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Fond childhood memories propel a passion for possibility and sustainable fuel

Boeing’s SAF feedstock expert Onofre Andrade witnessed the transformative economic power sustainable biofuels had on his job-deprived rural village, while growing up in central-west Brazil.

When he was a young boy, his father joined with other farmers to form a co-operative that built a sugar cane ethanol plant. It still operates today. Prior to this co-op being developed, the sole source of jobs was farm labor.

“The sugar cane ethanol co-op provided much-needed jobs, and that sparked hope in the lives of many people I care about,” said Andrade. “The success of the ethanol plant catalyzed other co-ops and sparked capacity-building opportunities — including a co-op-led school started by my mother.”

Andrade joined Boeing before SAF was a hot topic, but his early experience continues to give purpose to him and his family.

Boeing’s SAF feedstock expert Onofre Andrade was inspired by seeing good jobs come to his rural village in Brazil when his father started a sugar cane ethanol co-op. (Onofre Andrade photo)

“I hope to inspire my kids the way my dad inspired me.”

Onofre Andrade, sustainable aviation fuel feedstock expert



Carissa Pajel at Boeing SAF lab. (Boeing photo)



Peter Nease and Clarence Santiago fueling ecoDemonstrator with SAF. (Boeing photo)

Advanced Technology

To meet the commercial aviation industry’s net-zero ambition by 2050, it will take an approach that includes SAF and other advanced technologies. Boeing has extensive experience on the “and,” through research, studies, testing and partnerships. The future of flight will incorporate the latest digital design, test and production tools, airframe, propulsion and systems technology, and different power and energy solutions will apply to different market segments and aircraft sizes.

Informed by the company’s extensive evaluation and testing of alternative propulsion sources and renewable energy and its research partnerships, and supported by Boeing’s expertise in commercial aircraft design and history of innovation on alternative energy and propulsion systems, Boeing has launched a new effort to conceptually design and assess the potential environmental impacts of “Future Flight Concepts.” These concepts are exploring applications of technologies including electrification and alternative fuels, such as hydrogen.

NASA awards sustainable flight program to Boeing and partners

In January 2023, NASA selected Boeing and its industry team to lead the development and flight testing of a full-scale Transonic Truss-Braced Wing (TTBW) demonstrator airplane through the Sustainable Flight Demonstrator (SFD) program. Through this unprecedented public-private partnership with NASA, Boeing and its industry partners are contributing more than half of the funding needed to shape the demonstrator program.

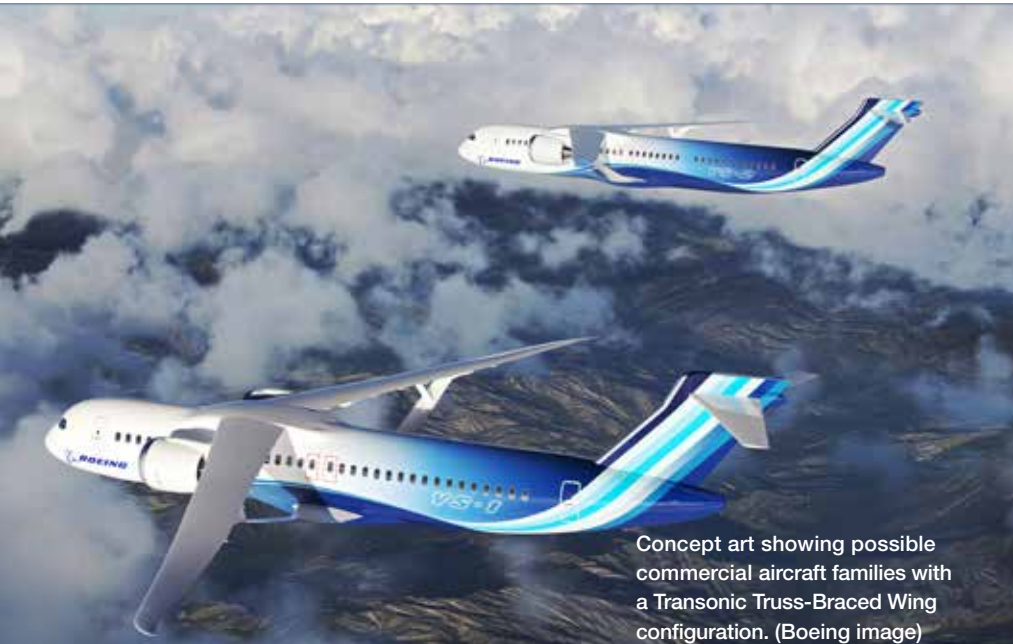
Why it matters: The technologies demonstrated and tested will inform future designs and could lead to breakthrough aerodynamics and fuel efficiency gains.

When combined with expected advancements in propulsion systems, materials and systems architecture, a single-aisle airplane with a TTBW configuration could see reduced fuel consumption and emissions of up to 30% relative to today’s most efficient single-aisle airplanes, depending on the mission.

Years in the making: The TTBW airframe concept is the result of more than a decade of development supported by NASA, Boeing and industry investments. Under previous NASA programs, including the agency’s Subsonic Ultra Green Aircraft Research program, Boeing conducted extensive wind tunnel testing and digital modeling.

“One of the key outputs of this activity is really the learning, the knowledge. What at the integrated airplane level ... will the benefits be? And depending on the results of this effort, and market conditions — that’ll dictate whether this shows up on a future commercial product.”

Todd Citron, Chief Technology Officer



Concept art showing possible commercial aircraft families with a Transonic Truss-Braced Wing configuration. (Boeing image)

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Wisk unveils self-flying, eVTOL aircraft

Wisk, a technology joint venture, is developing its 6th Generation aircraft. Designed with the **highest safety standards**, it will be the first candidate for certification of an autonomous, passenger-carrying electric vertical takeoff and landing (eVTOL) aircraft in the U.S. The Gen 6 aircraft has room for four passengers, carry-on luggage and personal items, can fly 90 miles (145 kilometers) and recharges in 15 minutes.

