SUSTAINABILITY
IN THE WIND INDUSTRY

MEGAVIND

Accelerating decarbonization and circularity in the wind industry

THERE IS MOUNTING EVIDENCE that climate change related impacts are becoming more visible and occurring more frequently, with increasingly destructive force. This further accelerates the demand for society to reduce environmental impacts across sectors. A sustainable transition is required to move to new manufacturing methods with reduced carbon emissions and minimized use of virgin raw materials, with production powered by renewable energy sources. Wind power is expected to be one of the important energy conversion technologies contributing to this transition. Wind turbines for power production have undergone tremendous innovation and development. Today the energy used for manufacturing a wind turbine is paid back in less than a year. Nonetheless, the wind industry aims to further reduce the environmental impact from wind turbine manufacturing, operation and end-of-life. The goal is to increase climate performance and reduce use of virgin raw materials by keeping materials in use within a circular economy. This leaflet introduces the wind power industry's contribution to a sustainable transition, while also shedding light onto challenges the industry seeks to address in coming years, in collaboration with other sectors and the full wind value chain. The sustainability transition for wind power will benefit several other industries, including hard-to-abate sectors. Taking a leading position in decarbonization and circularity requires continued research and innovation to support the journey.

Research and Innovation Recommendations

R&I of material substitution in wind turbines, to increase recycled content, to minimise environmental impacts and to enable recycling of waste streams.

This includes reducing environmental impact by developing alternative materials to minimise use of virgin raw material and make separation and recycling easier. Research into assessment of environmental impacts of materials to avoid toxic or scarce materials is also needed.

R&I to create a market for recycling manufacturing waste and end-of-use wind turbines, including efficient recycling processes and new products that incorporate recycled materials.

A fact-based approach should be taken, and recycling solutions should be environmentally sustainable, cost-efficient and capable of handling large volumes of waste on a global scale. This includes developing facilities and equipment to process the waste streams as well as supporting the development of products/industries that incorporate recycled materials.

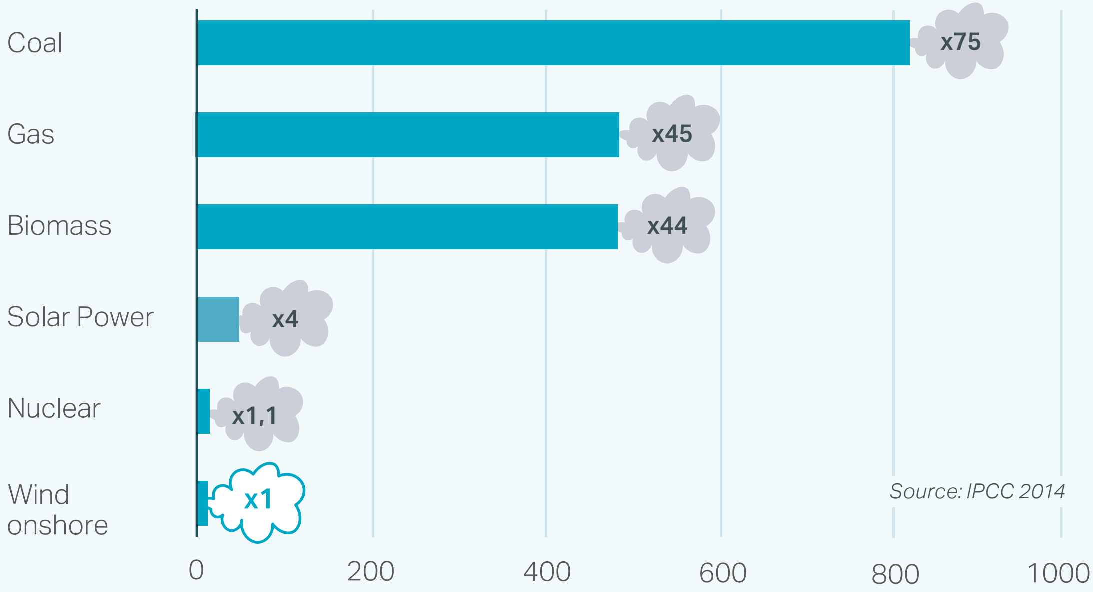
R&I to reduce CO2 emissions from the use of steel in wind energy technology.

This includes optimization of design to use less steel and the development of more sustainable methods for manufacturing wind turbine substructure steel components.

R&I to extend the operational lifetime of wind turbines.

This includes new designs, materials and maintenance programs. This also includes R&I into leading edge protection for blades as well as service and maintenance solutions and new monitoring systems for turbines. Furthermore, digitalisation and AI have the potential of increasing the intelligence of the wind turbine and e.g., through pre-emptive actions reducing the wear and tear from surroundings.

