SIEMENS

Environmental Product Declaration

A clean energy solution – from cradle to grave

Offshore wind power plant employing SWT-4.0-130

siemens.com/wind

Assessing the performance of a wind power plant

The environmental impact of wind power

The world today faces the challenge of meeting growing demand for energy while reducing greenhouse gas emissions. One solution is to increase the contribution of renewable energy systems such as wind, sun, or biomass to the electricity mix. Siemens Wind Power is pioneering this approach by offering an extensive wind turbine portfolio that includes the SWT-4.0-130 geared turbine.

Siemens has performed a Life Cycle Assessment (LCA) of an offshore wind power plant employing SWT-4.0-130. The LCA evaluated the inputs, outputs, and potential environmental impacts that occur throughout the wind power plant lifecycle. It encompasses raw material extraction, materials processing, manufacturing, installation, operation and maintenance, and dismantling and end-of-life.

The results are presented in this Environmental Product Declaration (EPD) in order to communicate the impacts of our wind power plant to our stakeholders. All results are verified by internal reviews. The international ISO 14021 standard (Environmental labels and declarations – Self-declared environmental claims – Type II) is the basis for this EPD. The data presented has been derived from a full-scale LCA in accordance with ISO 14040.

Designed to deliver clean energy

Offshore wind power plant

Each wind power plant has specific site constraints that influence the choice of turbine, tower height, foundation size, and infrastructure.

This EPD is based on a full-scale LCA of an average European offshore wind power plant with 80 SWT-4.0-130 turbines installed. It includes wind turbine components such as a nacelle, rotor, and tower, as well as the foundation, cables to grid, and substation.

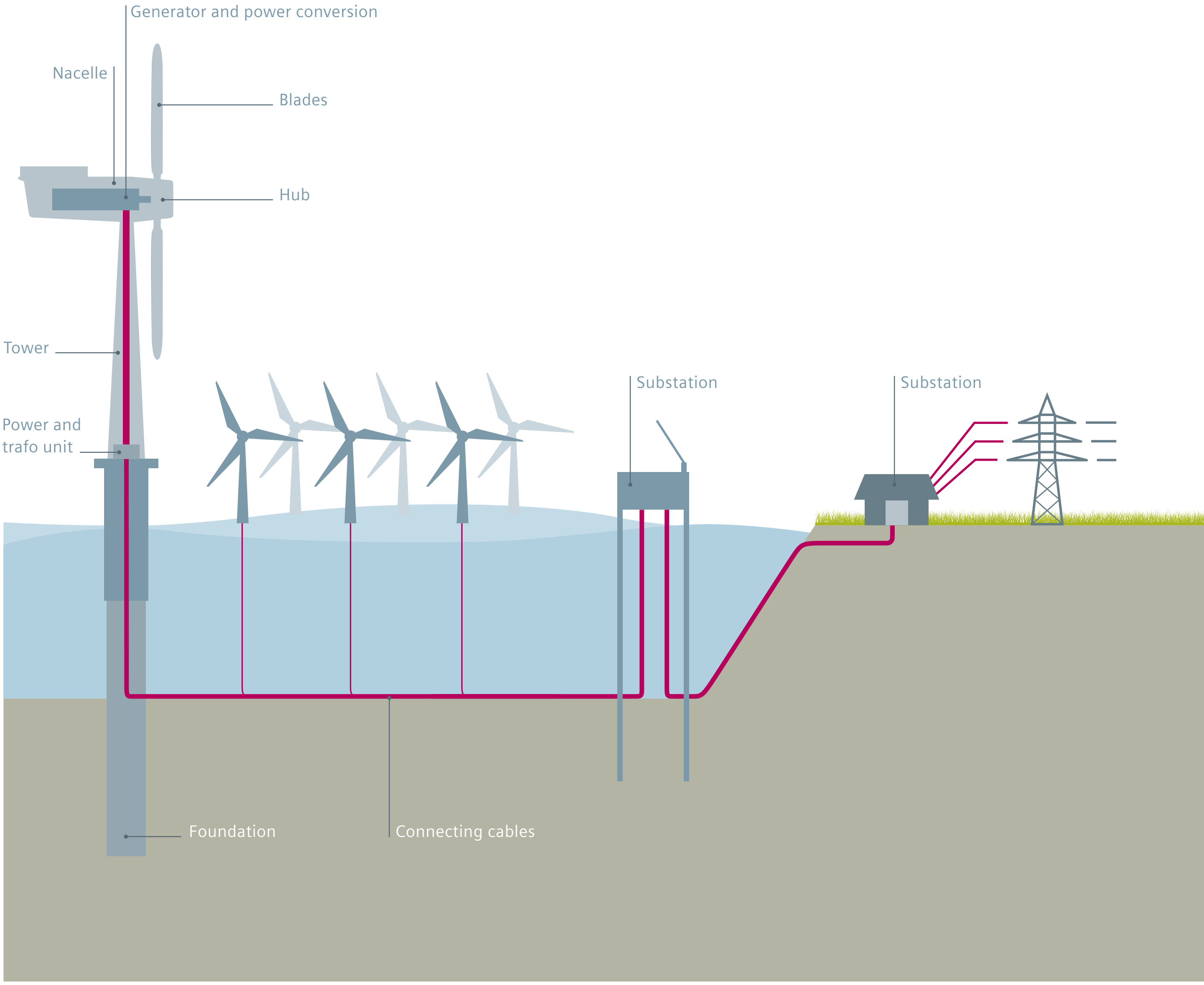
The functional unit for this LCA is defined as 1 kWh of electricity delivered to the grid.