Why it matters: Wisk will be the first candidate for certification of an autonomous, passenger-carrying electric vertical takeoff and landing (eVTOL) aircraft in the U.S.

“Wisk is excited to partner with Boeing on the development of this autonomous aircraft. Our combined experience uniquely positions Wisk to succeed in this exciting new mobility market.”

Brian Yutko, CEO, Wisk



Wisk 6th Generation autonomous, passenger-carrying electric vertical takeoff and landing aircraft. (Wisk photo)



Space Launch System in flight.
(Boeing image)

Taking a SAF and other advanced technology approach

It will take a “SAF and” approach, not a “SAF or” approach, to achieve the **commercial aviation industry’s net zero ambition by 2050**. As part of our approach, which includes **SAF and other technologies**, Boeing continues to advance the **safety and viability of other energy carriers and their use on aircraft**. Since the mid-2000s, Boeing has conducted **six hydrogen technology demonstrations with crewed and uncrewed aircraft using hydrogen fuel cells and combustion engines**. Boeing successfully tested a cryotank designed for space with the capacity to hold 16,000 gallons of **liquid hydrogen** or the energy equivalent of the Jet A fuel in a typical regional jet.

Boeing was reminded of the challenges and opportunities associated with hydrogen with the recent Artemis mission. Chris Raymond, Boeing’s chief sustainability officer dives into more detail in this [Fortune article](#).

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Sustainability test bed turns 10

The Boeing ecoDemonstrator marked its 10-year anniversary in 2022 — accelerating innovation by taking promising technologies out of the lab and rigorously testing them in an operational environment.

By the numbers:

The program has tested over 225 technologies to help enhance safety, decarbonize aviation and improve operational efficiency and the passenger experience.

- Nine platforms served as flying test beds:
 - 2012: American Airlines 737-800.
 - 2014: Boeing 787-8 Dreamliner.
 - 2015: TUI 757.
 - 2016: Embraer E170.
 - 2018: FedEx 777 Freighter.
 - 2019: Boeing 777-200.
 - 2020: Etihad Airways 787-10.
 - 2021: Alaska Airlines 737-9.
 - 2022-2024: Boeing 777-200ER (Extended Range).
- Approximately one-third of those technologies progressed onto Boeing’s products and services, including:
 - More aerodynamically efficient winglets on the 737 MAX.
 - iPad apps that provide real-time weather and other information to pilots, enabling them to improve fuel efficiency and reduce emissions.
 - Custom approach path information to lower community noise.
 - Flight deck touch-screen displays and a camera system on the 777X that will enhance safety by helping pilots avoid ground obstacles.



“I am proud of the ecoDemonstrator’s role in pioneering the use of sustainable aviation fuel (SAF) for the industry. Not only has almost every one of our platforms flown on SAF, we conducted the industry’s first commercial flight on 100% SAF in both engines in 2018 with FedEx Express and tested SAF emissions with NASA. That is what we do — partner across the industry to help safely decarbonize aerospace.”

Rae Lutters, ecoDemonstrator program manager

The 2022 Boeing ecoDemonstrator, a 777-200ER (Extended Range) flies on a blend of 30% SAF and 70% conventional jet fuel. (Boeing photo)

 **Video:** [See flying lab.](#)

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Boeing partners for a clean energy economy

Throughout 2022, Boeing joined forces with innovative partners from around the world to scale renewable energy and sustainable technologies for a more sustainable aerospace and future.

Why it matters: Boeing is aware that no one entity can decarbonize the commercial aviation industry alone. It will take “everyone” to achieve the industry’s net zero ambition by 2050. We recognize the significant capital investment required in the journey and appreciate the partnership and support of the financial community to channel liquidity into the ongoing transition pathway.

- **Avolon and SkyNRG:** Boeing partnered with Avolon, ORIX Aviation, SFS Ireland and SkyNRG to identify opportunities for a commercial-scale SAF production facility in Ireland. The country is a global leader in aviation finance and airline operations with a planned growth of renewable energy sources. The study will be completed in 2023.
- **Alder Fuels:** Boeing has committed to support testing and qualification of Alder Fuels-derived SAF on its airplanes to further grow the global SAF market. This technology enables the conversion of sustainable forest and agricultural residues into a low-negative carbon “greencrude” for jet fuel conversion — displacing the typical jet fuel need by up to 75% in the U.S. The first plant will be completed in 2024.
- **ACT FOR SKY:** Boeing is a member of ACT FOR SKY, a voluntary organization of 19 companies that works to commercialize, promote and expand the use of SAF produced in Japan.



At the Farnborough Airshow in June 2022, Boeing and Mitsubishi Heavy Industries announced we will build on our decades-long partnership. (Boeing photo)

- **Mitsubishi Heavy Industries (MHI):** Building on their decades-long partnership, Boeing and MHI agreed to study sustainable technologies for a low-carbon society. Their focus areas include green hydrogen, carbon capture, electrification, sustainable materials, emissions propulsion technologies, new aircraft design concepts as well as new feedstocks and technologies for SAF production.
- **NASA:** Boeing and NASA continued their partnership testing the emissions from SAF. This year, the team conducted tests on the 2022 Boeing ecoDemonstrator, a 777-200ER (Extended Range) with Rolls-Royce Trent 800 engines and a 787-10 with GENx-1B engines ([see Page 44](#)).
- **Rocky Mountain Institute and Five U.S. Airlines:** Boeing, along with five major U.S. airlines and others, joined the Contrail Impact Task Force led by the Rocky Mountain Institute to explore the formation, impact, and mitigation of persistent condensation trails, or “contrails,” and their climate effects.
- **Roundtable on Sustainable Biomaterials (RSB):** Boeing has been a member of the Board of Directors since 2021 and has chaired RSB’s SAF Policy Platform to advance stakeholders’ collaboration on renewable energy.
- **SpiceJet, Council of Scientific and Industrial Research-Indian Institute of Petroleum (CSIR-IIP):** Boeing partnered with these organizations to explore SAF use in India, supporting the country’s environmental goals and self-reliance initiative. Boeing is currently assisting in the certification process for SAF developed by CSIR-IIP by providing review and support.
- **Virgin Atlantic:** In December 2022, partnering with Boeing, Virgin won the UK Department for Transport’s 100% SAF Trans-Atlantic Flight Fund Competition. This UK government initiative, which will see a 787 cross the Atlantic on 100% SAF in 2023, will showcase the spectrum of sustainable aviation approaches to the flying public and inform our journey toward routine commercial industry 100% SAF flights by 2030.

