Carbon and Graphite in Renewable Energy

Wind Power

Overview

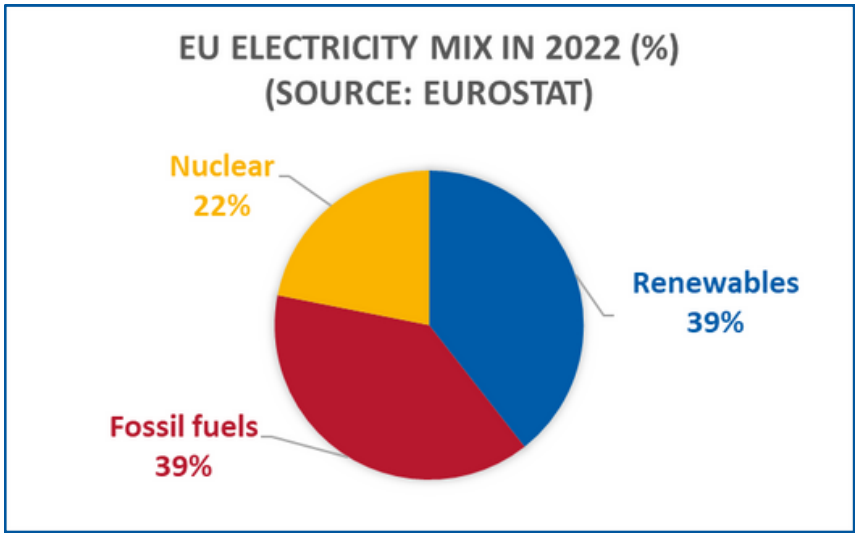
Wind power, a key component in the global shift to renewable energy, is seeing significant growth, especially in Europe. In 2021, wind energy contributed 37% of the EU's total renewable electricity and 15% of its overall electricity. The EU's offshore renewable energy strategy, recognizing the potential of its five sea basins for offshore wind and ocean energy, is driving ambitious targets including 60 GW of offshore wind by 2030 and 300 GW by 2050. The role of carbon and graphite in wind energy generation is crucial in achieving these objectives, underpinned by the revised Regulation on Trans-European Energy Networks (TEN-E) that became operational in June 2022, supporting these strategic ambitions.

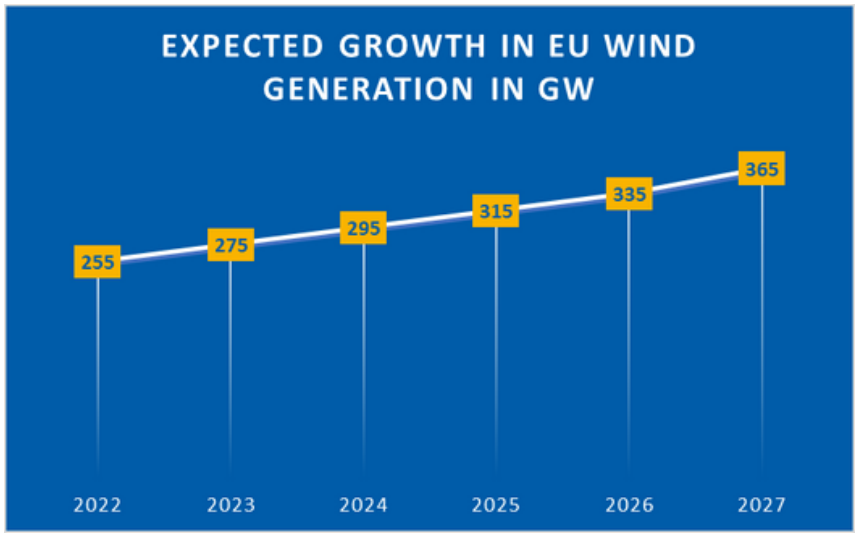
Renewable Energy Forecasts

In the decades to come, the world's renewable energy sector will be growing at an unprecedented rate. Forecasts suggest a significant increase in the adoption of renewable energy sources, with wind power playing a major role in this transition. The International Energy Agency (IEA)* projects that renewable energy will account for almost 95% of the increase in global power capacity through 2026, with wind and solar PV leading the charge.

