Carbon Fibre Infosheet

Properties

Carbon fibre or Carbon Fibre Reinforced Plastic/Polymer (CFRP) is actually a carbon fibre-reinforced composite. It usually takes the form of a multilayer resin-coated fabric, which has minimal weight, yet remarkable mechanical resistance. Carbon has up to four times the tensile strength of high-grade steel, while also being extremely flexible, which has led to its use in aircraft, spacecraft, and sports cars, among other applications.

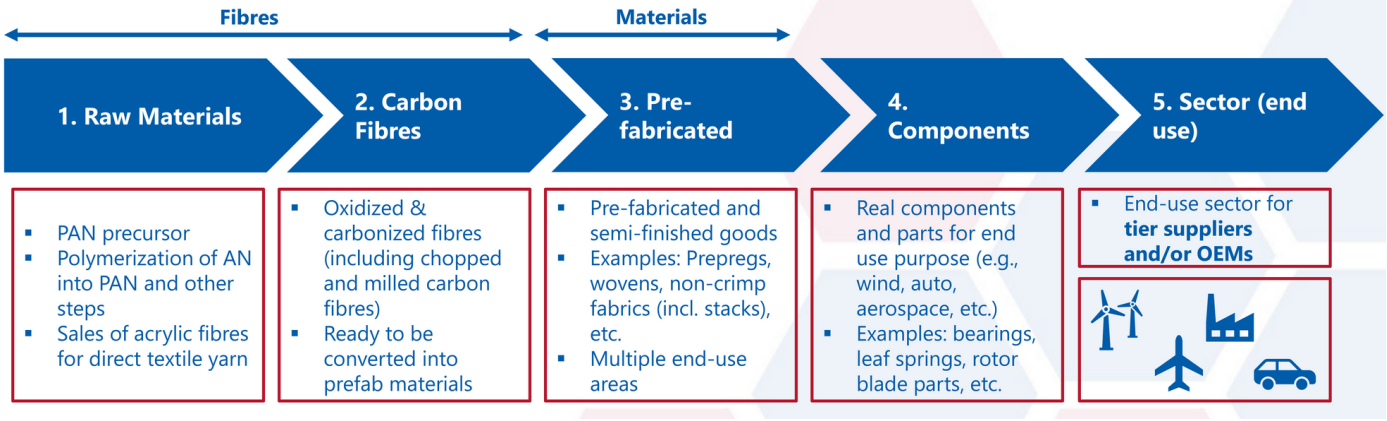
Two of the most famous examples of a cars for which carbon fibre was used was the Lexus LFA and the BMWi3. Their bodies consisted of more than 65% of carbon fibres.

These properties make it an ideal manufacturing material for various parts. The properties of carbon fibres are close to that of steel and the weight is close to that of plastic.

Key advantages of carbon fibres:

- High stiffness,
- High tensile strength,
- Low weight-to-strength ratio,
- High chemical resistance,
- High-temperature tolerance,
- Low thermal expansion.

Production



Polyacrylonitrile is the most versatile precursor for carbon fibre and chopped and milled carbon fibres for compounds.
Pitch-based carbon fibres are increasingly used in satellite manufacturing.

The major types of carbon fibre produced are:

- Continuous Carbon Fibre
- Short Carbon Fibre
- Short and Milled Carbon Fibre

The major forms of carbon fibre composites are:

- Polymer Matrix Composites (PMC)
- Ceramic Matrix Composites (CMC)
- Carbon Fibre Composites (CFC)