Wind has the lowest carbon footprint among energy sources

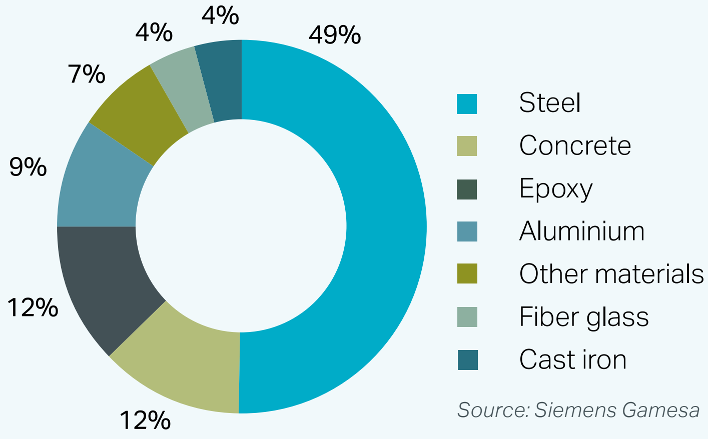


Lifecycle CO2e emission (Kg CO2e/MWh)

The carbon footprint of wind energy is 4 times lower than solar PV and 75 times lower than coal.[1]

The power sector accounts for around 40% of global CO2 emissions.[2] Around 60% of the electricity generation is produced using coal as energy source and around 20% from gas.[3] The path to net zero emissions requires significant decarbonization of the power sector. Transitioning to wind power is one of the most effective means to reduce GHG emissions from electricity generation.

