Business Jets Workshop 2025

21st – 22nd January 2025
EASA Headquaters
Cologne, Germany

#easabusinessjets

EASA
European Union Aviation Safety Agency

"Aviation is proof that given the will, we have the capacity to achieve the impossible".

Edward Vernon Richenbacher

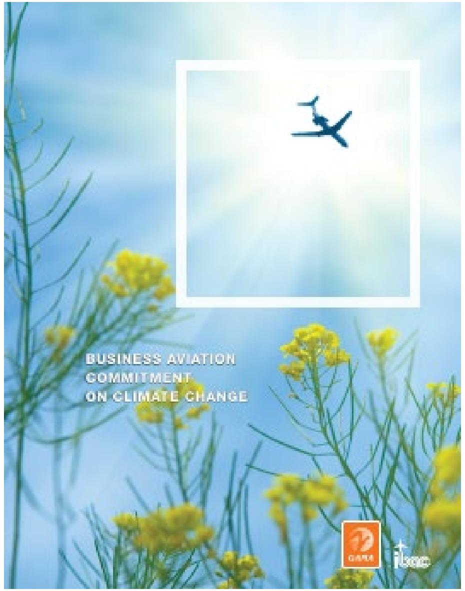
Bruce Parry

Senior Advisor
Government & Industry Affairs
Bombardier

European Union Aviation Safety Agency

The Business Aviation Commitment on Climate Change

- In 2009, the business aviation industry published the Business Aviation Commitment on Climate Change (BACCC)
- Published by the International Business Aviation Council (IBAC) and the General Aviation Manufacturers Association (GAMA)
- The BACCC was comprised of;
  - 3 aspirational goals
  - That would be derived from 4 key mechanisms



