

MARKET REPORT 2022

THE GLOBAL MARKET FOR CARBON FIBERS AND CARBON COMPOSITES

Market Developments, Trends,
Forecasts and Challenges
– freely accessible short version –



SHORT
VERSION

Michael Sauer & Denny Schüppel

TABLE OF CONTENTS

1 General information.....	5
2 Carbon fiber: Global market overview	8
2.1 Global carbon fiber demand	8

**Contents of the extended version:
(exclusive for members of Composites United;
available for purchase by non-members)**

1 General information	5
2 Carbon fiber: Global market overview	8
2.1 Global carbon fiber demand.....	8
2.2 CF production capacity by manufacturer.....	13
2.3 Market concentration by production capacity.....	25
2.4 Production capacity by manufacturer: Development.....	27
2.5 Production capacity by filament count (K-number).....	31
2.6 Production capacity by region.....	34
3 Carbon Composites: Global market overview	38
3.1 Overview of the carbon composites market.....	41
3.2 Overview of the ceramic composites market.....	46
4 Summary and Outlook	49
4.1 Technology.....	49
4.2 Overview - Market Data.....	54
5 Bibliography	56

About Composites United e.V.

Composites United e. V. (CU) is one of the largest networks for fiber-based, multi-material lightweight design. Around 350 members have combined forces in this high-performance industry and research association to jointly develop lightweight engineering solutions of the future. Several regional clusters and specialist networks support the association`s activities in the DACH-region, as well as international representative offices in Japan, South Korea, China and India.

Composites United e.V. (CU) was created with effect from January 1 2019, from the two existing associations Carbon Composites e.V. and CFK Valley e.V. The headquarter is located in Berlin, but CU also has offices in Augsburg and Stade, as well as local representatives in numerous other locations. Further information on the activities of Composites United can be found at:



www.composites-united.com.

The Authors

Michael Sauer studied materials science at the University of Augsburg. After working at OSRAM AG and Premium Aerotec AG, he currently works as a scientific associate and project manager at Fraunhofer IGCV. He is currently working on a PhD in the field of carbon fiber recycling at the Technical University of Munich. Since 2017, he has also been active for Composites United in the Market Report department and has been the lead author of the annual market report since 2018.



Denny Schüppel studied mechanical engineering at TU Dresden and INSA Lyon. He worked at Fraunhofer IKTS, Cetex and Daimler AG

before joining Composites United in 2014. There, Denny Schüppel was in charge of project and knowledge management until 2019, among other things, and took over the network management of Ceramic Composites in 2019. Since then, he has also been co-author of this market report.

Important Note: Published short report version

Composites United e. V. expressly points out that this version of the Composites Market Report 2022 is a published shortened version. It can be quoted without restrictions.

A corresponding non-published extended version with a significantly larger overall scope is available from Composites United e.V. This extended version cannot be quoted without restrictions and is not released for publication by or distribution to third parties. The extended version is personalized and its basic use is reserved for the members of the Composites United for their internal use as a source of information. However, the extended version may also be purchased by third parties. Composites United e.V. reserves the right to release and/or publish it in individual cases.

For further questions, please contact:

market.report@composites-united.com

1 General information

Now in its thirteenth edition, the Composites Market Report of Composites United e. V. (CU) - The global market for carbon fibers and carbon composites - has been published annually since 2010 as an overview of current market developments in the field of carbon fibers (CF) and carbon composites (CC). For this report, information and data were occasionally provided by CU-members or collected by the CU itself, as well as verified and supplemented with the help of external market data.

Composites United e.V. explicitly points out that due to the complex and dynamic market development with individually differing data sources, the information shown here can never provide a completely closed overview of the real market conditions. The aim of Composites United e.V. is to provide an insight into current trends and overarching development-directions based on the shown sources. All information is non-binding and without liability, so that no claims can be made against Composites United e.V. for the use of the data, e.g. in the commercial sense.

It should also be noted that direct comparisons with previous versions of this market report or external market reports must take into account the explained framework conditions and any assumptions applicable in the individual case. In the interest of the best possible comparability, the CU tries to achieve a uniform and, as far as possible, consistent presentation in its publications on the basis of the given data. Although new content is continuously added, the structure is kept as consistent as possible for this purpose.

Important note on current crisis situations with global impact

The exact extent and impact of current crisis situations on the global carbon fiber market are subject to a persistently volatile data basis at the current level. The very dynamic developments in combination with economic and political measures that are difficult to predict in the short term further complicate a reliable forecast. This applies in particular with regard to the forecasts shown for specific areas. In this respect, it must be pointed out that the illustrations, diagrams and data shown can only represent one possible scenario of future developments. The exact manifestation of the underlying influencing variables must be further investigated in future studies. However, it is of course a clear objective of the CU to obtain the most robust information possible on the basis of the given data. We are at your disposal for an optimal evaluation and use of the data:

market.report@composites-united.com

With regard to current crisis situations with a global impact, the focus is on various events. First of all, there are the tense trade relations between the USA, China and Europe in various aspects, as well as trade tariffs in effect in each case. Furthermore, the global supply chain is still affected by ongoing regulations and direct consequences in the context of the SARS-CoV-II pandemic. In the reporting period, the crisis situation in Ukraine is also in the focus of attention. Overall, the global CF market environment proved to be very resilient in the year under review and, after the corresponding distortions of the previous reporting years, again showed clear growth potential. However, the individual effects of such framework conditions are extremely complex and are consolidated in this report in an overarching context. We are at your disposal for a suitable interpretation of individual factors.