49% of the carbon impact of wind energy is related to steel

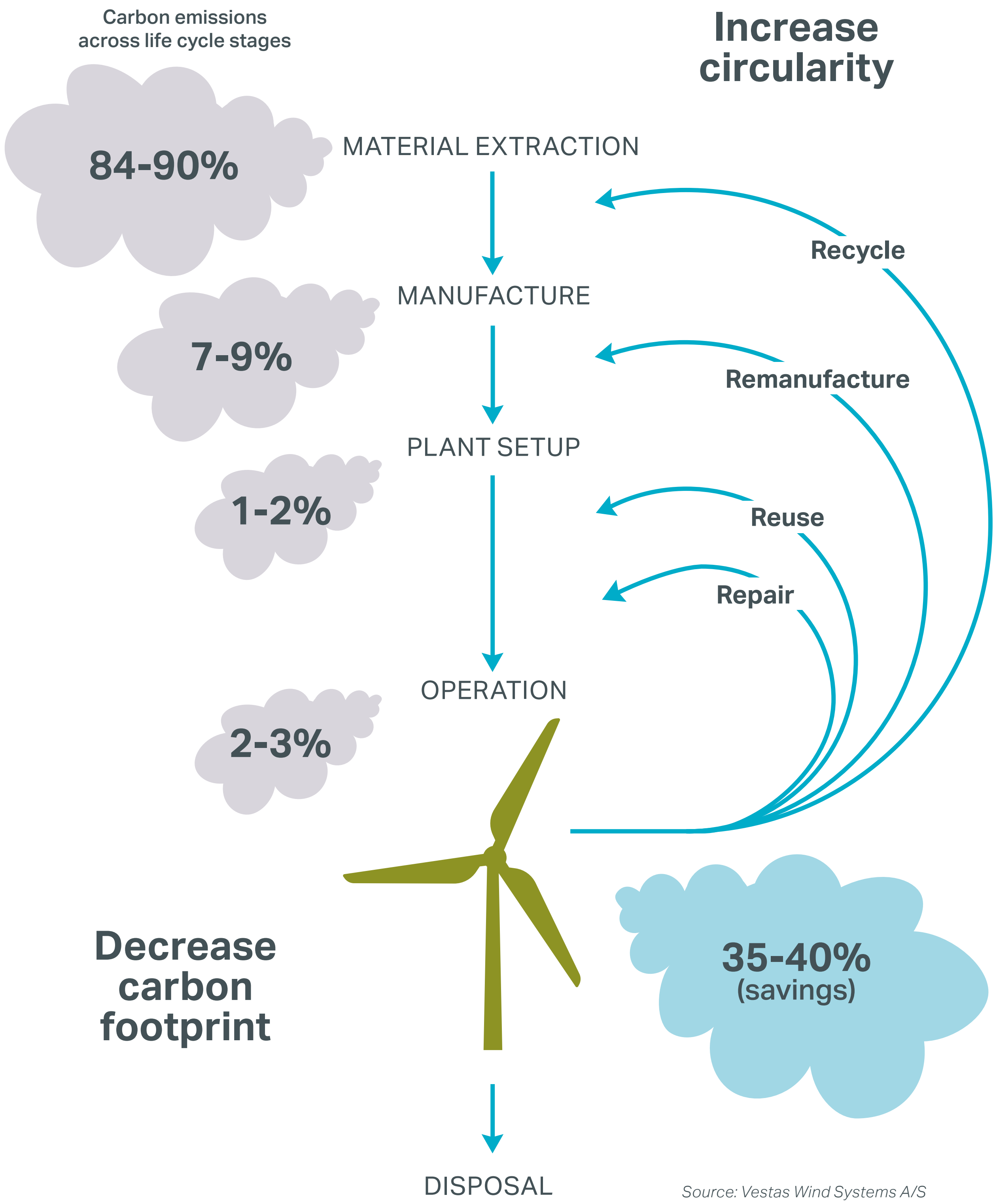


Global warming contribution per material group in the wind power plant (CO2eq)

The steel industry is accountable for about 7-9% of the CO2 emissions globally.[4] **Wind power is key to decarbonizing the steel industry to reach net zero by 2050.**

The wind industry is partnering with the steel industry to accelerate the decarbonization of steel manufacturing through projects on hydrogen generated from electrolysis of water and electric arc furnaces powered by renewable energy. The wind industry also needs to optimize the use of steel by design and develop more sustainable methods for manufacturing wind turbine substructure steel components. Finally, use of secondary steel must be pushed to higher numbers than the actual 80%[5] that are recycled globally today.
Partnerships: SteelZero, HYBRIT, First Movers Coalition, SALCOS and others.

DECARBONIZATION AND CIRCULARITY



Source: Vestas Wind Systems A/S

To reduce the carbon emissions in the lifecycle of a wind turbine, focus is on greenifying the energy in the supply chain by increasing energy efficiency and using renewable energy sources. In parallel, the wind industry can increase circularity by maintaining materials and prolonging their lifetime, thus reducing the volume of materials flowing in and out of the economy.

84-90% of the carbon footprint of a wind turbine comes from material extraction

Waste from end-of-life wind turbines are mainly steel, metals, composites and electronic components. Extraction of the materials used for a wind turbine counts for 84-90% of the carbon footprint of the total lifetime.

The industry needs to substitute materials that are difficult to recycle and set targets for recycled content in the products.

We need support to develop new materials that are designed for circularity and to integrate materials that are based on recycled materials into wind turbines. This will make circular materials attractive to other industries as well and support recycling of waste streams from manufacturing processes. It will be necessary to develop governance for circular materials and how toxicity and scarcity are evaluated. The ambition is that virgin materials will only be used to replenish existing material streams in the future with a larger extent based on recycled material.

85-90% of a wind turbine is already recyclable

Wind turbine blades remain the biggest challenge to recycle; fully recyclable in theory, but not recycled in practice.

Waste generated when manufacturing wind turbine blades and at the end-of-use requires cost-efficient recycling solutions capable of handling large volumes. These waste streams have different characteristics, however, they could benefit from combined solutions. A value chain for recycled materials must be established. Waste streams, recycling technologies, use cases and recycled material off-takers must be connected to secure a demand for the outputs from recycling processes. An increased focus on the development of markets, value chains, recycling technologies, and synergies and collaboration across industrial sectors is therefore recommended. Examples of ongoing projects with cross-disciplinary partnership: DecomBlades (DK), Zebra (FR), SUSWIND (UK).

85 times energy payback with 50% operational lifetime extension

Wind farms are energy neutral in less than a year and generate around 55 times more energy than consumed during their entire 20-year lifecycle.

Keeping wind turbines in operation has a significant positive impact on environmental performance. Extending the lifetime of a wind turbine increases its carbon emission savings; for instance, 50% life extension will provide close to 50% carbon emission savings per kWh delivered. The possible lifetime extension of a wind turbine relies on an assessment of the remaining life of its components. Design life can be increased beyond 20-25 years through research and innovation into implementation of new designs, materials and maintenance programs. Implementation of reliable condition monitoring systems, optimizing operation and maintenance, will in the future provide needed information about the remaining life of different components and hence possible life extension potential. An alternative to life extension is repowering, which in many cases provides even better energy payback and GHG emission savings. This applies for partial repowering where key components, e.g., blades and nacelle, are updated or upgraded. Full repowering is another option, where an old wind turbine is decommissioned and replaced by a new and more powerful wind turbine

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1) Schlömer S., T. Bruckner, et. al, 2014: Annex III: Technology-specific cost and performance parameters.
2) IEA, 2019, Greenhouse Gas Emissions from Energy Data Explorer.
3) IEA, 2019, World Energy Balances: Overview.
4) World Steel Association, Climate change and the production of iron and steel policy paper.
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