What’s next: The commercial aviation industry’s ambition is to achieve net-zero carbon emissions for global civil aviation operations by 2050, while also growing the societal benefits of air transportation. Boeing will continue to work across sectors and industry to ensure the benefits of aerospace remain available for generations to come.

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University partnerships strengthen sustainability at Boeing

Why it matters: Strong university partnerships are one way Boeing demonstrates that it is looking outside the aerospace industry to give and receive support for research and development and to attract top talent.

Here are some universities partnering with Boeing on sustainability:

- **Yale Center for Natural Carbon Capture:** In April 2022, Boeing pledged \$10 million to research efforts in natural carbon sequestration to scale natural solutions to mitigate GHG. The Center’s focus is on near-term solutions that can capture approximately one gigaton of CO₂ per year, the equivalent to current annual airline emissions. This approach offers potential co-benefits such as improved soil health and biodiversity conservation.
- **University of Sheffield:** Boeing is the founding member of the Energy Innovation Center (EIC), which is focused on driving SAF development. In early 2023, the EIC was announced as the UK’s SAF Clearing House, in partnership with the University of Dayton, reinforcing the critical role this first-of-its-kind facility in the UK will play in the global ecosystem. The EIC builds on Boeing’s long-standing relationship with Sheffield, which started with the co-founding of an advanced research center for manufacturing and led to the opening of Boeing’s first European manufacturing facility, demonstrating a successful model for university and industry collaboration.

Fossil-Free Future for Aerospace: His Majesty King Charles III visits Cambridge University, when he was Prince of Wales, to see plans for a new Whittle Laboratory building that would act as a hub for the university-led Aviation Impact Accelerator (AIA), of which Boeing is an official industry adviser, focused on accelerating the move toward the commercial aviation industry’s climate goals. (University of Cambridge photo)

- **University of Cambridge:** In 2023, Boeing is celebrating 20 years of collaboration with the University of Cambridge. Among other research projects, Boeing is partnering with the university’s Whittle Lab on its Aviation Impact Accelerator (AIA) to draw from a multidisciplinary range of expertise. AIA develops interactive, evidence-based models, simulations and visualization tools for decision-makers and others to understand low-emissions flight pathways, complementing our own Cascade tool. The AIA tool will help Boeing and interested parties understand how policies, scenarios and technology transitions support the industry’s net-zero carbon emissions from commercial aviation by 2050.
- **Cranfield University’s Digital Aviation Research and Technology Centre:** This partnership focuses on technologies that are relevant to the operational efficiency pillar of our sustainable aerospace strategy.
- **Villanova University:** The Resilient Innovation through Sustainable Engineering (RISE) Forum advances corporate sustainability by identifying and applying data-driven sustainability solutions. Boeing has access to faculty and graduate students who possess the technical expertise to examine real-world problems by evaluating various technologies or operational innovations through a systems perspective.

What’s next: We will continue to partner with academic institutions at the forefront of sustainable aerospace research.



Alicia Piscitelli. (Boeing photo)

Studying sustainable materials in forestry waste: University partnerships nurture the sustainability talent pipeline, which benefits graduates and the company. Alicia Piscitelli secured a position on Boeing’s Research & Technology team after completing three company internships and earning both master’s and doctorate degrees from Villanova’s sustainable engineering program.

Boeing’s circular economy expert and Associate Technical Fellow (see Page 30), Christin Datz, was Piscitelli’s master’s thesis adviser as she researched ways to advance the sustainable product life cycle. Piscitelli’s doctoral research focused on renewable feedstock material for thermoset polymers used in interior aircraft composites. She studied ways to synthesize phenolics with renewable feedstocks derived from pine root oil and forestry waste.

Most recently, she’s helping Boeing to find sustainable ways to manage polymers at the end-of-life phase of the sustainable product life cycle.

Boeing partners with decision-makers for sustainable aerospace

Boeing is working with decision-makers and policy institutions globally to create tailor-made paths forward to decarbonize commercial aviation.

Why it matters: The commercial aviation industry’s ambition of net-zero carbon emissions by 2050 has multiple levers to work toward meeting this target. SAF is seen as the best solution to accelerate toward this goal as it is a drop-in solution to the aviation ecosystem.

Around the globe: Here’s a snapshot of Boeing’s global policy partnerships.

- **Americas:** Partnering with International Air Transport Association (IATA), Boeing hosted a SAF Roundtable at the IX Summit of the Americas and asked heads of state to develop sound policies to incentivize the production of SAF across the western hemisphere, highlighting the potential of the region. Boeing also partnered with seven airlines from across the Americas, using nearly 400,000 liters (106,000 gallons) of SAF for commercial flights during the week of the summit, avoiding the release of over 214 tonnes of CO₂.
- **Australia:** SAF will unlock its share of an extra \$10 billion each year in GDP, generating 26,000 jobs, while reducing emissions by around 9%. Boeing and Bioenergy Australia hosted a panel at the Prime Minister’s Sydney Energy Forum to accelerate the production of SAF, where the Australia Transport Minister announced plans for a Jet Council. Boeing also chaired the SAF Alliance of Australia and New Zealand to make key policy recommendations on scaling SAF.
- **China:** Boeing and Peking University Institute of Energy released a report that compiles results of a yearlong research effort into SAF, the basis of a plan to decarbonize air travel in the world’s second-largest commercial aviation market.

