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# Sustainable Product Life Cycle

Boeing increasingly looks at every stage of the product life cycle through a sustainability lens

We continue to evolve our approach so that our next generation of products consider the full breadth of sustainability including environmental, health, safety and human factors improvements by targeting the following seven areas:



**Demand/Sales.** Customers continue to demand higher-efficiency, lower emissions products. Globally, airlines and governments are increasingly accountable to emerging sustainability standards, which requires that they evaluate the life cycle of aircraft they operate.

**Cascade:** Boeing’s data modeling and visualization tool quantifies the potential of four strategies to cut emissions, including fleet renewal, operational efficiency, renewable energy and future aircraft introduction.

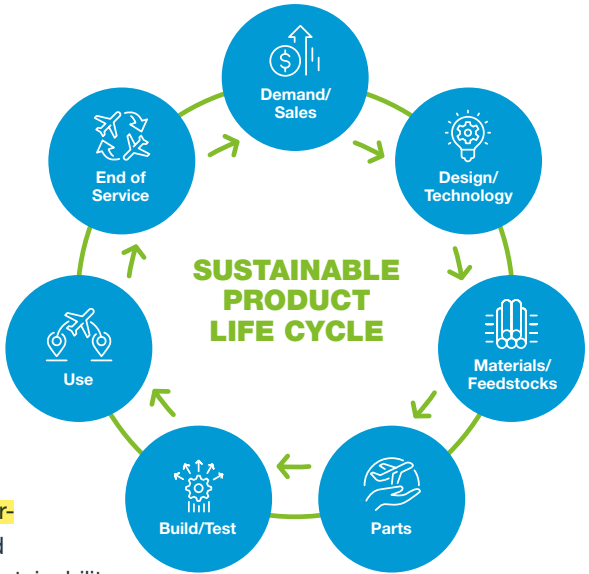


**Design/Technology.** Boeing evaluates new product designs and technologies to determine if they are safe and sustainable by conducting an environmental life cycle assessment. We strive to evaluate new aircraft design concepts, materials and technologies early in the development process to assess how much we can reduce the risks and expenses associated with its environmental footprint. We aim to examine whether more sustainable approaches exist for new product design, considering everything from selecting materials and parts to improving manufacturing processes and in-service operations to recycling the plane.

**SAF-Compatible Commercial Airplanes:** Boeing is collaborating with suppliers to achieve our goal that all commercial airplanes we deliver by 2030 will be compatible with SAF.



**Materials/Feedstocks.** Boeing examines coatings that improve our planes’ aerodynamics, fuel efficiency and longevity, in part by using more parts that can be repurposed. Lighter composite materials permit us to design more fuel-efficient aircraft like our primarily composite 787 Dreamliner. Boeing simultaneously supports research into regenerative feedstocks that can replace constituents that are nonrenewable resources. For example, the bio-based regenerative feedstocks from forestry waste and pine root oil that we are researching at Villanova University may one day be integrated into the epoxy resins used in our interior parts, enabling us to reduce the feedstock-related emissions from extraction and refining compared to petrochemical-based feedstocks. Meantime, we recycle the metals used in manufacturing our aircraft back into our supply chain, reducing reliance on virgin materials.



“Across Boeing Defense, Space & Security, we believe that operational effectiveness and sustainability are two sides of the same coin. A more sustainable, lower cost, energy efficient defense enterprise is a more operationally effective one.

That’s why we have a history of partnering with our customers to pioneer the use of sustainable aviation fuels and are leveraging digital design and production to reduce our carbon footprint throughout the life cycle of our products”

Ted Colbert, president and CEO of Boeing Defense, Space & Security

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**Parts.** Boeing aims to reduce carbon emissions and waste from parts, components and systems procured from suppliers. We reduce carbon emissions from the movement of millions of airplane spare parts by consolidating shipments, eliminating single-use packaging and redesigning warehousing networks to regional hubs. In addition, we use additive manufacturing to 3D print some of our own parts. Doing so allows us to change the designs of some parts in a way that can lessen their environmental impact by creating lighter consolidated parts that use less raw material, fewer machining processes and leave less waste. [See Page 64 for more information.](#)

**Supplier Collaboration:** In 2021, Boeing co-founded an industry effort through the International Aerospace Environmental Group to establish a voluntary sectoral framework for ESG engagement, including assessment and awareness, throughout the aerospace manufacturing industry.

**Used Serviceable Material Offerings:** Boeing Service business provides access to recertified used parts from retired aircraft called used serviceable material.



**Build/Test.** Reducing waste from operations while boosting the use of renewable energy and digital technologies can help our manufacturing and other work sites reduce their environmental impact while building and testing a product. Boeing cuts waste to landfill, water, energy and hazardous chemicals. Read more about how we do so on [Page 52](#). For example, when testing aircraft, Boeing uses blended sustainable aviation fuels.

**Sustainable Operations:** Since 2020, Boeing has maintained workplace net-zero GHG emissions at manufacturing sites and other facilities (Scope 1 and Scope 2) and in its business travel (Scope 3, Category 6) by expanding conservation and renewable energy use while securing carefully selected, third-party-verified offsets for the remaining GHG emissions.

**ecoDemonstrator:** To accelerate innovation for current and future airplane sustainability, our 10-year-old ecoDemonstrator flying test bed program takes promising technologies out of a lab and tests them in an operational environment.