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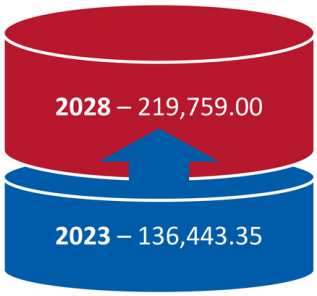
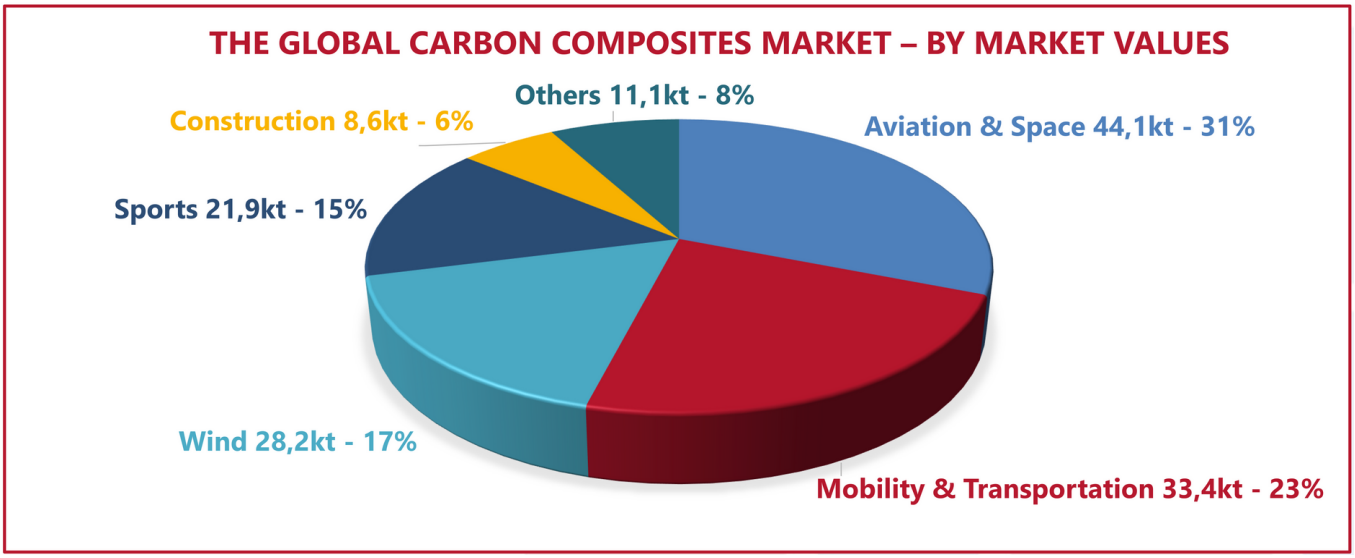
Carbon Fibre Markets

The Global Market

The Global Carbon Fibre Market size is expected to grow from 136,143.35 tons in 2023 to 219,759.00 tons by 2028, and at a CAGR of 10 to 11 % during the forecast period (2023-2028).



The major regions in the industry are North America, Latin America, the Middle East and Africa, Europe, and the Asia Pacific, with **Europe accounting for the largest share in the market.**



Europe is expected to dominate the carbon fibre market due to the presence of established automotive, aerospace, defence, and wind energy industries.

By end-user industry, the market is segmented into:

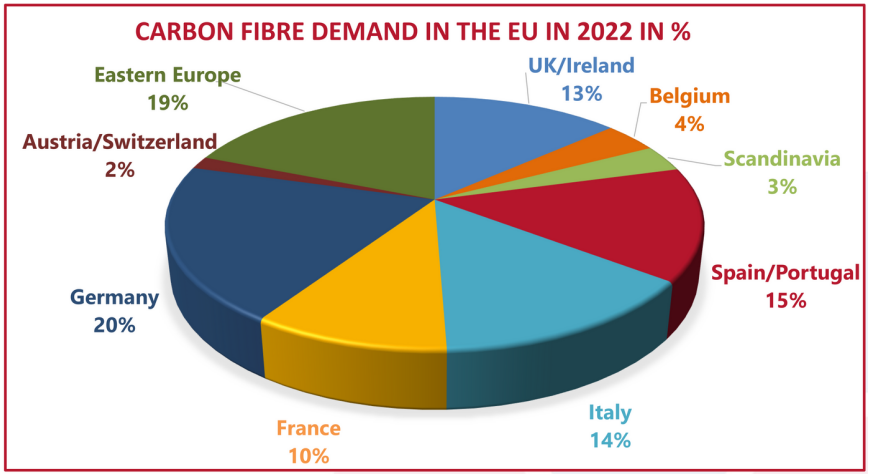
- Aerospace and Defence,
- Renewable energy/Wind Turbines,
- Automotive,
- Construction and Infrastructure,
- Sports/Leisure/Marine Applications,
- Industrial and Engineering Applications,
- Other Applications such as Pressure Vessels.

Carbon fibre is produced in Europe in

- France,
- Germany,
- Hungary,
- Spain,
- United Kingdom.

Precursors material is produced in

- Italy,
- Poland,
- Protugal,
- Sweden.



Graphs Source: Global carbon fibre market remains on upward trend, Mark Holmes

Carbon Fibre Applications

Automotive Applications

Carbon fibre-reinforced plastic (CFRP) is a lightweight material with excellent stiffness, strength, and fatigue properties compared to metals.

In the automotive industry, CFRP offers numerous advantages such as:

- weight reduction,
- integrated parts,
- crashworthiness,
- durability,
- toughness,
- and aesthetic appeal.