The identified average wind speed is relative to the turbine IEC classification. Class I: 10 m/s for SWT-4.0-130.

Product and system description, including main components

Product and system description	Main characteristics
Turbine	SWT-4.0-130
Number of turbines in wind power plant	80
Expected lifetime	20 years
Expected average wind speed	10 m/s
Distance to grid	30 km/22 km
Annual energy production to grid per turbine (wake, availability, and electrical losses of 15% substracted)	Approx. 18,000 MWh
Estimated energy production of the wind power plant in 20 years	29,000,000 MWh
Nacelle	4.0 MW geared (steel, iron, copper)
Blades	63 m (fiberglass, epoxy)
Tower	68 m (steel)
Foundation	790 t (steel)
Substations	9,400 t (steel, concrete)

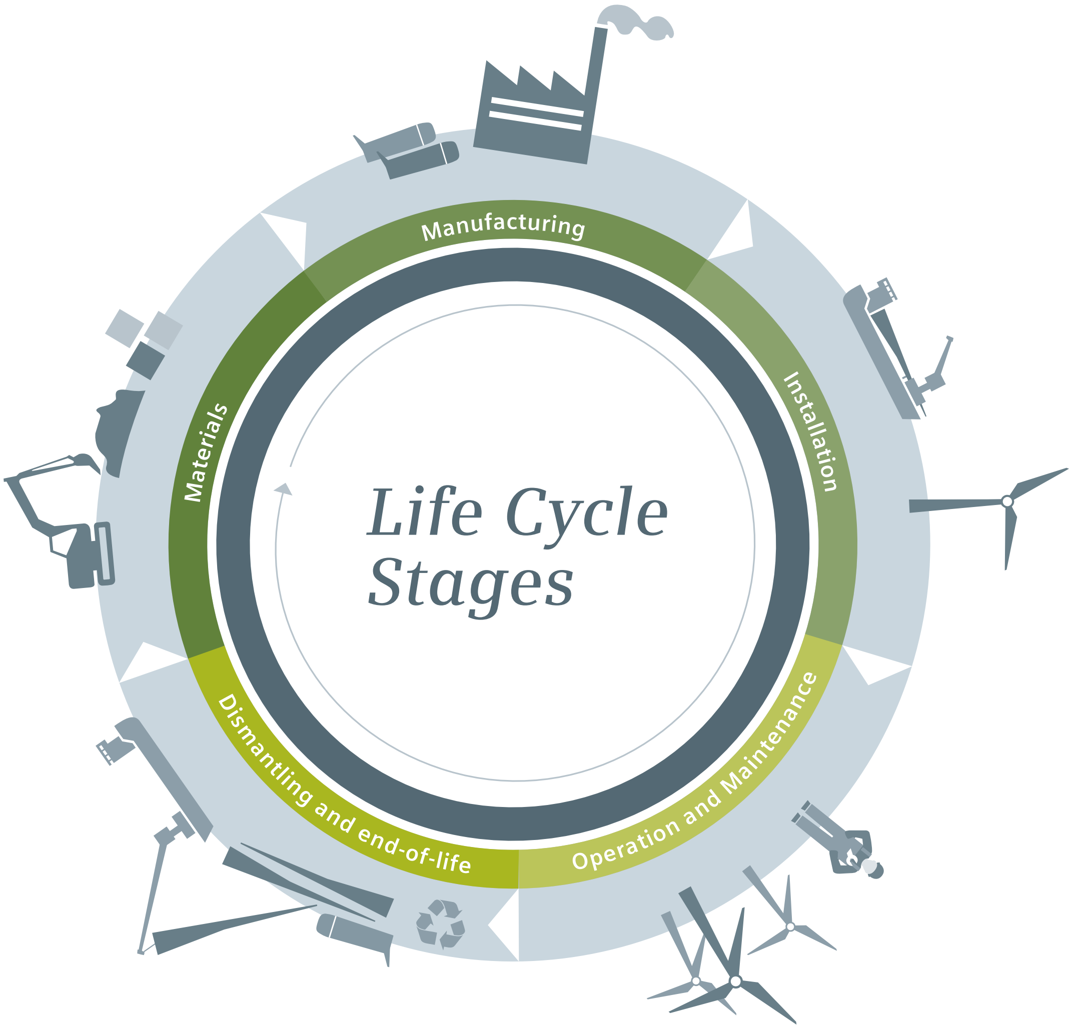
System boundaries for an offshore wind power plant