Boeing Global Sustainability Policy & Partnerships Vice President Brian Moran (right) is joined by Mohamed Al Ghailani, Boeing’s sustainability lead for Middle East, Türkiye and Africa, at COP27, where they engaged with government, industry and civil society partners. (Boeing photo)

- **Europe:** Boeing became a member of the European Commission’s Renewable and Low-Carbon Fuels Value Chain Industrial Alliance. As part of the Aviation Working Group, Boeing is partnering with the European policymakers to inform how to scale production and uptake of SAF. In 2022, Boeing also took the lead as Sector Champion for Aviation in the World Economic Forum’s First Movers Coalition (FMC), which has assembled 24 of the world’s leading companies. All airlines and air transport companies in this sector have set a target to procure 5% of their fuel demand as advanced SAF. The group works to overcome technology barriers and bring forward supply with the intent of striking binding commitments between buyers and sellers.
- **Middle East:** Boeing discussed real-world climate actions at the 2022 COP27 via panels and keynotes with partners and stakeholders, amplifying that the only way to keep 1.5 degrees C alive is through cross-sector partnerships, strategies, regulation and data to keep all parties on track.
- **Singapore:** Boeing joined the International Advisory Panel (IAP) set up by the Civil Aviation Authority of Singapore to develop Singapore Sustainable Air Hub Blueprint by 2023. Boeing provided insight into IAP’s report on scaling SAF and improving air traffic management to create a conducive policy framework for the region’s busiest aviation hub. Boeing also briefed the Association of Southeast Asian Nations Air Transport Ministers on key strategies for sustainable aviation, encouraging further discussion amongst the member states on accelerating regional cooperation.
- **UK:** Boeing hosted the seventh Jet Zero Council meeting in its offices, presenting its Cascade tool to the Secretary of State for Transport and Secretary of State for Energy and Net Zero. The work of the council is crucial for the UK Jet Zero Strategy. Boeing was appointed co-chair of the Defence Supplier Forum Climate Change and Sustainability Aviation Group with the Royal Air Force. Boeing also leads a NATO group on behalf of the UK focused on accelerating military adoption of SAF to support defence sustainability and energy security.



- **U.S.:** The SAF Grand Challenge engages federal government agencies to develop a comprehensive strategy for scaling up new technologies to produce SAF on a commercial scale from renewable or waste resources. Objectives include: expanding SAF supply and end use; reducing its cost; enhancing its sustainability; supplying at least 3 billion gallons of SAF annually by 2030; and sufficient SAF to meet 100% of aviation fuel demand by 2050, which is projected to be around 35 billion gallons per year.

- What’s next:** Boeing will continue to work closely with governments, customers and decision-makers globally to achieve our shared goal in 2023 and beyond, including:
- Partnering on SAF road maps across the APAC region, including Australia, New Zealand, Southeast Asia and Japan.
 - Helping to develop Australian Jet Zero Council.
 - Advocating to policymakers, the finance community and suppliers through regional workshops with FMC around the world to build local capacity for SAF supply, enhance demand commitments and unlock commercial challenges.
 - Supporting the release of global SAF guidance on future supply and demand issues for buyers and sellers.
 - Working closely with the UAE government on shaping sustainable transport agenda at COP28.



Gonzaga University Senior Design students receive the Adient Aerospace Ovation seating; left to right in photo: Hannah Dunn, Micah Donald, Brady Jurgens, Emily Andresen. (Zack Berlat, Gonzaga photo)

Lighter seats lift efficiency

Boeing’s Cabin and Interiors and Payloads Engineering teams are finding innovative ways to reduce waste, emissions and weight during the product life cycle for complete customer solutions that promote sustainability. One of those ways involves a group of college students in Spokane, Washington. Boeing and joint venture aircraft seating partner, Adient Aerospace, joined with Gonzaga University’s School of Engineering and Applied Science students to support a sustainability-focused research initiative. The students are using Adient Aerospace’s Ovation seat prototype to study cabin product design, manufacturing and maintenance to find new approaches to increase sustainability measures.



Gonzaga University senior design students Brady Jurgens, Hannah Dunn, Emily Andresen and Micah Donald study Ovation seat design and structure. (Zack Berlat, Gonzaga photo)

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Habitat restoration along the Lower Duwamish Waterway in Seattle. (Boeing photo)

OPERATIONS

Responsible and Resilient

Quality

We design quality into every aspect of our business and drive personal accountability to ensure quality in everything we do and in every product we deliver. We promote quality with our people, our culture, metrics and oversight.

The Boeing Quality Management System (QMS) has a foundation in AS9100, which is the internationally recognized and premier aerospace QMS standard. Boeing aims to flow down AS9100 certification and compliance to its suppliers in order to enable effective and efficient processes that meet multiple customer, statutory and business requirements.

QMS and the company’s Safety Management System (SMS) work together and are built into the company’s organizational structure, policies, processes, procedures and resources. Our customers and our regulators have extremely high expectations of Boeing, and these systems help to operationalize safety and quality in order to meet those expectations.

We incorporate safety and quality metrics into our primary annual incentive structures, further driving our focus across the enterprise at every level of the organization. We operate with four enterprisewide operations councils focused on strengthening quality, manufacturing, supply chain and program management in every program. We deliver quality through a relentless commitment to integrity, safety and sustainability, which is fundamental to our mission.

[Learn more about our approach to quality.](#)



A sustainable approach to supplier quality success

Boeing is expanding a new proactive quality tool called Requirements Consumption Review (RCR) to ensure suppliers fully understand all requirements prior to building a product — and it’s significantly reducing waste and rework down the line to enable first-time quality.

Why it matters: The program is having a positive impact on quality.

- Boeing conducts the review for newly designed products or products that have moved to a new supplier and that may generate a defect, for example, given the part’s complexity.
- RCRs have resulted in a 95% first-time quality yield, compared to 60% for similar parts that did not involve the tool.
- First deployed across Boeing’s Defense, Space & Security business, RCRs are now being implemented across Commercial Airplanes and Global Services as well.

