



OPERATIONAL ADVANTAGE AND RESILIENCE THROUGH SUSTAINABILITY

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SUSTAINABILITY LANDSCAPE

- Climate change is a key **national security concern**
- Governments and society **expect action** on climate change
- **A more sustainable** military is more **operationally effective** and **resilient**
- Militaries are the **biggest source of emissions** for many governments with **Net Zero commitments**
- The Armed Forces are **not immune** to the impacts of the **wider energy transition**
- **Collaboration is essential.** No single entity, company, industry or government can stop climate change



Ministry of Defence @DefenceHQ

Today marks 100 days to go until #COP26 and Defence is playing its part in supporting the UK's world-leading **sustainable aviation fuel** commitments. 📍 @RoyalAirForce @transportgovuk #TogetherForOurPlanet #OneStepGreener

Up to **50%** of aviation fuels could now come from sustainable sources

Defence aviation fuel standards

Algae will fuel future fighter jets

Changes to Aviation Fuel Standards will spur innovation

UK Defence leading the world in green operations



MINDEF/SAF will meet national targets set under the Singapore Green Plan

Reduce Carbon Emissions Growth

to slow growth by **66%** to cut **50%** from 2010 levels

Reduce Water Consumption

2030 target **10%**

Progressively replace less-efficient water fittings with more efficient

Continue investing in water-recycling systems (e.g. in vehicular waste)

Reduce Waste

2030 target **30%**

Extend food waste segregation recycling processes from current 14 canteens to all SAF canteens

Increase number of recycling bins

Recycle more by putting to prior reuse other waste types

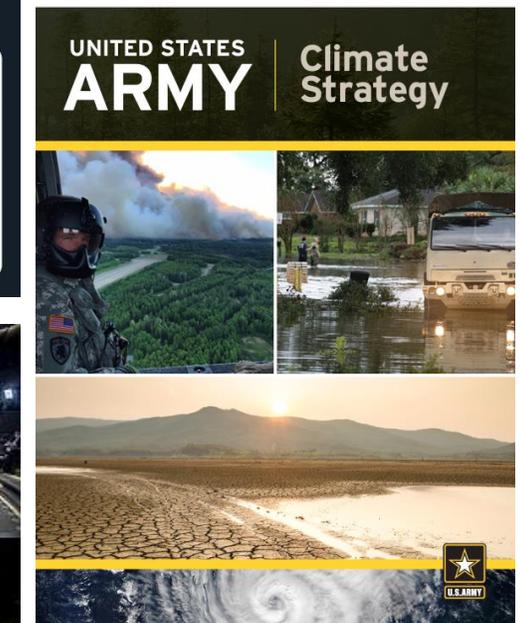
Governance Taking Ownership

Transition to a fully electric Army administrative vehicle fleet by 2025. Changing infrastructure to be built in camps and bases

Equip newer ships such as Littoral Mission Vessels with readily-available green technologies (e.g. energy-efficient LED lighting)

Use green aviation fuel for some F-35s

Increase solar adoption from 20 to 50 MWp by 2025



UNITED STATES ARMY | Climate Strategy

Images showing a soldier in a field, a military vehicle, a desert landscape, and a satellite view of Earth.