BACCC – Goals & Evolution

2009

Objective 1

Reducing CO_2 emissions 50% by 2050, relative to 2005

Objective 2

Improving fuel efficiency 2% per year from 2010 until 2020

Objective 3

Achieving carbon-neutral growth from 2020

2021

Objective 1

Net-zero CO_2 emissions by 2050

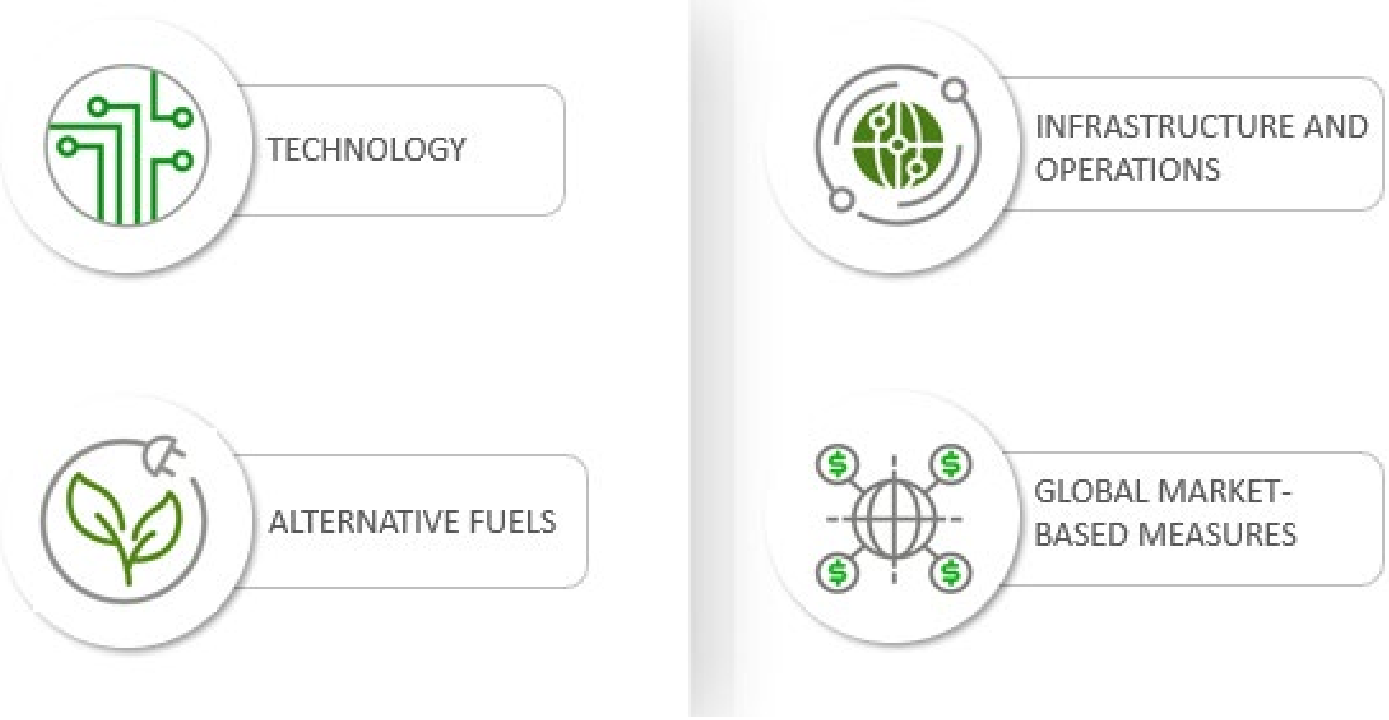
Objective 2

Renew commitment to improve fuel efficiency by 2% per year from 2020 until 2030

Objective 3

Continue carbon-neutral growth from 2020

BACCC – 4 Mechanisms

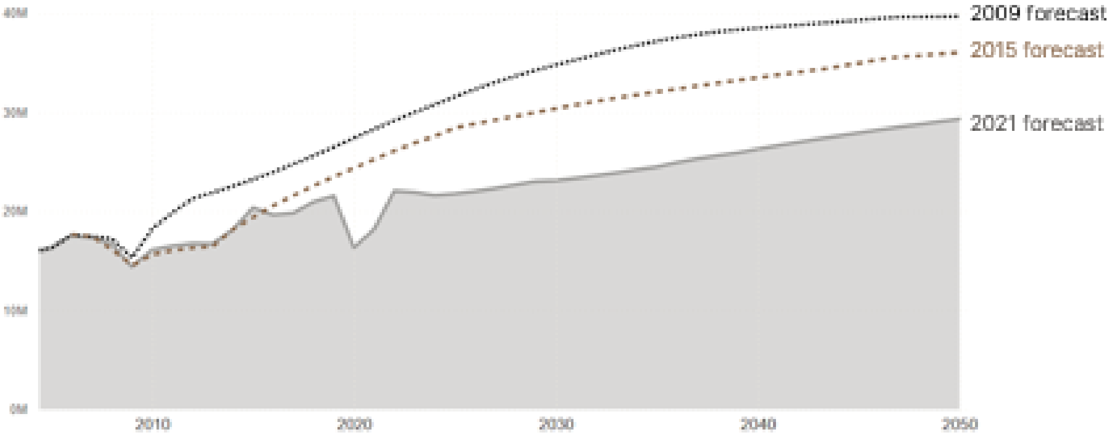


BACCC – Basis for Calculations

FORMULA

$$\text{Year } CO_2 \text{ emission (t)} = \frac{\text{total fleet number X flight hour X fuel flow X 6.75 (fuel density)}}{\text{2204.623 (lbs to ton)}} \text{ X 3.16 (} CO_2 \text{ emission from 1 unit aviation fuel)}$$

BUSINESS AVIATION TOTAL CO_2 EMISSIONS – COMPARISON
[million tons, 2005 – 2050F]