In order to enable a better comparability with other market reports and to assure a higher plausibility of the shown information, the two most common growth rate factors and their calculations are summarized in the following:

Averaged Annual Growth Rate (AAGR) = Arithmetic Mean Return (AMR) = Arithmetic average of n annual growth rates (AGR):

$$AAGR(t_1, t_n) = \frac{AGR(t_1) + AGR(t_2) + \dots + AGR(t_n)}{n} = \frac{1}{n} \sum_{i=1}^n AGR(t_i)$$

Compound Annual Growth Rate (CAGR) = annual growth rate over n years assuming a proportionally constant growth:

$$CAGR(t_1, t_n) = \left(\frac{A(t_n)}{A(t_1)} \right)^{\frac{1}{n}} - 1 \quad \leftrightarrow \quad A(t_n) = A(t_1)(1 + CAGR)^n$$

2 Carbon fiber: Global market overview

2.1 Global carbon fiber demand

For the reporting year 2022, a global average carbon fiber demand of about 107,000 t was determined. For an observation horizon since 2010, this corresponds to an average annual growth rate of +10.30% (CAGR 2010-2022). For a shorter development period over the past five years, the growth rate is +8.40 % (CAGR 2018-2022). In retrospect, the influence of the SARS-CoV-2 crisis situation is evident. After a significant decline, there has since been a renewed pronounced upswing. The resulting CAGR growth rates are currently back in the pre-crisis range. However, it should be explicitly noted that this is a snapshot of the given market situation. Any catch-up effects after the restoration of some supply chains and distribution channels can hardly be filtered out from the actual market development. In addition, further global crisis situations have arisen during the observation period that could potentially lead to distortions in the CF market environment. Of particular importance here is the crisis-related influence on global trading networks, up to and including far-reaching supply bottlenecks, especially in the high-tech supply sector, as well as in trade with basic raw materials. In addition, the dynamic developments on the global energy markets are currently a potentially central factor of influence. In this context, the comparatively high concentration of fiber manufacturers' production sites in a relatively small number of locations and their local framework conditions must be taken into account. In addition, the now distinct unique selling points of the material group along wide-ranging fields of application strengthen the market structure. On the material and technology side, long-term demand markets are accompanied by new product innovations, which continuously generate further growth impulses.

Not only the recording of the current market situation, but in particular the prediction of further development is thus fundamentally subject to challenging framework conditions. In the sense of the best possible delimitation with the aim of an overarching assessment, two scenarios are further elaborated in relation to Figure 1:

- **Scenario 1** is based on a demand estimate along currently available production quantities. This means that it is assumed in a simplified way that all the fibers requested can also be produced. In this respect, the expansion situation of the CF manufacturers' production capacity is indirectly reflected here. Expansion measures that are about to be completed are already taken into account. In the authors' view, this estimate is quite suitable for estimating an expected "lower production limit", even if not all enquiries can always be met in real terms. Expansion measures in the CF market environment represent long-term and capital-intensive projects, so that it is only possible to react to real market demand with a noticeable delay, or this is even assumed in advance expectations. On the other hand, these extended investment periods result in improved traceability and data collection, which can be used in the sense of this scenario.
- **Scenario 2** is based on a continued market development with a constant annual growth rate (CAGR 2010-2022) compared to the base year (2022). For a use of the shorter observation horizon along CAGR 2018-2022, a slightly lower development would be given in the colored area (cf. Fig. 1).

Of course, the definition of numerous other scenarios would be possible as an alternative. The present selection represents different perspectives, but

obviously cannot determine them with final certainty. Future short-term upswings or setbacks in market development, caused for example by external impulses, cannot be anticipated. However, these can lead to significant effects in the concentrated CF market as a whole, as can be seen around 2020, for example. In addition to global influencing factors, the individual development of a single large market participant or location can already cause significant effects in the overall global market. Such a distortion is possible both in the sense of an increase and a downturn. Especially on the basis of the characteristically high innovation power of the fiber composite industry, a disruptive leap innovation or the market entry of additional application areas is also favored. In this respect, the two development forecasts shown are not necessarily to be understood as upper and lower limit lines, but represent two independent variants of numerous possible trajectories.