U.S. ARMY

SUSTAINABLE AEROSPACE FIRSTS

2008



Diamond DA20



Virgin Atlantic 747

2009



The Boeing 787 Dreamliner



South Carolina 787 Final Assembly Facility

2010



U.S. Navy F/A-18



C-17 Globemaster

2011



International Aerospace Environmental Group

2012



ecoDemonstrator 737-800



Phantom Eye

2014

2015



small-scale farmers in South Africa



Boeing uncrewed demonstrator

2016



Transonic Truss-Based Wing

2018



ecoDemonstrator 777 Freighter



carbon composite fiber

2019



Cora electric air taxi

2021



100% SAF capable airplanes by 2030



testing SAF emissions



cryogenic fuel tank technology

2022

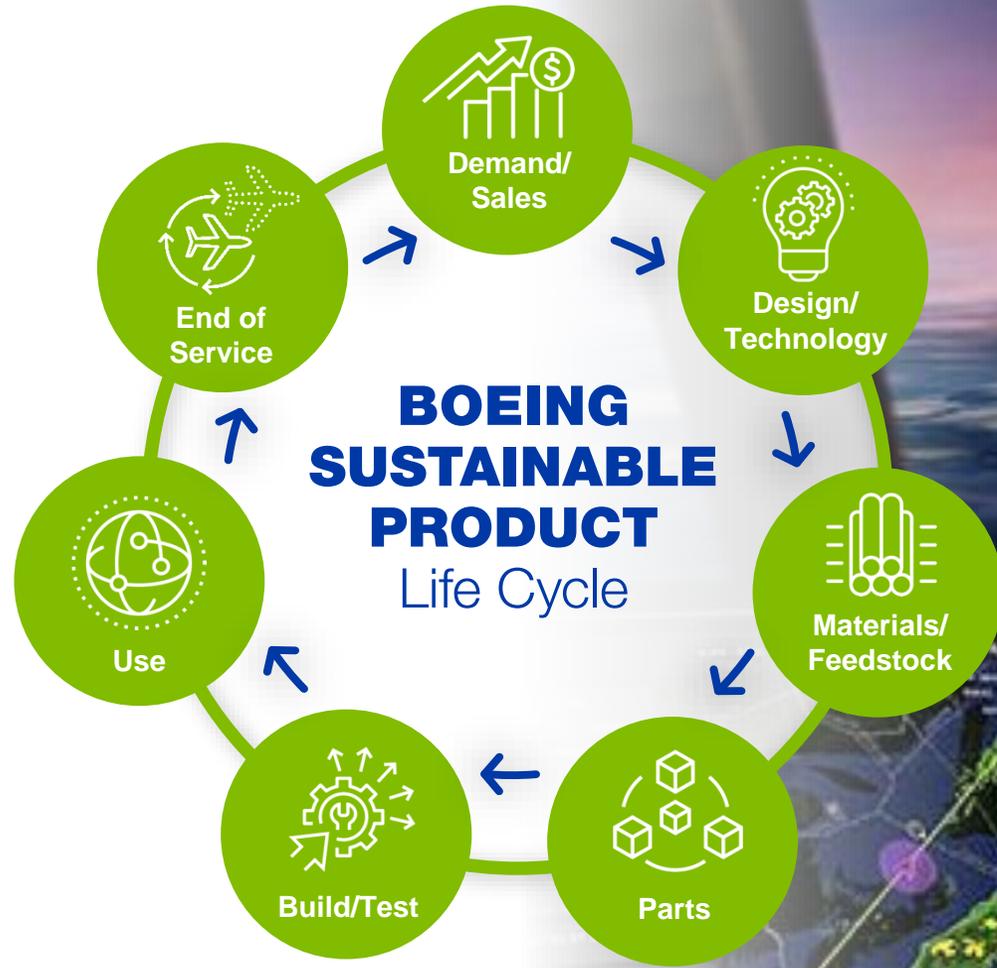


2M gallon SAF procurement

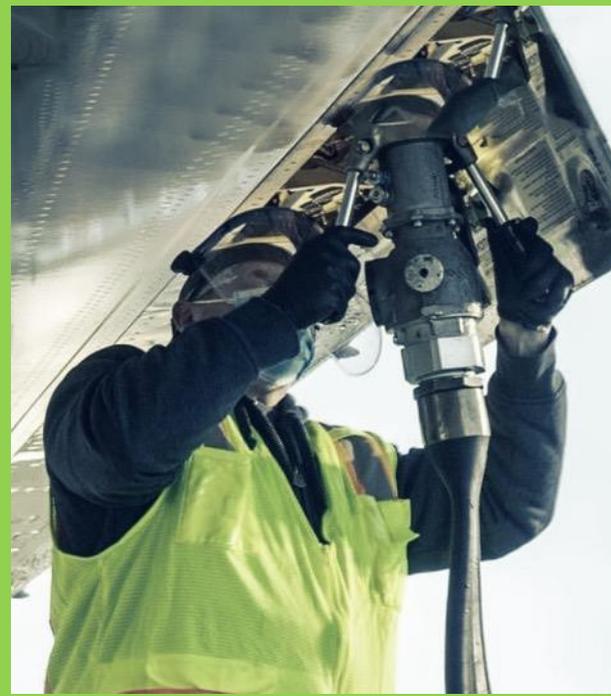


Alder Fuels partnership

SUSTAINABILITY IS BUILT IN



EVERYTHING FOR ZERO



Fleet
renewal

Operational
efficiency

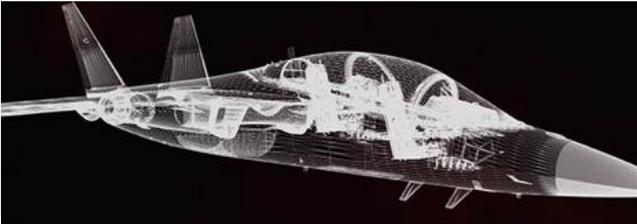
Renewable
energy

Advanced
technology

OPERATIONAL ADVANTAGE & RESILIENCE THROUGH SUSTAINABILITY

Digital design & Manufacturing

Dramatically reduce the time, cost and resources (material and energy) required to develop new weapons systems, Out innovate hostile nations.



Fleet renewal

Delivering greater warfighter capability and better environmental performance (E3-E7, KC-135-KC-46)



Digital tools (Mission Accelerator)

Reduce fuel burn – stay on station for longer, fly further, carry more payload. Optimize maintenance and avoid unnecessary part changes. In both cases reduce logistics burden and associated force protection.