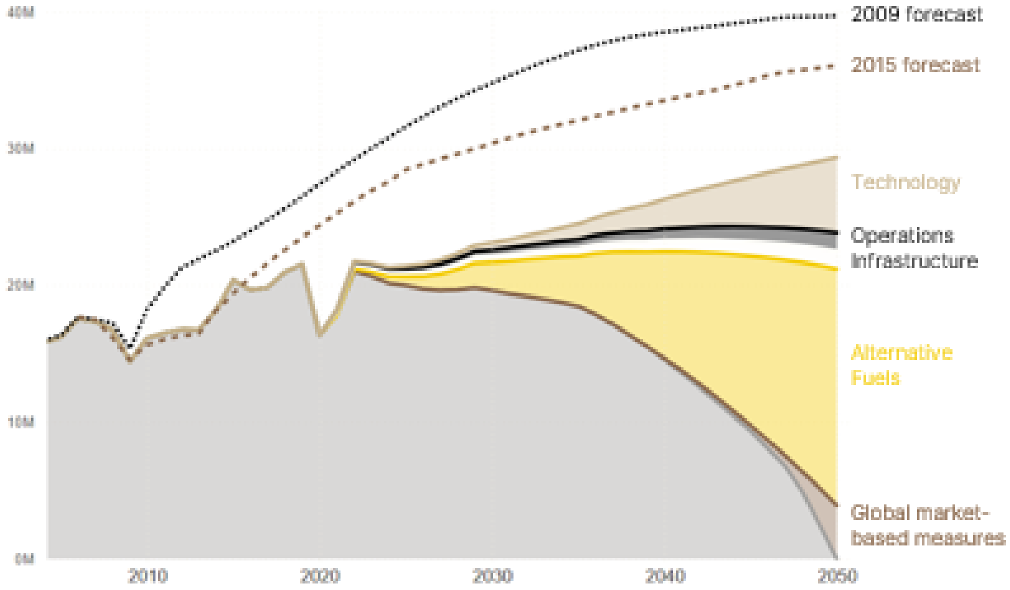
DATA SOURCES and ASSUMPTIONS

- **Fleet** – Based on expected deliveries and retirements. Forecast considering GAMA Aircraft shipment reports and a 17-year lifespan
- **Flight Hours** – Average Flight Hour forecast from FAA
- **Fuel Flow** – Average fuel consumption, considering manufacturer specifications, weighted by aircraft size
- **Constants** – Fuel density (6.75 lbs/US gallon) and Jet fuel emission factor (3.16 kg CO_2/kg of fuel)

Sources: GAMA, ASCEND, Jetnet, TRB 10-year Forecast and Bombardier Calculations

BACCC – 4 Mechanisms contribution

BUSINESS AVIATION TOTAL CO_2 EMISSIONS – 2021 FORECAST
[million tons, 2005 – 2050F]



ASSUMPTIONS

- **Technology** – constant at 2050 level (Jet – 54% CO_2 reduction improvement / TBP – 56% CO_2 reduction improvement)
- **Operations & Infrastructure** – constant at 2050 level (4.5%)
- **Reduction through SAF** - continues to improve at the same rate, reaching 88% by the end of 2060
- **Net Zero:** To achieve net zero carbon emissions by 2050, 11 million tons need to be offset from 2040 to 2050