Carbon fibre and carbon fibre composites are mainly used in luxury and super cars where these parts can lead to a weight reduction of 10% and more and consequently can lead to increased fuel efficiency of up to 8%.

Aerospace Applications

The aerospace segment plays a significant role in the market, generating substantial revenue by utilizing PAN-based carbon fibres to enhance aircraft fuel efficiency. Composite materials, particularly carbon fibre-based ones, currently constitute 40% of an aircraft's composition.

Each Boeing jet incorporates around 32 to 35 tons of carbon fibre. In the case of the European Airbus A380 XWB, composites account for 53% of its weight.

The demand for aerospace applications is rising due to increased disposable income and globalization, leading to higher demand for commercial aviation.

Carbon fibre composites are especially crucial in space applications, providing superior stiffness and thermal protection. These applications include solar array panels, optical platforms, fairings, and antenna reflectors.

Carbon Fibre Applications

Defence Equipment

The lightweight characteristics combined with high tensile strength give carbon fibre a clear advantage over its metal counterparts for many **military and defence applications**:

- Missiles
- Drones
- Trucks
- Wheels
- Weapon stocks
- Helmets
- Tent posts
- Tactical ladders

Wind Turbines

Wind turbines use carbon fibres because of the high tensile stifness of carbon fibre which enables the wind turbines to withstand harsh weather conditions and lower weight enhances efficiency, consumption, and demand for renewable energy.

Europe has many offshore wind energy installations, especially in the United Kingdom and Germany. Wind energy accounts for the second largest share 14,7 % in value and is the largest market segment in volume.

Medical Industries

Carbon fibre reinforced plastics (CFRP) have emerged as a game-changing material in the field of **medical industries**, particularly in **orthoses and prostheses**:

- Applications include energy-storing keels, hydraulic cylinder frames, pylon tubes, and orthotic uprights.
- Carbon fibre implants act as scaffolds for tissue regeneration with excellent biocompatibility.
- No adverse reactions have been reported, making carbon fibre a trusted choice in orthopaedic procedures.
- Carbon fibre technology enhances mobility, durability, and patient well-being in the medical field.

Carbon Fibre Applications

Pressure Vessels and Hydrogen Production

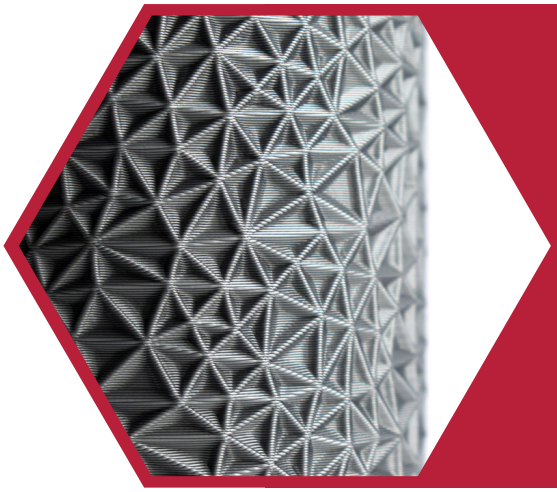
Carbon fibre and composite materials play a pivotal role in the manufacturing of **pressure vessels used for gas and hydrogen tanks** for fuel tanks and mobile pipeline applications. This innovative approach ensures the safe storage and transport of hydrogen, a key component in the pursuit of sustainable energy solutions.

- Carbon fibre and composites are utilized in manufacturing hydrogen tanks for fuel tanks and mobile pipeline applications.
- Europe leads in hydrogen fuelling stations, aiming for 3.7 million hydrogen-powered FCEVs and 45,000 fuel-cell trucks and buses by 2030.
- Hydrogen is a key priority for the European Commission (EC) to achieve a sustainable economy and climate-neutral EU by 2050.
- The EC's "Hydrogen Strategy for a Climate-Neutral Europe" calls for a €65 billion investment in hydrogen transport, distribution, storage, and refuelling stations.
- Various support policies and funding mechanisms, such as the Clean Hydrogen Partnership and ETS Innovation Fund, are in place.
- Rapid development of transport, delivery, and storage technologies is crucial for hydrogen's viability as a fuel source across industries.
- Regulations to reduce CO2 and greenhouse gas emissions in aviation and shipping are driving the need for hydrogen-powered solutions.
- The EU-funded SpaceTech4Sea project explores adapting aerospace technology for maritime applications.

3D Printing and Engineering

When it comes to achieving exceptional physical properties, carbon-fibre-reinforced materials have become the preferred choice over standard options like PLA, ABS, Nylon, or PETG.