From cradle to grave

Life cycle of a wind power plant

The lifecycle has been divided into five main stages: Materials, Manufacturing of the main parts; Installation; Operation and Maintenance; Dismantling, Recycling, and Disposal at the end-of-life. Relevant transport activities and energy consumption were included in each life cycle stage.



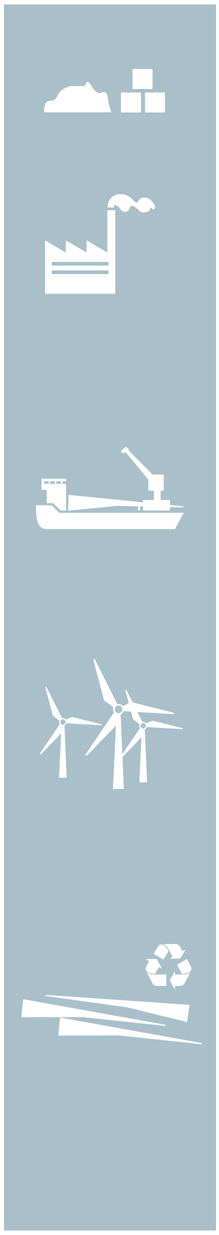
Materials
We identified the types and quantities of materials and energy that had to be extracted and consumed to produce the turbine components and the elements needed to connect the wind power plant to the grid.

Manufacturing
We collected data from Siemens' own production sites and from main suppliers. Consumption data for manufacturing as well as waste and subsequent treatment is based primarily on annual manufacturing data from European production sites. Transport of materials to the manufacturing site is included in the data.

Installation
Components, auxiliary resources, and workers are transported to the site during this stage. On-site installation includes preparing the site; erecting the turbines; and connecting the turbines to the grid. These installation activities result in the consumption of resources and production of waste. Associated data has been collected from actual on-site installations.

Operation and Maintenance
The structural design lifetime of a SWT-4.0-MW turbine is designed to last 20 years. We collected actual site data, including manpower, materials, and energy required for service and maintenance over the turbine's lifetime. Wake, availability, and electrical losses have been included in our assessment to define a realistic estimate of annual energy production delivered to the grid.

Dismantling and end-of-life
At the wind power plant's end-of-life the components will be disassembled and the materials transported and treated according to different waste management systems. For the turbine components, we assumed that recycling would apply to all recyclable materials; for example, metals. Recycling leads to the recovery of materials, which subsequently reduces primary material extraction. The rest of the materials are either thermally treated or disposed of in landfills. The end-of-life stage described here represents the current status of waste management options in Northern Europe.