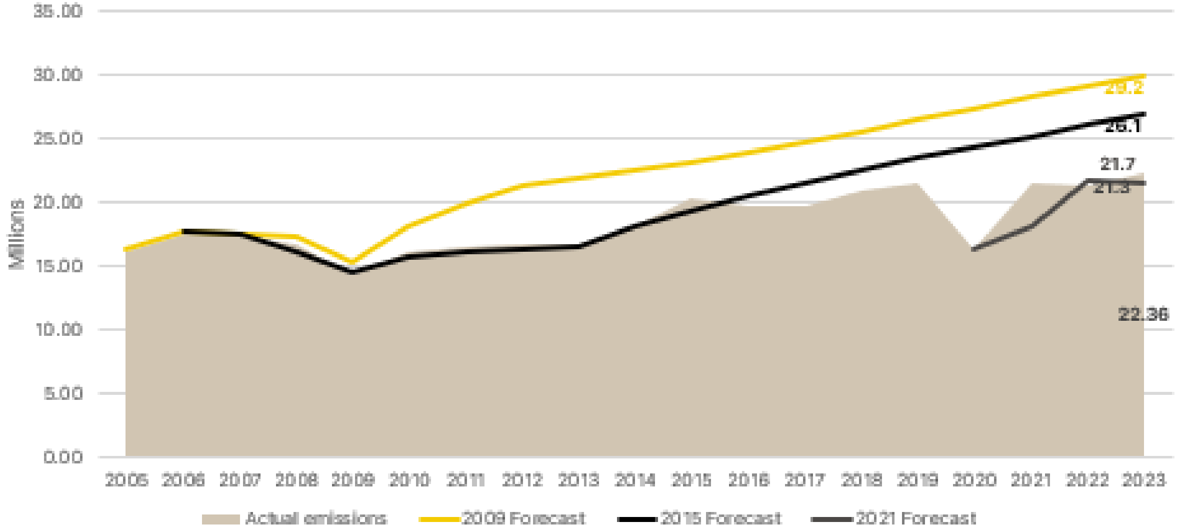
Success of our commitment to climate change hinges on significant adoption of SAF

Sources: GAMA, ASCEND, Jetnet, TRB 10-year Forecast and Bombardier Calculations

Today our sector is performing at our 2021 forecasted CO_2 emission levels

BUSINESS AVIATION TOTAL CO_2 EMISSIONS – COMPARISON

[million tons, 2005 – 2023]



INSIGHTS

COMPARED TO 2009 FORECAST

- Between 2009 and 2023, we emitted 76M tons less CO_2 than 2009 forecasted levels

COMPARED TO 2015 FORECAST

- Due to the pandemic we see a drastic drop in flight activity in 2020(-26% , leading to the forecast review
- Between 2015 and 2023, we emitted 26M tons less CO_2 than 2015 forecasted levels

COMPARED TO 2021 FORECAST

- CO_2 emission levels in 2022 are at par with forecasted levels in 2021. However, the flight activity returned to pre-pandemic levels faster than expected
- In 2023, we emitted 0.8M tons more CO_2 than 2021 forecasted levels

In 2023, our fleet of 38,000 emitted 22.3M tons of CO_2

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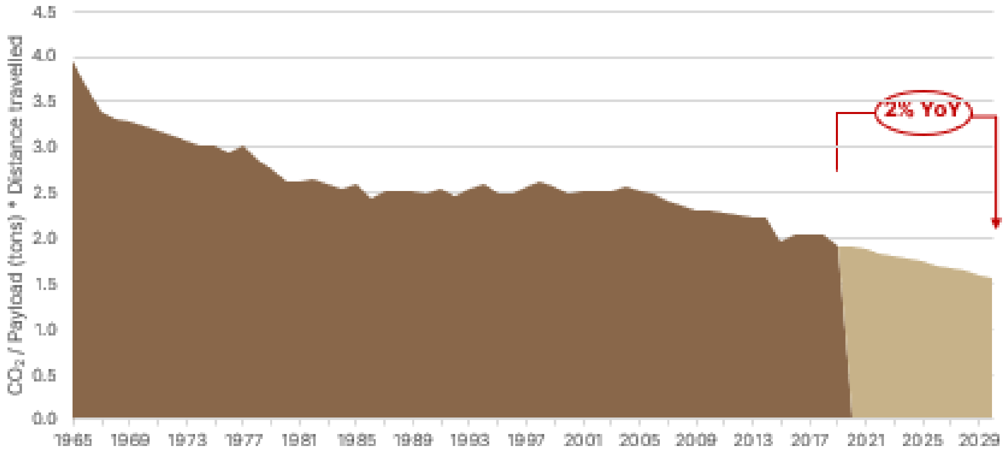
2015 and 2009 forecast – based on last update done in May 2016

