Technology Roadmap for Environmental Improvement

Fact Sheet

The largest contribution to emissions reduction in aviation comes through aircraft technology and sustainable aviation fuels. Many aircraft operators are in the process of renewing or expanding their fleets. Between 2014 and 2018, an average of 1,700 new commercial aircraft were delivered each year.

- Each new generation of aircraft yields a typical 15% fuel efficiency improvement compared to the generation it replaces. This replacement occurs on average every 20 years, although smaller serial improvements and retrofits occur in the intervening period.
- New generation aircraft recently introduced or about to enter the market in the coming few years:

Seat category	Aircraft Category	2010 reference	New generation (examples)	Entry into service	Fuel saving vs reference
51 – 100	Regional jet	ATR/CRJ	MRJ	2020	20%
		E-Jet	E-Jet E2-190/-195	2018/19	17%–24%
101 – 210	Narrow body	A320/B737	A220/A320neo/B737 MAX	2016/2017	15%–20%
211 – 300	Wide body	B767	A350/B787	2015/2011	20%–25%
301 – 400		A330/B777	A330-800neo/B777X-8	2020/23	14%–20%
401 – 500		A330/B777	A330-900neo/B777X-9	2018/2021	14%–20%

- Next generation tube-and-wing aircraft configurations are still expected to enter service before 2035. These aircraft will contain technologies that **evolve** from current iterations.
- After 2035, the potential to improve further on fuel economy on a tube-and-wing aircraft is likely to be limited. New **revolutionary technologies** of airframe and propulsion systems are expected to take place after 2035.

Potential in fuel burn and CO_2 reductions for aircraft propulsion technologies

Around 80% of the fuel savings mentioned in the table above are due to improvements in the aircraft engine. More improvements can be expected from an **evolution** of current engine technology followed by a **revolution** of the propulsion systems.

	Timelines and examples of propulsive technologies	Impact on Jet Fuel Burn compared to baseline
Current - Operational	**2010–2019:** Higher bypass and pressure ratios, lighter materials	**10- 15%***
Evolutionary development	**~2020-25:** High pressure core + ultra-high by-pass ratio geared turbofan	**20-25%***
Revolutionary development	**~2030:** Open rotor	**30%***
	~2030-40: Hybrid electric propulsion (depending on battery use)	**40 to 80%***
	~2035-40: Fully electric propulsion (primary energy from renewable source)	**up to 100%***

All values compared to **baseline tube-and-wing aircraft of technology level widely in service in 2015*

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Potential in fuel burn and CO_2 reductions for aircraft design

Improvements in fuel consumption and CO_2 emissions can also be made through airframe and equipment upgrades. These reductions are referenced to a standard tube-and-wing aircraft without the quoted technology. The Evolutionary and Revolutionary reductions presented are also a consequence of better propulsion systems.

	Timelines and examples of aircraft design technologies	Impact on jet fuel burn compared to baseline
Evolutionary Technologies	**Currently: Airframe Retrofits** (winglets, riblets, lightweight cabin furnishing)	**6 to 12%**
	Currently: Materials and Structure (composite structure, adjustable landing gear, fly-by-wire)	**4 to 10%**
	2020+: Electric Taxiing	**1 to 4%**
	2020-25: Advanced Aerodynamics (hybrid/natural laminar flow, variable camber, spiroid wingtip)	**5 to 15%**
Revolutionary Technologies	**~2030-35:** Strut-braced*	**30%**
	~2035: Double bubble fuselage*	**35%**
	~2035-40: Box/joined wing*	**30-35%**
	~2040: Blended wing body**	**27 to 50%**
	~2035-45: Full electric aircraft (short range)	**Up to 100%**

*With advanced turbofan engines ** With hybrid propulsion

Most promising technologies for next-generation aircraft (before 2035)

- Tube-and-wing aircraft with more efficient engines (geared turbofan, high pressure-ratio core, ultrahigh bypass ratio engines).
- Composite structures for wing and fuselage
- Winglets, riblets and variable camber with new control surfaces
- Active load alleviation and structural health monitoring
- Fuel cells for onboard electricity supply
- Advanced fly-by-wire systems
- Laminar flow control technology (natural and hybrid)
- As more effort is put into reducing fuel burn and emissions, the gains become smaller. Achieving more than 30-35% reduction in fuel burn with current airframe-engine configuration will become challenging.

More radical technologies for the longer-term future (2035 onwards)

- More radical aircraft concepts and new energy sources are being studied for their potential to significantly reduce emissions. It is estimated that they could contribute to achieving the long-term overall industry goal of reducing aviation's global carbon footprint by 50% by 2050, compared to 2005 levels.
- Aircraft design solutions that can lead the industry closer to those goals involve a fundamental change in the geometry of the aircraft combined with radically new propulsion systems.
- Hybrid-electric aircraft on a new airframe body such as the Blended Wing Body can achieve CO_2 emissions reductions of up to 40%.
- Fully electric aircraft, with electricity generated from a carbon-free source, can completely eliminate CO_2 emissions in the aircraft operation.
- Electric propulsion will start entering the market in small (~2-5 passengers) vehicles in the shape of electric aero-taxis (2020-25), and in larger vehicles (over 80 passengers) in the shape of hybrid-electric propulsion (~2030).
- With the scaling of electric technologies, short-range, fully electric civil aircraft (100-150 passengers) can be optimistically expected by 2035-40.

Partnership

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