Sustainable Aviation Fuel

Creating fuel local to operations at home and potentially during long term deployments. Fragmented supply landscape but new opportunity for strategic and operational resilience



Responsible supply chain sourcing & additive manufacturing

Reduces vulnerabilities in the supply chain.



Modifications & upgrades

Through life upgrades to increase capability and reduce fuel burn (more time on station).



Training systems (surrogate, synthetic, augmented, collective – T-7, Gladiator, Red6)

Reduced peacetime emissions, better preparing crews for real world threats and saving hours on front line jets.



Energy resilient infrastructure

Ability to operate off-grid at home and deployed. Reduced logistics burden when deployed (with reduction in associated force protection costs) and reduced financial costs at home.



SAF: INTEROPERABILITY

- We have enjoyed decades of **common standards** around Jet Fuel
- There are now **seven types of SAF** approved for commercial use but militaries are inconsistent in which platforms they approve to use which type of SAF
- The EU, UK and others are introducing **SAF mandates**
- SAF is already flowing into the global **jet fuel supply chain**
- We now have a in issue in terms of **Civil-Military** Interoperability and **Military-Military** interoperability
- Unless this is solved militaries will need to create **independent fossil fuel supply lines**
- We need alignment between military and commercial standards. This would also allow the military to buy SAF, supporting energy resilience and the scaling up of the SAF sector (as NATO supports)



SAF: RESILIENCE AND FREEDOM OF ACTION

- SAF will be produced in a **more fragmented way** than fossil fuels due to the nature of the feedstocks (agricultural waste, municipal waste, industrial waste gases, etc.)
- SAF provides an opportunity to produce fuel on shore from various pathways. This provides **strategic resilience**
- Technologies such as power to liquid provide an opportunity to achieve **local SAF production** at major long term deployments where sufficient energy can be provided. This could be highly significant in terms of freedom of action and **freeing operations from traditional supply lines**



SAF: DECARBONISATION

- Within defence, aviation is typically a **major source of emissions**
- SAF has the **largest potential** for near-term and long-term impact
- **Air Forces' emissions** have some similarities to airlines, the Air Transport fleet (like long haul fleets) tend to create the bulk of emissions
- **Commercial derivative fleets** will follow the technology roadmaps of the commercial sector
- **Fast Jets** (as we know them today) will be unlikely to have any alternative to hydro carbons



COMMERCIAL INDUSTRY VIEW

~27% of CO2 emissions

~73% of CO2

	2020	2025	2030	2035	2040	2045	2050
Commuter 9-50 seats <60 minute flights <1% of industry CO2	SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF
Regional 50-100 seats 30-90 minute flights ~3% of industry CO2	SAF	SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF
Short haul 100-150 seats 45-120 minute flights ~24% of industry CO2	SAF	SAF	SAF	SAF potentially some Hydrogen	Hydrogen and/or SAF	Hydrogen and/or SAF	Hydrogen and/or SAF
Medium haul 100-250 seats 60-150 minute flights ~43% of industry CO2	SAF	SAF	SAF	SAF	SAF potentially some Hydrogen	SAF potentially some Hydrogen	SAF potentially some Hydrogen
Long haul 250+ seats 150+ minute flights ~30% of industry CO2	SAF	SAF	SAF	SAF	SAF	SAF	SAF

Source: ATAG Waypoint 2050 Report

ELECTRIFICATION



Architecture



Battery electric



Fuel cells

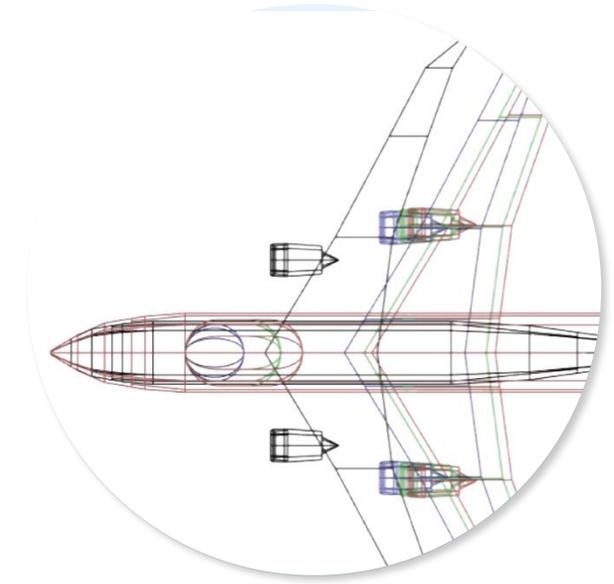
HYDROGEN



Hydrogen fuel cells
and combustion



Onboard and airport
storage and distribution



Airplane-level
integration



Composite cryotank



