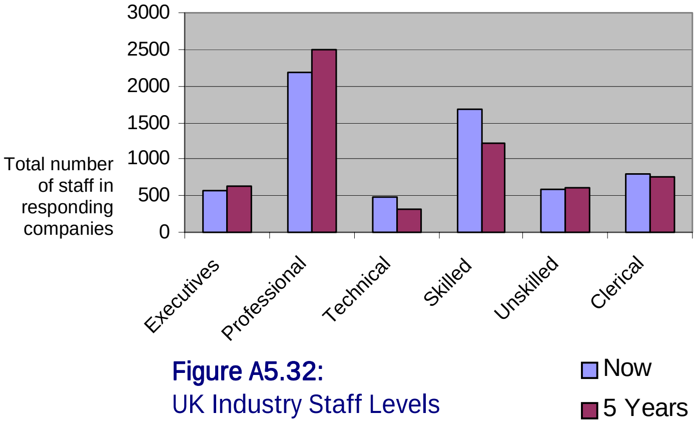


Figure A5.32:
UK Industry Staff Levels

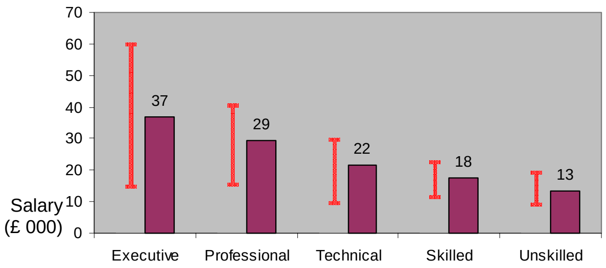


Figure A5.33:
UK Industry Salary Ranges

Annex 6: SIC Codes

SIC Codes Used

The list of SIC codes below was used to classify the industry and the sectors that it served, allowing for more useful data interpretation at a future date. Notably, there are no codes for the composites industry, although 12% ticked this option as being applicable to their business. There is also no code for the offshore industry, but uses are related to oil or gas extraction. It would appear that the proposed review of the SIC codes is timely, and that the industry should make representations for a sub-code under Plastics code covering the "Composites/Reinforced Plastics" industry.

Agriculture	0100
Chemical/Pharmaceutical	2400
Construction	4500
Defence (not aircraft)	2960
Electronics	3200
Food	1500
Machinery	2900
Medical	3310
Mining/Quarrying	1300/1400
Office equipment	3000
Sports	3640
Telecommunications	6420
Ceramics	2620
Composites	No Code
Metals	2700/2800
Rubber	2511
Plastics	2520
Textiles	1700

Water	4100
Electrical	3100
Gas	4020
Petroleum	2320
Offshore	No Code
Pleasure boat	3512
Motor vehicle	3400
Shipping	3510
Railway	3520
Civil Aircraft	3530
Military Aircraft	3530/2960
Spacecraft	3530

Annex 7: European Directives

European Directives Affecting the Industry

The following directives are the main pieces of legislation that affect the composites industry, either now or in the near future.

End-of-life Vehicles

Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of-life vehicles.

Waste prevention is the priority objective of the Directive. To this end, it stipulates that vehicle manufacturers and material and equipment manufacturers must (amongst other points):

- design and produce vehicles which facilitate the dismantling, re-use, recovery and recycling of end-of-life vehicles;
- increase the use of recycled materials in vehicle manufacture;

The aim of this Directive is to increase the rate of re-use and recovery to 85% by average weight per vehicle and year by 2006, and to 95% by 2015, and to increase the rate of re-use and recycling over the same period to at least 80% and 85% respectively by average weight per vehicle and year.

Waste Electrical and Electronic Equipment

COM (2000)347, Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Waste Electrical and Electronic Equipment and on the restriction of the use of certain hazardous substances in electrical and electronic equipment

The European Commission has adopted a proposal for a Directive on Waste Electrical and Electronic Equipment (WEEE) and a proposal for a Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment. The proposed Directives are designed to tackle the fast increasing waste stream of electrical and electronic equipment and complements European Union measures on landfill and incineration of waste. Increased recycling of electrical and electronic equipment, in accordance with the requirements of the proposal for a WEEE Directive, will limit the total quantity of waste going to final disposal. Producers will be responsible for taking back and recycling electrical and electronic equipment. This will provide incentives to design electrical and electronic equipment in an environmentally more efficient way, which takes waste management aspects fully into account. Consumers will be able to return their equipment free of charge. In order to prevent the generation of hazardous waste, the proposal for a Directive on the restriction of the use of certain hazardous substances requires the substitution of various heavy metals and brominated flame-retardants in new electrical and electronic equipment from 1 January 2008 onwards.

Incineration of Waste

Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste.

The aim of this Directive is to prevent or to limit as far as practicable negative effects on the environment, in particular pollution by emissions into air, soil, surface water and groundwater, and the resulting risks to human health, from the incineration and co-incineration of waste. This aim shall be met by means of stringent operational conditions and technical requirements, through setting emission limit values for waste incineration and co-incineration plants within the Community and also through meeting the requirements of Directive 75/442/EEC.

Landfill of Waste

Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste

With a view to meeting the requirements of Directive 75/442/EEC, and in particular Articles 3 and 4 thereof, the aim of this Directive is, by way of stringent operational and technical requirements on the waste and landfills, to provide for measures, procedures and guidance to prevent or reduce as far as possible negative effects on the environment, in particular the pollution of surface water, groundwater, soil and air, and on the global environment, including the greenhouse effect, as well as any resulting risk to human health, from landfilling of waste, during the whole life-cycle of the landfill.