Objective 2: Fuel Efficiency target - 2020 to 2030

$$\text{Fuel Efficiency} = \frac{CO_2}{\text{Payload (tons)} \times \text{Distance travelled}}$$

BUSINESS AIRCRAFT FUEL EFFICIENCY – 2021 FORECAST
[CO_2 tons per ton of payload per km travelled, 1965 – 2030F]



ASSUMPTIONS

- **CO_2** – Same calculation as Objective 1
- **Distance** – Estimate using average flight hour forecast from FAA and cruise speed
- **Payload** – Average payload, considering manufacturer specifications, weighted by aircraft size

2020-2030 Target Rationale

- 2% year over year fuel efficiency **shows continuous improvement** in the next decade
- Key drivers for fuel efficiency are distance travelled, introduction of new aircraft, retirement of old aircraft, technological advancements

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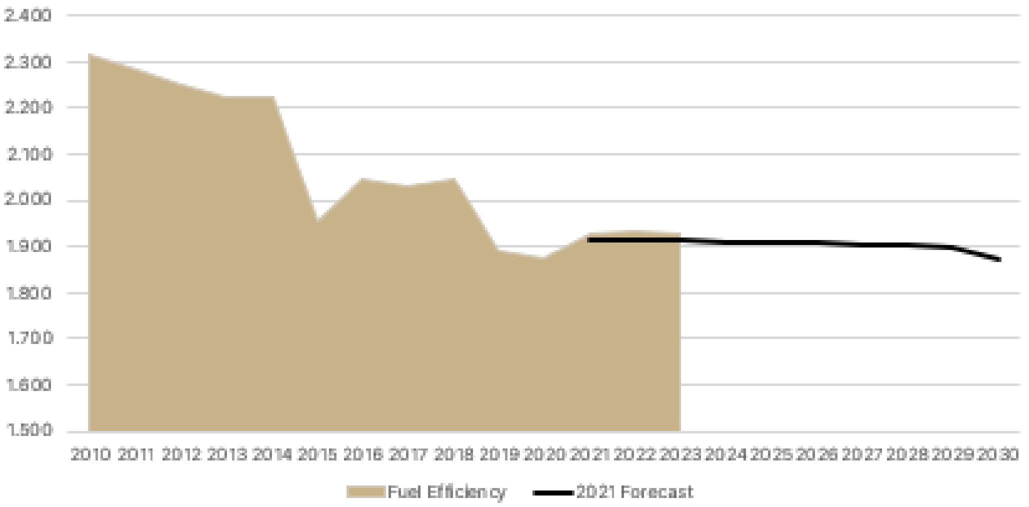
Objective 2: Fuel Efficiency - 2020 to 2030

BUSINESS AIRCRAFT FUEL EFFICIENCY – 2021 FORECAST
[CO_2 tons per ton of payload per km travelled, 1965 – 2030F]



In 2023, our fuel efficiency was 0.2% less than 2022

ASSUMPTIONS

- **CO_2** – Same calculation as Objective 1
- **Distance** – Estimate using average flight hour forecast from FAA and cruise speed
- **Payload** – Average payload, considering manufacturer specifications, weighted by aircraft size