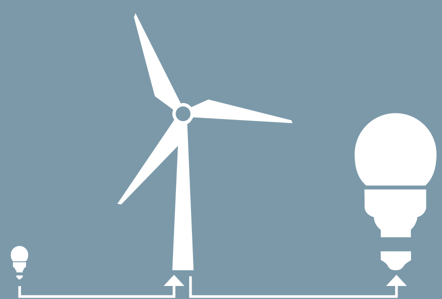


Environmental footprint

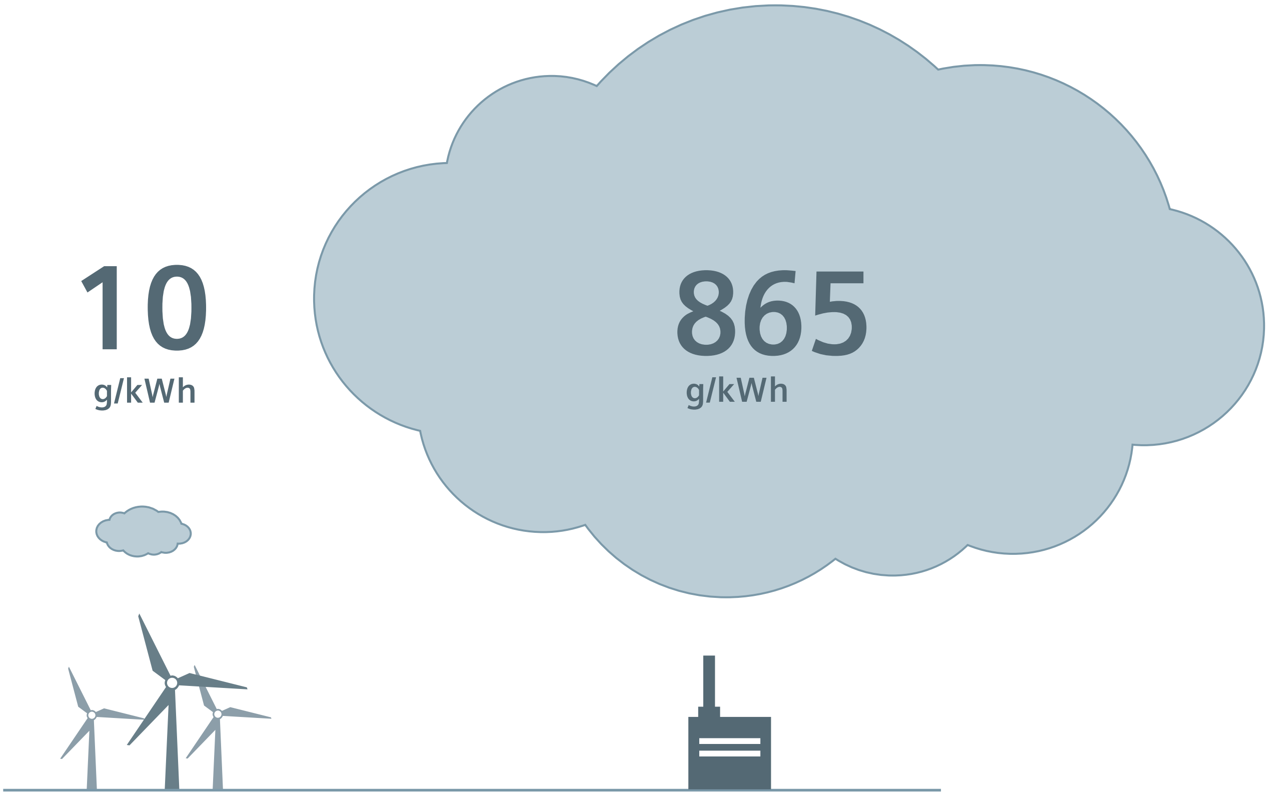
Low greenhouse gas emissions
Greenhouse gases such as CO_2 and methane contribute to global warming. Electricity produced by wind turbines contributes significantly less to global warming than electricity produced by fossil fuels. During its lifetime, the wind power plant emits less than 1,2% of the CO_2 emitted per kWh by an average power plant using fossil fuels.