“When we send a purchase order to a supplier, it can be a detailed process to ensure we receive high-quality products that meet our exacting requirements. This early involvement approach involves a cross-functional team that works proactively with the supplier to go through the purchase order together, including all the critical technical requirements, and establish confidence and clarity from the start. It also demonstrates that we are invested in their success.”

Doug Ackerman, vice president of Supplier Quality

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Digital factory of the future


Boeing is utilizing an industry-leading technology to transform the way we design, test and build airplanes. Today, Boeing engineering teams are studying how recent lessons learned from across the company could shape the factory of the future — with digital transformation as a major driver.

Why it matters: Stability and optimized performance is happening.

- Boeing’s T-7A Red Hawk team was able to build the first several aircraft in simulations before production even started and then join the aft and forward fuselages in less than a half-hour, a process that would normally take days.
- Although commercial airplanes are larger and production requirements are different from military aircraft, Boeing teams will apply those learnings to future programs. That knowledge, combined with more than a century of development experience on other programs, will guide future production.

It comes down to this: This will enable Boeing to predict performance of the production system and see how changes in the airplane design affect that performance, or vice versa. It will also allow teams to “build” the first several aircraft in a simulation, flattening the learning curve. Supplier readiness and success around first-time quality enables Boeing to operate more sustainably as a business.

By driving quality within the supply chain, Boeing demonstrates its commitment to sustainability by reducing rework and/or delayed parts in the value stream to minimize time lost and waste.

 **Video:** [Take a look at our future factory.](#)



“Creating a digital twin of our factory operations will help to increase stability and optimize performance prior to physically building a product. We have long used models to predict aircraft performance and refine them with test data as it comes available. Similarly, we will build models to predict production system performance and refine them as systems come online.”

Howard McKenzie, chief engineer and executive vice president of Engineering, Test & Technology

A simulated view of what a future commercial factory could look like. The concept builds off of lessons learned from how the T-7A program operates in St. Louis — no fixed tooling, no holding fixtures. The part becomes the tool, which is a revolutionary concept. (Boeing image)

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Sustainable Operations

Boeing appreciates sustainable aerospace starts inside our four walls. We are focused on continuous improvements in pursuit of the sustainable product life cycle across key elements including greenhouse gas emissions (Scope 1 and Scope 2), energy usage, water and waste management. We take action to decrease our impact through renewable energy procurement, targeted infrastructure and equipment investments, efficiency standards and conservation initiatives that include deployment of best practices and employee engagement strategies. Core to this strategy is the ongoing engagement of our employees each year through education and initiatives focused on ways in which they can reduce their environmental impact at work, and at home. Boeing's environmental strategy is guided by a comprehensive review and assessment of the most significant environmental challenges and risks facing the company, and our environmental priorities are set with internal and external stakeholders. The analysis includes direct input and perspectives on industry best practices and community requirements from diverse stakeholders, such as customers, environment-focused nongovernmental organizations (NGO) and the company's global leadership. The information helps Boeing identify and update our understanding of current and emerging sustainability issues that are critical to the company and our stakeholders. It also informs our next-generation environmental strategy and targets.





Since 2020, Boeing has achieved net-zero GHG emissions at manufacturing and work sites by expanding conservation and renewable energy use while securing carefully selected, third-party-verified offsets for the remaining greenhouse gas (GHG) emissions.



787 final assembly. (Boeing photo)

Operational Targets Progress

Boeing invests in sustainable operations to **reduce the impact of our manufacturing sites** and is focused on **conserving resources**. We prioritize **reducing emissions, energy, water and waste throughout our global operations** and have set 2025 waypoints toward 2030 goals to share our progress and remain accountable as we increase production. Boeing's sustainable operations strategy is managed within the **Global Enterprise Sustainability organization**, in close partnership with stakeholders across the enterprise. Through our Sustainable Operations subcouncil, we track performance across the enterprise and at the site level to assess our progress, identify challenges and opportunities, and share best practices.

Performance Area ¹	2025 Targets vs. 2017 ²	2022 Progress Toward 2025 Targets and Drivers	2030 Targets ³
 Greenhouse Gas Emissions	Reduce emissions by 25% ¹	31% Reduction Procurement of renewable energy and renewable energy credits, low commercial production activity and infrastructure investments.	<ul style="list-style-type: none">• Net-zero emissions.⁴• 55% GHG reduction from 2017.• 100% renewable electricity.
 Energy⁵	Reduce energy consumption (natural gas, other fuels and electricity) by 10%	11% Reduction Conservation initiatives, infrastructure investments, remote working conditions and reduced production activity.	<ul style="list-style-type: none">• 10% energy reduction from 2025.
 Water⁶	Reduce water withdrawal by 20%	19% Reduction Increased water intake efficiencies and low production activity.	<ul style="list-style-type: none">• 5% reduction from 2025.
 Solid Waste⁷	Reduce solid waste to landfill by 20%	40% Reduction Conservation initiatives, vendor management and remote working conditions.	<ul style="list-style-type: none">• 30% reduction in solid waste produced from 2025.• Over 90% diversion from landfill or incineration.• Zero solid waste to landfill certification where applicable at major sites.
 Hazardous Waste⁸	Reduce hazardous waste by 5%	9% Reduction Projects to reduce unused and expired materials, and partnerships to reduce waste generation.	<ul style="list-style-type: none">• 5% hazardous waste reduction from 2025.

1. Operational goals shown are absolute targets and not indexed to production levels or growth. 2022 performance was affected by changes associated with occupancy and operations during the COVID-19 pandemic, as well as conservation and changes in how Boeing purchases energy. The targets were established against a 2017 base year. The 2025 goals will act as a milestone to guide actions and progress to the 2030 goals.

2. All 2025 reduction goals were set with an operational boundary of the Core Metric Sites, which represent the majority (70%) of Boeing's operations, and includes emissions from electricity use and natural gas.

3. The 2030 reduction goals set with an operational boundary of The Boeing Company and includes all Scope 1 and Scope 2 emissions.