**Use.** Boeing provides solutions for customers to lower their carbon footprints while they are using our aircraft. For example, armed with real-time data, flight crews can make adjustments to optimize fuel use, and thus minimize the carbon footprint of each flight. Digital tools empower our airline customers to conserve fuel, track emissions and enhance their operations' overall efficiency, while defense customers can conserve fuel and lower emissions with platform-agnostic digital systems with maintenance, supply chain and flight planning recommendations based on analytics.

**Government Services:** As our tools ingest flight, maintenance and supply data, our analytics produce results that drive efficiency across the system. Read more on [Page 37](#).



**End of Service.** Up to 90 percent of the parts and materials in Boeing aircraft can be reused and recycled across aerospace and other industries. We manage and recertify used parts for aircraft, and engine platforms for our customers.

**Remanufactured:** Boeing remanufactures aircraft, such as the 115 AH-64D Apache for government customers, which includes upgrading configurations with the latest technology and keeping valuable materials in a closed loop.



**Boeing Converted Freightier Fleet Renewal:** Boeing's passenger-to-freighter programs provide airlines an economical way to replace less efficient, older-generation freighters with more efficient freighters created from repurposed passenger aircraft.

# Innovation and Clean Technology

Our company and our industry recognize finding solutions to climate change as an urgent challenge of our time. We are united in our goal to ensure billions of passengers can continue to fly every year to connect with friends and family, discover new places and cultures, engage in commerce and care for those in need.

Achieving this objective requires a portfolio of innovative solutions and partnerships that allows our sector to decarbonize. We are focused on four key areas: fleet renewal, operational efficiency, renewable energy and advanced technology. In 2022 we set ambitious 2030 targets related to our products, and throughout this section we share progress toward those goals and essential partnerships that will help us achieve them.

More about the governance of this strategy can be found in the Approach & Governance Section on [Page 13](#) of this report.



Sharing Cascade at the opening of the Boeing Research & Technology Sustainability Research Center in Tokyo, CSO Chris Raymond explains how the modeling tool projects the multiple paths to net-zero carbon emissions for commercial aviation. (Boeing photo)

## The Cascade effect

Boeing debuted The Boeing Cascade Climate Impact Model (Cascade) at the Farnborough International Airshow in 2022. This web application uses digital technical data pulled from across the world to visualize how introducing various sustainable aviation options would impact global emissions. Cascade uses life cycle modeling to accurately quantify how choices in the four key areas impact the atmospheric concentrations of carbon dioxide.

Cascade is a way to visualize the climate impact of global commercial aviation while creating scenarios to calculate what kind of positive impacts our levers to decarbonize aviation would have on carbon emissions: fleet renewal, operational efficiency, renewable energy and new aviation technologies like hybrid, electric or hydrogen airplanes.

**Why it matters:** It's a data-driven way for our stakeholders to make informed decisions about how to reach the commercial aviation industry's net-zero 2050 ambition.

[Learn more about Cascade](#)

“Cascade helps airline operators, industry partners and policymakers see when, where and how different energy carriers and life cycle emissions affect their sustainability goals. The tool shows how incremental changes can cut emissions in commercial aviation.”

**Neil Titchener**, program leader, Cascade



Neil Titchener, program leader, Cascade. (Boeing photo)



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# Four Strategies to Advance Sustainable Aerospace Together



Fleet  
Renewal



Operational  
Efficiency



Renewable  
Energy



Advanced  
Technology

Cross-sector global partnerships required

# Fleet Renewal

New airplanes provide significant efficiency gains — historically each generation reduces fuel use and emissions 15%-25%. Deploying the latest generation of airplanes is one of the most significant contributions to CO<sub>2</sub> emissions reduction available over the next decade. Boeing will continue to invest in efficiencies that reduce fuel use and carbon emissions. [More detail on the sustainability of Boeing's products can be found here.](#)



In December 2022, Boeing and United Airlines announced the carrier is investing in its future fleet with an order for 100 787 airplanes, with the option to purchase 100 more. The deal is the largest 787 Dreamliner order in Boeing's history. United is also purchasing 100 737 MAX jets. (Boeing photo)

## New orders mean more efficient fleets

**774 big things:** In 2022, our customers ordered 774 new commercial aircraft. New airplanes provide significant efficiency gains — each generation has reduced fuel use and emissions by 15%-25%.

**Why it matters:** Deploying the latest generation of airplanes is one of the most significant contributions to reducing carbon emissions available over the next decade.

**Research matters:** The emissions reductions available today in our latest generation of aircraft are a direct result of Boeing committing a significant amount of its research and development investment to sustainable technologies, such as:

- The Advanced Technology Winglet on the 737 MAX that reduces drag and increases lift.
- Lightweight carbon-fiber composite material on the 787 that is 30% lighter than aluminum.
- Folding wingtips on the 777X that offer unconstrained wingspan and contribute to 5% greater aerodynamic efficiency.

**Go deeper:** Read about [our orders and deliveries here.](#)

“With this investment in its future fleet, the 737 MAX and 787 will help United accelerate its fleet modernization and global growth strategy. The Boeing team is honored by United's trust in our family of airplanes to connect people and transport cargo around the world for decades to come.”

**Stan Deal**, president and CEO of Boeing Commercial Airplanes