What is "global warming"?
Global warming is an environmental impact caused by the increased concentration of greenhouse gases in the atmosphere. Each of these gases radiates different amounts of heat, which can be quantified in units of carbon called carbon dioxide-equivalent (CO_2eq). (IPCC ref)

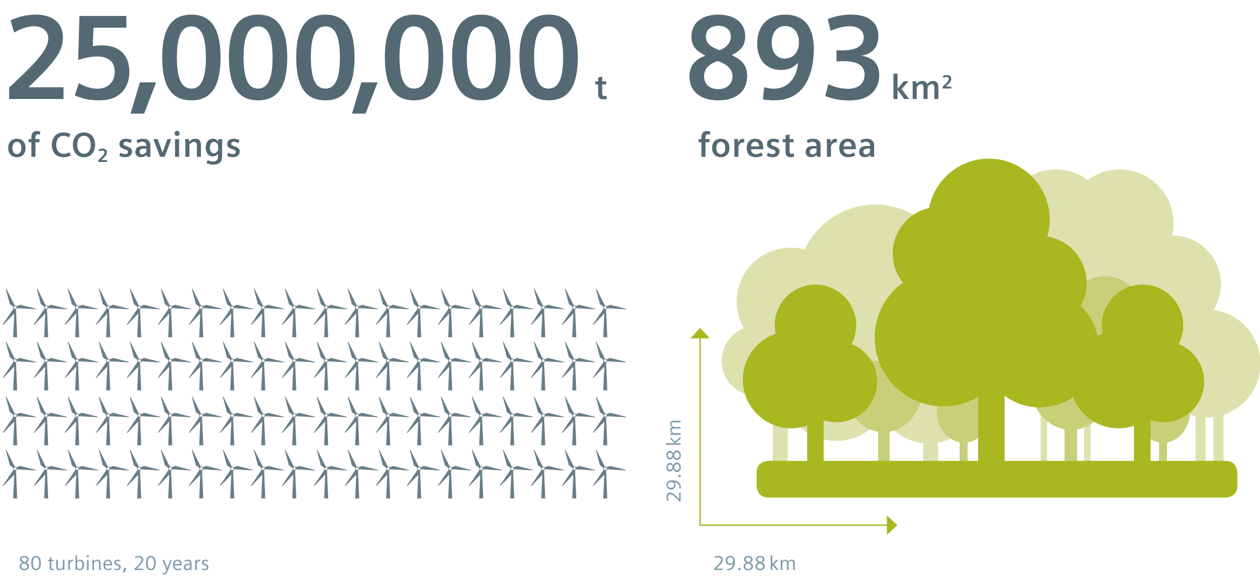
10.5 months energy payback time
The energy payback time for the wind power plant in this assessment is less than 10.5 months. That is the length of time the wind power plant has to operate in order to produce as much energy as it will consume during its entire lifecycle.



During its entire lifecycle the wind power plant produces 23 times more energy than it consumes.



CO_2 emissions from the wind power plant versus global fossil power production (IEA World Energy Outlook, 2012)