4. The net-zero achievement covers Scope 1 and Scope 2 emissions for all manufacturing and work sites within the company's operational control as well as Scope 3, business travel. This is achieved by **expanding conservation and renewable energy** use while securing carefully selected, third-party-verified offsets for the remaining greenhouse gas (GHG) emissions.

5. Energy includes natural gas, other fuels and electricity.

6. Water data represents approximately 84% of operations square footage.

7. Solid waste numbers represent values determined from scale-weighted containers as well as calculated weights. **Nonhazardous solid waste is sent to landfill for disposal**. This measure applies to all waste streams where Boeing is responsible for **waste disposal service** as a normal part of daily operations (excludes remediation and construction-related waste).

8. Hazardous waste is determined from U.S. EPA hazardous manifest or equivalent government shipping documents. All types of hazardous wastes that are generated at a facility and are discarded from the site for disposal, and would be considered part of the environmental footprint of the site. Actual tons of all Production or routine wastes shipped as hazardous waste (excludes remediation and construction-related waste).

Addressing Climate Change

We consider climate change to be an urgent issue. We support the goals of the Paris Agreement and encourage our value chain partners to do the same. Boeing achieved net-zero carbon emissions at manufacturing and other work sites and in business travel in 2022 for the third consecutive year, by expanding conservation and renewable energy use while securing carefully selected, third-party-verified offsets for the remaining greenhouse gas (GHG) emissions. Boeing strives to reduce operational GHG emissions, both during times of growth and during times of challenge. Our strategy for Scope 1 and Scope 2 emissions, which we detail in the following section, aligns to a 1.5 degrees Celsius global warming potential scenario, in support of the global climate goals.

To achieve our goals related to the climate and to GHG, we actively monitor emissions, fuel use and energy efficiency. We have set 2030 targets for performance in each of these areas that aim to reduce absolute emissions, maintain net-zero emissions for Scope 1 and Scope 2, and increase our adoption of renewable energy sources. As part of Boeing's business continuity program, we also monitor the length and severity of business interruptions. The scope of monitoring includes damaging weather, natural disasters, pandemics and public health crises. It helps us understand how to increase resiliency in light of a changing climate.

Enterprise GHG emissions from operations are calculated after the conclusion of the reporting year. However, the emissions from natural gas and electricity usage at Core Metric Sites are calculated and monitored on a monthly basis through the use of utility bills and are continuously validated

and updated throughout the reporting year. The emissions factors for these energy sources are validated at least annually and updated when appropriate following guidance from the World Resources Institute GHG Protocol. The energy data and emissions factors are verified as part of a third-party limited assurance process.

For the third year in a row, Boeing has achieved net-zero GHG emissions at manufacturing and work sites by implementing high-impact conservation investments, emphasizing and incentivizing conservation practices by employees, and increasing renewable electricity use while securing carefully selected, third-party-verified offsets for the remaining GHG emissions.

In 2022:

- **2025 GHG Target Progress:** Boeing had a 31% reduction in GHG emissions compared to 2017. GHG emissions were 8% lower than anticipated for the year. Procurement of renewable energy and renewable energy credits, low commercial production activity and infrastructure investments contributed to reduction in emissions from the operational footprint. The implementation of long-lasting infrastructure improvements and the contracting of renewable energy allow us to build on emissions reductions each year.
- **2025 Energy Reduction Target Progress:** Boeing had a 11% reduction in energy consumed compared to 2017. Energy consumption was 6% lower than anticipated for the year due to the impact of conservation initiatives, infrastructure investments, remote work and reduced production activity.



Boeing's Pollinator Prairie in Kansas. (Boeing photo)

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“Sustainability is something everyone should be thinking about. What kind of planet do you want to leave behind for future generations?”

Gregory Kurth, Mesa site facility maintenance engineer, Facilities & Asset Management

Boeing facilities prioritize conservation, energy efficiency and renewable energy

As energy consumption gives rise to GHG emissions, conservation and energy reduction measures help achieve both energy and GHG reductions.

Creating sustainable facilities:

Germany: Boeing’s new distribution center in Hamburg meets high sustainability standards and will be seeking Gold certification from the German Sustainable Building Council. To minimize the environmental footprint, the building is equipped with a heat pump and a photovoltaic system will be installed on the roof in the later half of 2023.

U.S.:

- Mesa, Arizona, recently completed construction of a new composites manufacturing facility. A quarter of the electricity used at the site is solar power. This partnership between Boeing and the Salt River Project brings the company closer to achieving its 2030 goal of 100% renewable electricity.
- Switching to LED lighting in Boeing’s Everett, Washington; Frederickson, Washington; and El Segundo, California, facilities is driving an annual recurring savings of 25.3 million kilowatt-hours, which is equivalent to powering more than 2,300 U.S. homes per year.

India: Boeing’s new engineering and technology campus in Bengaluru will leverage multiple design elements, including efficient ventilation systems, LED lighting, rainwater recovery and solar power generation.

Boeing expanded its strong presence in Europe with a new state-of-the art distribution warehouse near Hamburg, Germany. (Boeing photo)

It comes down to this: Boeing will continue to invest in conservation and renewable energy projects to advance the company’s operational environmental goals.

Conserving Resources

Engaging Employees in Conservation

Boeing has implemented multiple approaches to encourage the workforce to **support conservation by fostering sustainable behaviors**. Employees are a source of innovation; champions of projects and their combined actions contribute to achieving Boeing’s goals.

The programs that Boeing utilizes to get employees involved and contribute to the enterprise sustainability goals are designed to reach all aspects of the workforce (**Page 12**). Elements of sustainability are embedded within the Boeing Production system content and linked to Lean methodologies that **eliminate waste and promote more efficient, sustainable practices within operations**. Additionally, Boeing provides behavior change training and encourages recognition programs to help employees develop sustainable habits and reward them for their efforts.