This trend is driven by technological advancements, decreasing costs, and growing environmental concerns, emphasizing a shift towards more sustainable and cleaner energy sources. Graphite's role in this expansion is becoming increasingly vital, as it is a key component in wind turbine technology and energy storage solutions.

* The Role of Critical Minerals in Clean Energy Transitions, Flagship Report, May 2021





Source: Wind Europe 2023

ECGA
European Advanced Carbon and Graphite Materials Association
European Advanced Carbon and Graphite Materials Association
Avenue de Tervueren 168, box 11 | 1150 Brussels - Belgium
Phone: +32 477 225 303 | E-mail: graphit@ecga.net | Website: ecga.net

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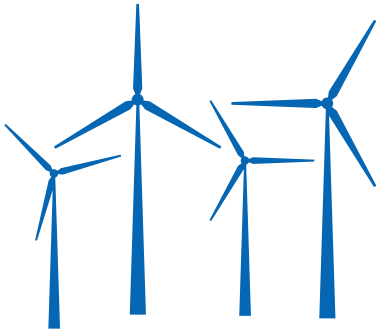
Materials Composition in Wind Turbines



Wind turbines, key components in renewable energy production, vary in their material composition based on make and model. Reports indicate that

- **Steel** constitutes the largest portion, making up approximately 66 - 79% of a turbine's total mass.
- This is followed by **fiberglass or carbon fiber composites**, which account for 11 - 16%, playing a crucial role in blade construction.
- Other significant materials include **iron or cast iron** 5 - 17%, used in various structural components, **copper** 1%, essential for electrical conduction, and **aluminum**, which may constitute up to 2% of the turbine.

Carbon and Graphite in Wind Turbine

Carbon and graphite are integral to wind turbine construction due to their superior strength, stiffness, and low density, vital for producing efficient rotor blades.

Carbon Fiber Composites in Rotor Blades:

- Carbon fiber composites are increasingly used in wind turbines, particularly larger offshore models, to produce longer and more efficient blades.
- Blades with carbon fiber are about 25% lighter than traditional fiberglass blades, enabling the construction of longer blades that capture more energy in low-wind conditions.

Trends in Turbine Design:

- The trend towards larger wind turbines, with rotor diameters exceeding 100 meters, is driven by the pursuit of higher energy capture and efficiency.
- The role of carbon and graphite in these large-scale constructions is essential for balancing the weight and durability of the blades.

Carbon in Wind Turbine Functionality

Carbon also plays a critical role in the functionality of wind turbines.

Carbon Brushes in Generators:

- Carbon brushes are used in double-fed induction generators (DFIG) for efficient power transmission. These brushes are essential for signal transfer, power transfer, blade control and protecting turbines from lightning strikes.
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Recycling in Wind Energy

Recycling of Wind Turbine Components:

- The average lifespan of a wind turbine is 20 to 30 years. Post-service, their components are nearly 100% recyclable.
- Concrete from turbine foundations is reused in new construction projects.
- Steel and aluminum parts are processed in foundries or steelworks for reuse.
- Fiberglass from turbine blades finds new life in various products, including fire hydrants.
- Carbon fiber is commonly reclaimed from end-of-life parts via pyrolysis, burning off cured resin, or solvolysis, dissolving it. This recycling aligns with the industry's sustainability goals.
- Used in various applications, including shaft grounding and electrical generation, carbon-metal brushes, which integrate metals like iron or copper into the carbon-graphite matrix, are critical. Some generators have collectors to isolate brush dust, or slip rings equipped with brush-dust trays, allowing for the reprocessing of this material.

Sustainability in Wind Energy

Graphite in Power Storage Solutions:

- In periods with no wind, lithium-ion batteries, with graphite as the anode material, are key for energy storage.
- The World Bank projects a **demand of 4.5 million tonnes of graphite per year by 2050** for low-carbon energy storage technologies, a 500% increase from 2018 levels and a 3018% increase over total graphite produced in 2019.
- Graphite's role in the battery industry is expected to drive the largest sector of demand within the graphite supply chain.

The role of carbon and graphite in wind power is increasingly significant, not only in turbine construction and functionality but also in sustainability and energy storage solutions. As the wind energy sector expands, driven by the EU's ambitious targets, graphite will continue to be a critical material in harnessing and optimizing renewable energy resources.

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