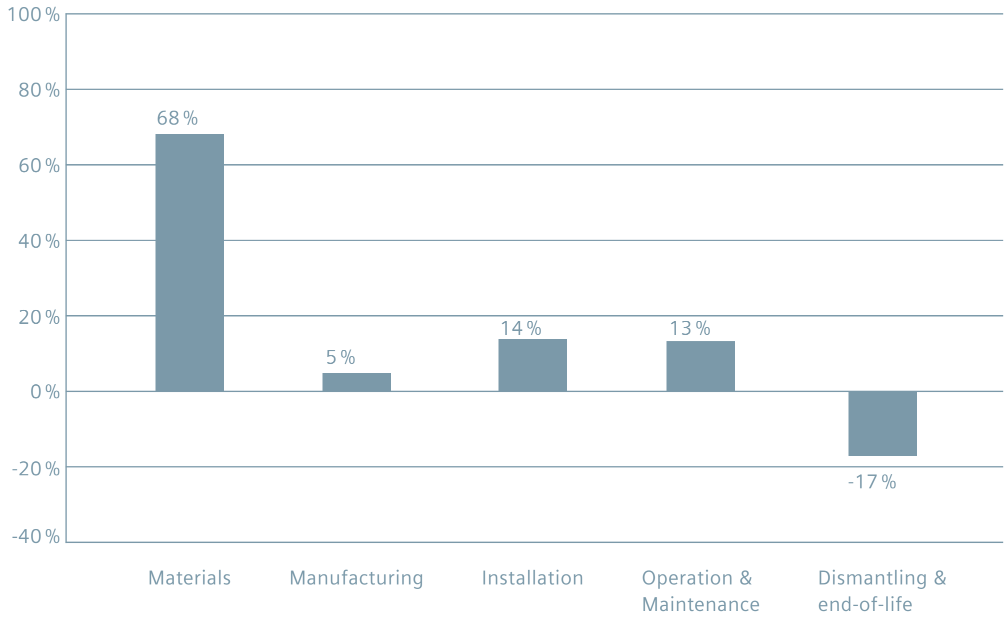


During its estimated lifetime the wind power plant produces 29,000,000 MWh and saves 25,000,000 tonnes of CO_2, which is equal to the amount of CO_2 absorbed by a forest with an area of 893 km² over 20 years.

Every stage counts

Contributions to global warming
To examine how much each stage of the wind power plant's life cycle contributes to global warming, we assessed their specific CO_2 emissions (figure below).

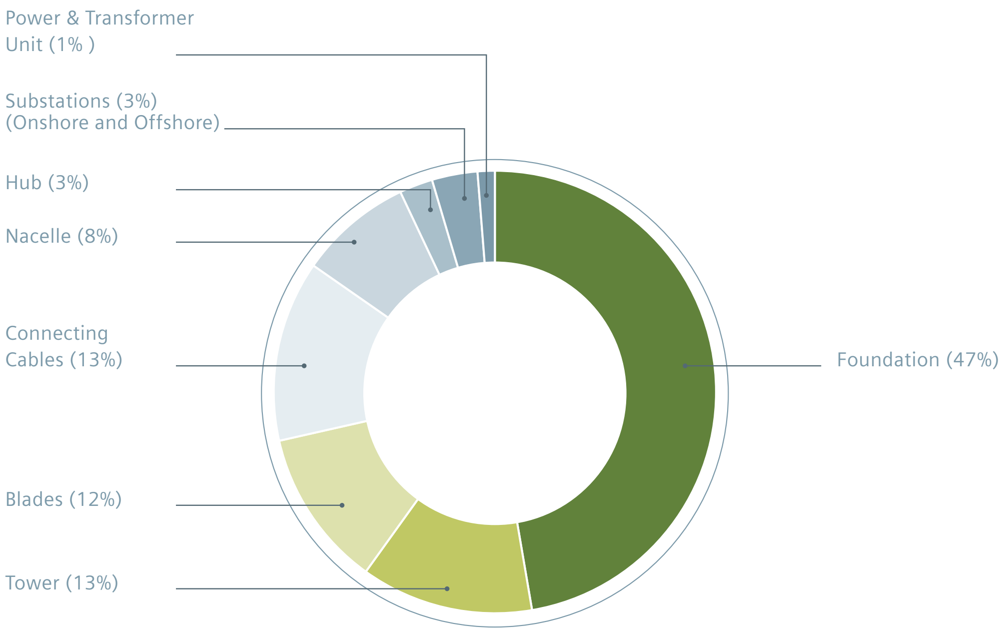
Percentage of global warming contribution from each life cycle stage ($g\ CO_2eq/kWh$)