- Advantages of Carbon-Fibre-Reinforced Materials:
- Ideal for end-use parts, manufacturing rigs, jigs, and functional prototypes.
- Carbon fibre increases strength while reducing weight, benefiting automotive, aerospace, and sports industries.
- Machine-specific characteristics, such as layer lines and dimensional accuracy, are still influenced by the 3D printing technology used.
- Carbon fibre's stiffness and strength allow for automatic deposition in various geometries by 3D printers.



Carbon Fibre Leisure and Sports

With cutting-edge advancements, athletes are experiencing enhanced speed, endurance, precision, versatility, and control in their respective sports. From professional cyclists conquering longer distances to golfers swinging with unparalleled accuracy, and tennis players executing versatile moves with exceptional racket control, to board skaters pushing the boundaries of what's possible with mind-boggling stunts, the realm of sports has entered an exciting new era.

Cycling

Light yet incredibly strong, **carbon fibre bikes** outperform traditional aluminium alloy counterparts. With their exceptional durability and lightweight design, these bikes can withstand high impacts, ensuring faster finishes and an unparalleled riding experience.

The inherent strength of carbon fibre allows cyclists to conquer challenging terrains while maintaining speed and control. Its high impact resistance ensures long-lasting performance and reliability.

Racket Sports

In tennis, carbon fibre has been used to make uniquely shaped and **lighter rackets.** This way players can hit the ball faster. Plus, they have a better grip of their rackets giving them much better control than say a steel or aluminium racket. The same holds true for other racket games like squash, badminton, and racquetball games.

Players who use carbon fibre golf clubs enjoy a higher advantage in regard to comfort and speed. These same parameters apply in other club games like hockey, cricket, and polo.

Ski and Snowboard

As more competitors recognize the benefits, the demand for lighter, tougher, and stiffer **carbon fibre boards** is on the rise, setting the stage for remarkable progress and enhanced performance in these exhilarating sports.

These cutting-edge boards offer reduced weight without compromising durability, allowing riders to effortlessly navigate slopes while enjoying unmatched responsiveness and control.

Water Sports

From water polo to rowing, canoe-kayaking to water skiing, carbon fibre composites are transforming equipment. Achieve unmatched strength and lightweight design, resulting in faster, more efficient boats.

Carbon fibre is twice as strong as fibreglass, allowing builders to use less material while maintaining the same level of strength. With its hardness six times that of fibreglass, carbon fibre provides sturdy and rigid hulls, ensuring stability at high speeds.

Carbon Fibre
Industrial Applications

From equipment and systems for HCl synthesis, distillation, absorption and desorption of corrosive media through heat exchangers, pumps, columns, vessels and internals, to materials and products for sealing applications with excellent corrosion, temperature, oxidation, and mechanical resistance in the areas of:

- **Medical technology**
- **Robotics and automation technology**
- **Measuring technology and optics**
- **Machinery manufacture**
- **Sports & leisure**
- **Antiballistic technology**
- **Marine industry**
- **Civil engineering**

Sustainbility and Longevity

The life span of carbon fibre and carbon fibre composites is very long and they therefore increase the sustainability of the product they are used for, be it the windmills or the high-end cars. They are corrosion resistance and do not require maintenance which is why they are chosen in the first place for such applications. Due to their lightweighting properties they are often contributing to high energy efficiency.

Carbon Fibre Sustainability and Recycling

Scraps and cuttings that arise in the manufacture of Carbon Fibre Reinforced Plastic (CFRP). Such residues can be mechanically reworked and can be reused in other applications.

Reuse

Equally, at the end of the life cycle of CFRP components and products can potentially be reused. Like the production scrap, these materials can be mechanically reconditioned and then used as a starting product for new components.

Examples are the processing of thermoplastic CFRP into injection molding granulate, and the processing of non-impregnated, dry fibre residues into new products.

Recycling

If further use is not possible the residual materials can be recycled.

Depending on the economic viability solvolysis is preferred, in which the fibres and the matrix are separated by a solvent and are available again as starting products for new CFRP components at the end of the process. If solvolysis is technically or economically not feasible, CFRP residues can be pyrolyzed. The valuable carbon fibres can be recovered through pyrolysis, while the matrix is used energetically in the process.

Contribution of Carbon Fibers to a More Sustainable World

A more sustainable world, where green electricity, emission-free mobility, and resource-saving constructions become a reality.

Rotor Blades for Wind Turbines:
- Blade length >100 m
- Nominal power up to 15 MW

Hydrogen Pressure Vessels:
- Pressure around 700 bar
- Mobile with zero emission

Carbon fibre armoring:
- Up to 80 % material saving
- 50 % CO2-Emission reduction

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