# Review of the Approach to Calculating GHG Avoided Emissions

To date, Toray Group has estimated GHG avoided emissions over the entire life cycle of products throughout their value chains, with reference to guidelines issued by the Japan Chemical Industry Association (JCIA), the International Council of Chemical Associations (ICCA), and the World Business Council for Sustainable Development (WBCSD) Chemical Sector.
In addition, the Group has consistently applied the same calculation methodology, placing importance on consistency with our long-term targets relative to the fiscal 2013 base year and the continuity of data.

In recent years, however, discussions concerning GHG avoided emissions have advanced, with new guidance issued by organizations and initiatives such as the WBCSD and GX League. At the same time, the market environment has changed due to technological advances, improvements in energy efficiency, and other factors. In light of these developments, we have reviewed our approach to calculating GHG avoided emissions.

As part of this review, the Group has updated the selection of products covered by the calculations and reference products, as well as the assumed scenarios and emission factors used in life cycle assessment (LCA). The revised calculations continue to be conducted with reference to guidelines issued by the JCIA, ICCA, WBCSD, and other organizations, and the calculations and the underlying assumptions have been reviewed by external experts.

Following this review, the GHG avoided emissions over the entire life cycle of products throughout the value chains involving Toray Group products were estimated at approximately 23 million tons of $CO_2$ equivalent in fiscal 2024. The fact that GHG avoided emissions are lower than the value calculated before the review is due primarily to revisions to the calculation approach, including the selection of reference products and assumed scenarios.

GHG avoided emissions are estimates based on certain assumptions and are attributable to the entire value chain in which products are used, rather than solely to Toray Group. In addition, the calculations are based on scenarios and underlying data considered appropriate for each product. Please note that the assumptions, such as the treatment of recycling at the end-of-life stage, and the approach to contribution rates differ from case to case. Therefore, GHG avoided emissions are not directly comparable across products or cases.

Details of the calculation approach and the products covered by the revised calculations are provided on the following pages.

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# Carbon Fiber for Aircraft

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| Toray Group Products Contributing to GHG Avoided Emissions | Carbon Fiber for Aircraft<br><br>The use of carbon fiber-reinforced plastic (CFRP) in aircraft structures enables aircraft to be made lighter while maintaining levels of strength and safety equivalent to those of conventional aircraft. |
| Products Contributing to GHG Avoided Emissions (End Products Incorporating Toray Group Products) | Aircraft with CFRP applied to 50% of the airframe structure<br> |
| Contribution to GHG Avoided Emissions | Weight reduction improves fuel efficiency, thereby reducing GHG emissions associated with fuel consumption. |
| Calculation Approach | • **Product Contributing to Emissions Reductions:**<br>A model aircraft with CFRP applied to 50% of the airframe structure (CFRP aircraft) (using the model developed by the Japan Carbon Fiber Manufacturers Association)<br>• **Reference Product:**<br>A model aircraft with CFRP applied to 3% of the airframe structure (conventional aircraft) (using the model developed by the Japan Carbon Fiber Manufacturers Association)<br>• **Calculation:**<br>Annual sales volume of carbon fiber for commercial aircraft converted into the equivalent number of aircraft × (life-cycle GHG emissions per conventional aircraft − life-cycle GHG emissions per CFRP aircraft)<br>• **Calculation Scope (System Boundary):**<br>Raw material procurement, parts manufacturing, aircraft assembly, use (flight), and end-of-life<br>• **Calculation Period:** Flow-based method; product lifetime of 20 years |
| Third-Party Review | Yes |

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# Energy-Saving RO Membrane Elements

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| Toray Group Products Contributing to GHG Avoided Emissions | Energy-Saving RO Membrane Elements (including sales of RO membranes on a standalone basis)<br><br>An RO membrane (reverse osmosis membrane) is a semipermeable membrane that selectively allows water molecules to pass through while restricting the passage of dissolved substances, such as ions and salts, and other impurities. RO membranes are used to separate and produce freshwater from seawater and brackish water. Desalination using the RO membrane process can reduce energy consumption compared with conventional evaporation methods and is now widely used.<br>In recent years, energy-saving RO membrane elements that enable operation with lower power consumption than with conventional RO membrane elements have been developed by optimizing the membrane surface structure. |
| Products Contributing to GHG Avoided Emissions (End Products Incorporating Toray Group Products) | Energy-Saving RO Membrane Elements<br> |
| Contribution to GHG Avoided Emissions | Compared with conventional RO membrane elements, energy-saving RO membrane elements enable reduced power consumption during operation. |
| Calculation Approach | • **Product Contributing to Emissions Reductions:** Energy-Saving RO Membrane Elements<br>• **Reference Product:** Conventional RO membrane elements<br>• **Calculation:**<br>Annual sales volume of energy-saving RO membrane elements × (life-cycle GHG emissions per conventional RO membrane element − life-cycle GHG emissions per energy-saving RO membrane element)<br>• **Calculation Scope (System Boundary):**<br>Raw material procurement, manufacture of RO membrane elements, use (desalination), and end-of-life<br>GHG emissions associated with raw material procurement, manufacture of RO membrane elements, construction of water treatment plants, and end-of-life treatment are assumed to be equivalent for the energy-saving RO membrane elements and the reference products. Accordingly, only the use stage (desalination) is evaluated.<br>• **Calculation Period:** Flow-based method; product lifetime of five years |
| Third-Party Review | Yes |