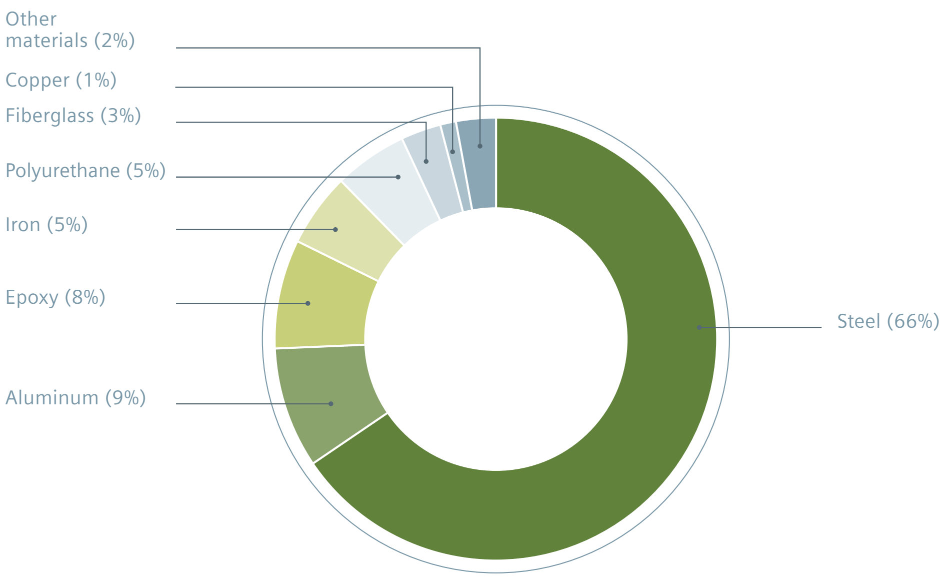
The main contributor to global warming is the Material stage (68%) because of emissions during material extraction. There are almost no emissions during wind power plant operation, and there is even an offset to emissions at end-of-life because so many of the materials are recyclable.

Component and material group contribution to CO_2eq emission
Each component and material group contributes to the total CO_2eq emissions of the wind power plant. Among the components, the turbine's tower and foundation contribute more than 50%, followed by blades, connecting cables and nacelle. In terms of material group contribution, steel has the highest impact on global warming, followed by aluminium and epoxy. The category with other materials consists of minerals, various plastics, chemicals, and wood.

Global warming contribution of main components in the wind power plant (CO_2eq)



Global warming contribution per material group in the wind power plant (CO_2eq)



Taking a holistic view

Assessing additional impact categories
Environmental sustainability also concerns problems other than climate change; for example, chemical pollution and resource depletion.

Electricity produced by a wind power plant can be assessed for different environmental impact categories. Such an assessment shows that focusing solely on reducing the greenhouse gas emissions raises the risk of increasing other environmental impacts. In this EPD we have chosen to present five different categories that are relevant to infrastructure projects.

The resource- and toxicity-related impacts were assessed using Impact 2002+v2.1 and USEtox v1.01.

Definitions of most relevant environmental impact categories

Global warming:
An environmental impact caused by the increased concentration of greenhouse gases in the atmosphere.