The approaches used include elements of gamification, which involves turning sustainable behaviors into fun and engaging programs. Key employee engagement avenues include:

- **The Conservation Best Practices program**, which is deployed across the enterprise to prioritize **reducing energy, water and waste** at our largest areas of operation.
- **The Energy Star Battle of the Buildings** competition to encourage employees to work together toward our sustainability goals and promote a culture of environmental stewardship.
- **Aerospace Sustainability Foundations Training**, an internal credential **training that allows employees to learn more about sustainable aerospace and practices** and how they can incorporate them into their work.

By emphasizing employee engagement throughout the sustainability programs, Boeing is benefiting local communities and utilizing the capabilities of its diverse workforce to achieve its operational sustainability goals.

Earth Month photo contest winners

Boeing’s Earth Month celebrations included a photo contest. Participants had the opportunity to submit a photograph with a description of what sustainability means to them.



Winner: Kaitlin Brush Brevig, BCA, Interiors Responsibility Center

For Kaitlin, sustainability means being able to find secret beauty in nature, without negatively affecting it. Photo entitled “Fog Camano,” located in the Puget Sound.



Runner-Up: Katie Ziegler, 777 Fleet Chief Office

For Katie, sustainability includes protecting the honey bees that pollinate plants, sustaining food sources for humans and animals. Factors threatening honey bees include pesticides, disease and their natural predators like the giant hornet. Making honey bees a regulatory and lifestyle priority is critical.

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Employees more than double goal in annual conservation competition

While Boeing focuses on conservation every day, the company hosts an annual competition starting on Earth Day in April to encourage Boeing employees to take daily actions that advance sustainable operations.

Employees across the globe took more than 231,000 60-second actions for the environment from Earth Day on April 22 to May 31, 2022. This was the equivalent of

reducing carbon emissions by not driving 7.8 million miles (12.6 million kilometers). Top 60-second actions included **using refillable water bottles, recycling and turning off equipment not in use.**

Winners from across the globe:
The Battle of the Buildings competition among sites was based on the number of actions per capita and the winners in each category were:

- BGS
- Everett, Washington
- San Antonio
- Winnipeg, Canada
- Seattle Spares Distribution Center
- Berlin

“When employees engage in taking 60 seconds for the environment, we know it cuts costs, helps protect the environment and gives employees a sense of belonging, drive and purpose.”

Steve Shestag, director, Sustainable Operations, Global Enterprise Sustainability



Always with quality and pride, the Boeing Spares Distribution Center employees in SeaTac, Washington, step up as Battle of the Buildings winners, including (left to right): April Nelson, Steven Yaummarath, Jo Dollente, Brandon Stanfield, Justin Roberts, Brett Nichols and AJ Flores. (Boeing photo)

Reducing Waste

Boeing is making strides to protect the land, water and air in our communities by **reducing waste from work sites and our supply chain**. Waste streams are as complex as our facilities, which range from office space to part fabrication to assembly of aircraft and space vehicles. Solid waste includes material that has been **discarded or abandoned or that is no longer useful or usable and has been designated for removal**. Items that are reused or reclaimed are excluded from solid waste. Boeing has dedicated teams working to prevent waste from going to landfills and to assess opportunities to return or reuse packaging for parts.

Boeing generates hazardous waste primarily from a variety of research, manufacturing and facilities maintenance processes. **Hazardous waste may be recycled upstream or downstream, as on-site or off-site reclamation and avoided generation through processes that extend useful life** of consumable chemicals to avoid hazardous waste. We look **to reduce hazardous waste in upstream activities by preventing or reducing the amount of hazardous waste generated through extending system life through contaminant removal**. Downstream, we look at hazardous waste generated from site operations. We implement **several recycling and recovery activities to reduce the need for new chemicals**.

Progress Toward 2025 Hazardous and Nonhazardous Waste Goals

- **Solid Waste – 40%** reduction compared to 2017. The continued trend of increased remote working conditions influences the overall reduction in solid waste. Conservation initiatives and vendor management continue to be opportunities to drive further reductions.
- **Hazardous Waste – 9%** reduction compared to 2017. Hazardous waste was 1% higher than anticipated during the year. Benefits from implementing conservation initiatives were outweighed by key events across the enterprise, including a historical flood event in St. Louis, which caused an unplanned increase in hazardous waste disposal from a water treatment system.

The Stingray gets Lean

As the U.S. Navy’s uncrewed aerial refueler, the MQ-25 Stingray is a model of efficiency, in the air and on the production line.

The digitally engineered aircraft features a **highly efficient engine and lightweight composite skin**, allowing it to stay in the air much longer, **using little fuel itself to complete its mission**.

Within the factory setting, robotic automation and advanced assembly techniques eliminate the need for drilling during aircraft assembly.

Now, the futuristic aircraft is setting new standards for efficiency with a renewed focus on **reducing waste through Lean manufacturing**.

Across Boeing’s production system, teams are building momentum with Lean principles. The MQ-25 is the first program within Boeing Defense, Space & Security to undergo a renewed focus on Lean.

A focus on the customer: “We know what Lean means to our Navy customer — operational excellence, stability and execution,” Troy Rutherford, MQ-25 vice president and program manager. “When we focus on removing waste from the system and listening to those who do the work, then production, innovation and creativity all take a huge leap forward. We’re excited to be the first program to engage with the Lean workshops.”

What is Lean? Lean is a way of thinking and acting that enables us to solve problems and continually improve. It is the foundation of Boeing’s production system and embraces just-in-time delivery, error-free production and continuous flow. Lean helps spot and **eliminate waste, wherever it is found, which also reduces costs**.

The MQ-25 Stingray is an uncrewed aircraft system, designed for the U.S. Navy, providing robust refueling capability. (Boeing photo)



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Facilities & Asset Management Reclamation team member Jon Kelley is Boeing’s 2022 Environment Champion. (Boeing photo)

Boeing Recognizes 2022 Environment Champion

Jon Kelley, Facilities & Asset Management Reclamation team member, brings heart, commitment and skill to reduce waste to landfill, conserve valuable resources and ensure the company is compliant with regulations that protect the environment and the public.