In general, the overall market situation is subject to numerous complex interrelationships. At the same time, however, central market characteristics can be identified. Particularly noteworthy at this point is the high market concentration, i.e. the representation of large market shares by a relatively small number of market players. In addition, a clear development trend of CF manufacturers towards vertical integration of their value chains can be seen. Especially in the area of the production of adapted PAN fibers as the key feedstock for carbon fiber production, most producers have their own extensive competences and in many cases also plant capacities. Often these are even located in the immediate local proximity of the downstream CF production. Switching between the production of different fiber variants at short notice is considerably difficult due to plant-side and technical restrictions, and usually involves extensive adjustments. Instead, production lines are usually designed specifically for one or a few product options. In many cases, this results in an influential market position due to far-reaching unique selling propositions. On the other hand, this also results in an exposed situation. Due to the strongly interlocked supply chains and product systems, an intrinsic amplification effect can result in the event of a single

irregularity. In the meantime, however, producers are increasingly reacting to this situation and have, for example, extended their internal process chains along the downstream stages and in some cases even into the area of their own component production. In these value-added fields respectively on the basis of the processing steps located here, there is significantly greater potential in the direction of horizontal diversification of the product portfolio. Thus, greater flexibility can be achieved in the event of differentiated customer needs or market changes. In the context of global trade conflicts, including sanctions and transport bottlenecks, this also opens up significantly improved security of supply and thus independence of the entire company's own manufacturing capacities. Carbon fibers are now extensively established as an independent class of materials and have successfully overcome their initial status as a high-performance solution for niche applications. As a result of the unique material characteristics, there are increasingly longer-term planning horizons for the industry in various contexts, which have a stabilizing effect on the overall market.

The trend shown in Figure 1, especially with regard to future forecasts, is subject to a large number of influencing variables. In the sense of an assessment that is as robust as possible, the determination is made in particular taking into account given production capacities as well as local utilization rates. Compared to the direct demand situation, these can be used to provide a much higher quality of information. Of course, this represents a decisive framework condition, including various assumptions, which also only characterize a possible perspective of the market development. An important aspect here is the assumption that product quantities demanded are always served on the production side. Particularly in the course of the market's recovery reaction, as well as with regard to the wide-ranging product portfolio with a high degree of specialization, together with the product-related design of relevant plant technology, this point is likely to result in a scattering factor that needs to be taken into account.

In summary, the overall picture at the time of reporting is promising. Despite numerous and far-reaching potential challenges, the global carbon fiber industry is demonstrating a high degree of resilience. Although the global economic situation in various areas can be regarded as quite tense, both the current development of demand and the further investment behavior of manufacturers point to continued growth. For the coming years, the longer-term effects of the market setback in 2020 and a more detailed distinction between any catch-up effects and real economic growth will be of particular interest. In addition, delivery problems for specific carbon-fiber products were observed in several cases during the reporting period. This is not only due to bottlenecks in the area of basic raw materials, but more often also to a presumed shortfall in specific production capacities. In this context, not only the general expansion situation, but also the underlying detailed structure of the product portfolios is of specific relevance. Overall, a clear recovery of the CF market as a whole can be seen at the time of reporting, despite volatile crisis situations.

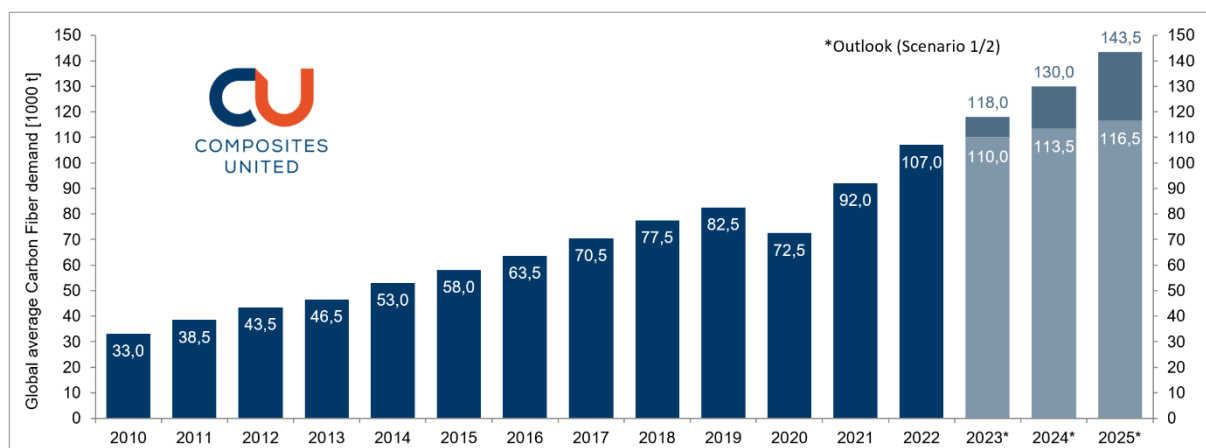


Figure 1: Development of the global average CF demand from 2010 to 2025 (*Estimations; 03/2023)

MARKET REPORT 2022
THE GLOBAL MARKET FOR CARBON
FIBERS AND CARBON COMPOSITES

Michael Sauer (Author) & Denny Schüppel (Co-Author)

Composites United e.V.

Oranienburger Straße 45

10117 Berlin | Germany

www.composites-united.com

Status: March 2023