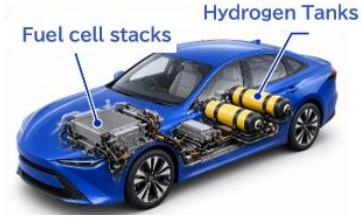
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# Carbon Fiber and CFRP for Wind Turbine Blades

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| Toray Group Products Contributing to GHG Avoided Emissions | Carbon Fiber and CFRP for Wind Turbine Blades<br><br>Wind power generation is a form of renewable energy that does not use fossil fuels during electricity generation and converts the kinetic energy of wind into electricity. Increasing the power generation capacity of wind turbines requires larger blades, for which lightweight, high-modulus carbon fiber-reinforced plastic (CFRP) is used. |
| Products Contributing to GHG Avoided Emissions (End Products Incorporating Toray Group Products) | Electricity generated at a wind farm<br> |
| Contribution to GHG Avoided Emissions | No fossil fuels are used to generate electricity during the use stage, and no direct GHG emissions arise from electricity generation. |
| Calculation Approach | • **Product Contributing to Emissions Reductions:** Electricity generated at a wind farm<br>The wind farm is assumed to be a 990 MW offshore wind farm consisting of 15 MW-class wind turbines with CFRP used in their blades.<br>• **Reference Product:**<br>Grid electricity (global electricity mix), also taking into account future changes in emission factors (Source of emission factors: World Energy Outlook 2024, IEA)<br>• **Calculation:**<br>Annual sales volume of carbon fiber and CFRP for wind turbine blades converted into the equivalent number of wind turbines × total electricity generation per wind turbine over its lifetime (kWh) × (life-cycle GHG emissions per kWh of grid electricity − life-cycle GHG emissions per kWh of electricity generated at an offshore wind farm)<br>• **Calculation Scope (System Boundary):**<br>Raw material procurement, parts manufacturing, wind turbine assembly, wind farm construction, use (power generation and maintenance), and end-of-life<br>• **Calculation Period:** Flow-based method; product lifetime of 30 years |
| Third-Party Review | Yes |

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# Carbon Fiber for Fuel Cell Electrode Substrates and High-Pressure Hydrogen Tanks

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| Toray Group Products Contributing to GHG Avoided Emissions | Carbon Fiber for Fuel Cell Electrode Substrates and High-Pressure Hydrogen Tanks<br><br>Fuel cell vehicles use hydrogen as an energy source and are expected to produce no direct GHG emissions during vehicle operation. Lightweight, high-strength carbon fiber is used in high-pressure hydrogen tanks that store hydrogen as the vehicle's energy source, while lightweight carbon fiber-based electrode substrates are used as electrode substrates in automotive fuel cells. |
| Products Contributing to GHG Avoided Emissions (End Products Incorporating Toray Group Products) | Fuel cell vehicles<br> |
| Contribution to GHG Avoided Emissions | Because fuel cell vehicles do not combust fossil fuels, they produce no direct GHG emissions during vehicle operation. |
| Calculation Approach | • **Product Contributing to Emissions Reductions:** Fuel cell vehicles<br>• **Reference Product:** Internal combustion engine vehicles (passenger vehicles: gasoline vehicles, commercial vehicles, diesel vehicles)<br>• **Calculation:**<br>Annual sales volume of carbon fiber for fuel cell electrode substrates or high-pressure hydrogen tanks converted into the equivalent number of fuel cell vehicles × (life-cycle GHG emissions per internal combustion engine vehicle − life-cycle GHG emissions per fuel cell vehicle)<br>• **Calculation Scope (System Boundary):**<br>Raw material procurement, parts manufacturing, vehicle assembly, use (driving and maintenance), and end-of-life<br>The scope also includes resource extraction and production of energy sources used during vehicle operation.<br>• **Calculation Period:** Flow-based method; lifetime driving distance*: 225,000 km for passenger vehicles and 570,000 km for commercial vehicles (Source: Determining the environmental impacts of conventional and alternatively fuelled vehicles through LCA, EUROPEAN COMMISSION, 2020) |
| Third-Party Review | Yes |