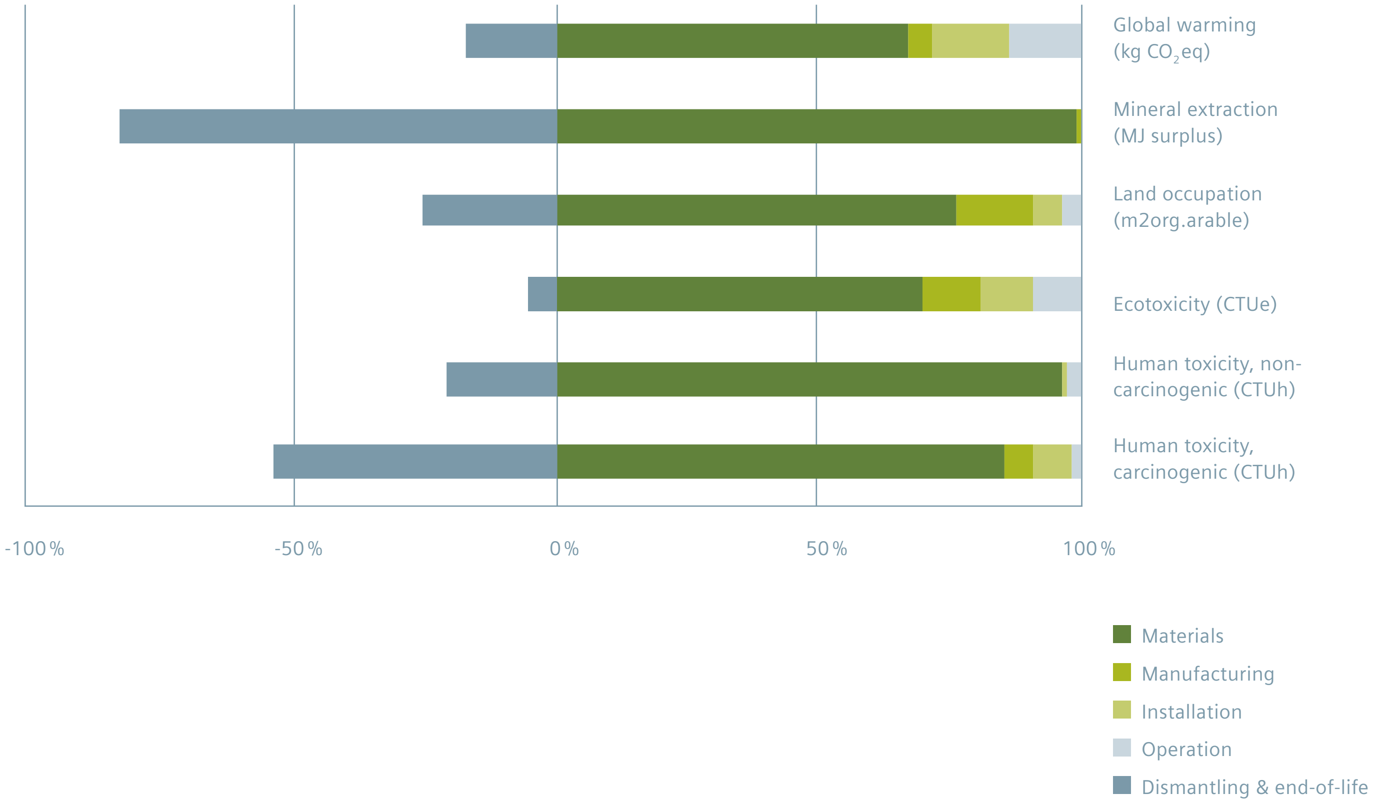
Mineral extraction:
The removal of minerals from the environment, which decreases their availability.

Land occupation:
The ecological damage to biodiversity resulting from land use. The damage is based on empirical observations of the number of plant and animal species affected per area type.

Ecotoxicity:
The toxic effects of natural or synthetic pollutants on flora and fauna.

Human toxicity:
The degree to which substances are toxic to humans.

Contribution of each Life Cycle Stage to the most relevant impact categories



Other environmental impacts

Planning a new wind power plant includes assessing the environmental impact of the installation and operation phases to minimize negative impacts. Often these assessments focus on birds, marine wildlife and visual impacts. How a wind power plant impacts its surroundings varies depending on its location and is not included in our LCA study.

End-of-life is not really the end

Recycling turbine materials
When wind turbines are dismantled, it is typically not because they have reached end-of-life but because they are replaced with larger turbines. Consequently, most dismantled turbines are refurbished and sold for installation elsewhere.

When disposing of wind turbines, recycling is the preferred solution. This not only prevents the materials from being sent to landfills, but also reduces the need for extracting of primary materials.

Options for recycling or disposal
The metals in the wind power plant components are to a great extent recycled at their end-of-life. The blades, which are made of epoxy and fiberglass, may be shredded and incinerated. The burning of epoxy generates energy, which can be recovered. The residues from fiberglass incineration can be used in other secondary applications e.g. for cement production. Increasing recyclability of the turbine components is high on our agenda and we continually participate in projects to support development of more recycling options.

Ready for the future

Siemens Wind Power strives to continually improve wind turbine performance by including environmental requirements in our design phase. We focus on increasing the annual energy output of the turbines and improving the material efficiency of their components.

Our improvement projects also focus on optimizing processes during manufacturing, installation, operation and maintenance, and dismantling and end-of-life. All these initiatives will contribute to even lower CO_2eq per kWh of electricity delivered to the grid.

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