In 2022, Kelley was recognized as the Environment Champion for his environmental passion and 40 years of commitment to Boeing. Throughout his career, Kelley has done more than his job required for conservation and protection of the environment and public safety. By doing this, he has helped Boeing’s Puget Sound sites maximize the conservation of materials and properly handle regulated materials, while providing guidance to business partners.

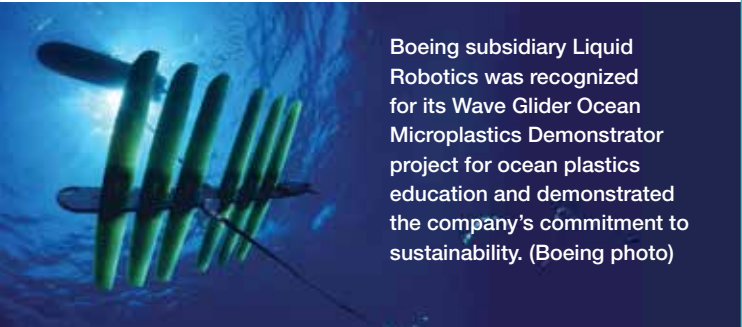
Kelley constantly redefines his job by raising the bar of efficiency and standard of quality. Leaning on his decades of experience, Kelley has helped to develop tools and training methods to increase his team’s efficiency without compromising safety or quality. He further demonstrates his commitment to sustainability by training and inspiring employees to prioritize conservation and cross-functional collaboration.

Kelley humbly describes his work as simply: “Doing the right thing to keep things out of the landfill.”

Boeing honors employees who embrace environment

Employee innovation recognized: Below is a sampling of the 15 environmental leader winners in six categories that focused on reducing waste, energy and water use.

- **In Everett, Washington,** 260 Boeing employees from 40 organizations generated 1,800 sustainability ideas to consider for future products in a “sustainability lab.”
- **Seattle** employees reclaimed about 2,500 gallons of water per day at the Seattle Developmental Center by reconfiguring piping and installing a more efficient system.
- **Winnipeg** employees conserved electricity equivalent to 60 homes’ annual use by installing occupancy sensors and upgrading LED lights, saving almost 720,000 kWh yearly.
- **A Mesa team** worked with the local utility company to lessen demand on high peak utility days during summer months by programming the Building Automation System to improve processes and generate 5,400 kWh, which earned rebates of \$30,000 annually.
- **An Everett team** reduced the amount of solvents required to flush paint pumps by removing filter housing. The result cut solvent use by 12 gallons per airplane and more than 10,000 pounds per year, saving almost \$19,000.
- **In Chennai, India,** employees reduced GHG emissions by consolidating shipments and transitioning from air to sea shipments for India suppliers.



Boeing subsidiary Liquid Robotics was recognized for its Wave Glider Ocean Microplastics Demonstrator project for ocean plastics education and demonstrated the company’s commitment to sustainability. (Boeing photo)

Reducing water consumption

Boeing sets rigorous water use reduction targets at our manufacturing sites to preserve this natural resource for the environment and our communities. Boeing’s water is sourced from local public utilities (surface, ground and reclaimed water) and company generation (on-site well, on-site reclamation and rain capture). This sourced water supports manufacturing, sanitation, drinking water, cooling and irrigation across the company. The majority of our water is from public water supply systems, and most consumption measurement is from water system revenue-grade meters. Water used within our facilities is discharged to public sanitary sewer systems. In some cases, Boeing pre-treats wastewater before discharging it to public sanitary sewer systems, in compliance with regulatory requirements. Boeing does not set voluntary effluent discharge standards beyond those set by regulation.

Boeing specialists work to identify efficiencies, best practices and new technologies to reduce water use and identify alternatives. We monitor irregularities that may require action and created a Conservation Best Practice program to minimize water use, applying many water management techniques endorsed by the U.S. Environmental Protection Agency.

In 2022, we achieved a 19% reduction compared to consumption in 2017. Water consumption was 7% lower than anticipated with sites implementing conservation initiatives to increase water intake efficiencies and with production activity remaining low. Building off the reductions seen by 2025, Boeing will transition to an absolute reduction goal to focus on the most water-intensive processes across the company.

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Biodiversity and Environmental Compliance

Boeing owns thousands of acres of habitat across five locations that are being protected or restored. Each habitat is actively managed and maintained by site employees, nonprofit organizations or contract biologists. For some locations, additional agreements and monitoring are in place to ensure all legal, contractual and certification requirements are met.

Each habitat is certified by the Wildlife Habitat Council (WHC), with three certified at the Gold level. The WHC's certification program is the only voluntary sustainability standard designed for broad-based biodiversity enhancement and conservation education activities on corporate landholdings.



- **Avian Project Award:** Awarded to Boeing for monitoring targeted species and food sources — and being managed by adapting to the environment. The Grasshopper Sparrow is also a happy recipient.
- **Grasslands Project Award:** Awarded to Boeing for monitoring of vegetation, wildlife use of vegetation, wildlife use and evaluation to create next steps for the project.
- **Pollinator Project Award:** Awarded to Boeing for monitoring targeted species and food sources yearly, and recognizes a policy integrated into overall site operations to minimize, eliminate or apply responsible use practices of pesticides and herbicides.

Sustaining biodiversity from Seattle to Charleston

The big picture: The WHC helps companies like Boeing advance biodiversity, sustainability, employee engagement and community relations goals with programs that translate sustainability goals and objectives into tangible and measurable on-the-ground actions. WHC Awards recognize programs and projects that demonstrate excellence in corporate conservation. Boeing's restored Emery Landfill in Wichita, Kansas, was recognized with three awards in 2022 (see left column for details).



5.85 acres of marine habitat,
Boeing Plant 2, Seattle, Washington



1.5 acres of pollinator
gardens, Pollinator Prairie,
Olathe, Kansas



2,668 acres of diverse habitat,
Santa Susana, Canoga Park, California



3,923 acres, Keystone/Fairlawn
Project, North Charleston, Boeing South
Carolina (including 2,025 acres of wetland)



82 acres, Emery Landfill, Wichita,
Kansas (including 56.5 acres of grassland)