2020-2030 Target Rationale

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Q&A

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Back up slides

Technology Assumptions

Technology Assumptions: Consensus from BACCC industry working group

Technology

	Low gain	Current Business aviation estimated TRL	Expected business aviation solution TRL 6	Expected Tech EIS	Turboprop	Jet engine a/c	For Retrofit	In prod A/C	New aircraft	Part of a disruptive configuration	2020 Low	2020 High	2035 Low	2035 High	2050 Low	2050 High
Aircraft Configuration											0.0%	0.0%	1.0%	4.0%	12.7%	24.8%
Advanced Wings (Truss Braced / Split / Hi-AR Wing / multiple wings)	5%	4	2030	2040	x	x			1	No					5%	15%
Double / Hybrid Fuselage / BWB Shape	10%	4	2030	2040	x	x			1	Yes					10%	20%
Aircraft level optimisation (MDO)	1%	6	2020	2025	x	x			1	Yes			1%	4%	3%	6%
Aerodynamics											0.0%	0.0%	3.9%	14.2%	3.9%	16.9%
Wingtip devices	1%	6	current	2025		x	1	1	1	Yes			1%	2%	1%	2%
Natural and Hybrid Laminar flow	1%	4	current	2025		x			1	Yes			1%	5%	1%	8%
Morphing wings	0%	4	2025	2035		x			1	Yes			1%	4%	1%	4%
Aerodynamics optimisation	0%	4	2025	2030		x			1	Yes			0%	3%	0%	3%
Shark Skin/Riblets	1%	6	2020	2025		x	1	1	1	Yes			1%	1%	1%	1%
Systems											0.0%	4.9%	0.0%	13.2%	0.0%	14.1%
Low Power WAI	0%	9	Current	2030	x	x			1	Yes	0%	1%	0%	1%	0%	1%
Batteries (Li-ion, solid state, graphene, etc)	0%	6	Current	Current	x	x	1	1	1	Yes	0%	1%	0%	2%	0%	2%
Solar power	0%	4	2025	2030	x	x			1	No			0%	1%	0%	1%
Automated tow truck	0%	9	Current	Current	x	x	1	1	1	Yes			0%	3%	0%	3%
SPO + cockpit automation	0%	3	2025	2030	x	x			1	Yes			0%	1%	0%	1%
More Electric Systems	0%	6	Current	2025	x	x			1	Yes			0%	1%	0%	1%
Advanced fly-by-wire	1%	9	Current	2020		x			1	Yes	0%	3%	0%	3%	0%	3%
Integrated Systems	0%	3	2025	2030	x	x		1	1	Yes			0%	1%	0%	1%
Hydrogen fuel cells (for systems power and auxiliary power un	0%	4	2030	2035	x	x			1	Yes			0%	1%	0%	1%
Wireless, Fiber optics, power line communication	0%	4	2025	2030	x	x			1	Yes			0%	1%	0%	2%
Structural Concepts											1.0%	2.0%	2.0%	4.0%	4.0%	7.9%
Active load alleviation	1%	9	Current	Current		x		1	1	Yes	1%	2%	1%	3%	2%	5%
Additive manufacturing	0%	5	2025	2030	x	x	1	1	1	Yes			1%	1%	2%	3%
Materials											1.0%	3.0%	4.0%	7.9%	4.0%	7.9%
Composite primary structures	1%	9	Current	Current	x	x		1	1	No	1%	3%	1%	3%	1%	3%
Composite primary structures 2nd generation	3%	3	2030	2035	x	x			1	Yes			3%	5%	3%	5%
Advanced alloys	1%	8	Current	Current	x	x		1	1	Yes	1%	3%	1%	3%	1%	3%
Engine Technologies											0.0%	0.0%	19.3%	33.0%	33.5%	49.8%
Boundary Layer Ingestion Engine or Hybrid (including distribut	0%	1	2030	2035		x			1	Yes			0%	10%	0%	10%
Hybrid Electric Propulsion (Several Sub-Configs including dist	15%	4	2035	2040	x	x			1	Yes			15%	20%	30%	40%
More efficient gas turbine	5%	5	2025	2030	x	x			1	Yes			5%	7%	5%	7%
Open rotor/unducted fan (system architecture)	5%	6	Current	2025	x	x			1	No			5%	10%	5%	10%
Total Technology											2.0%	9.6%	27.7%	57.6%	48.6%	77.1%
Technology improvements used in Model											9.6%		42.7%		62.8%	

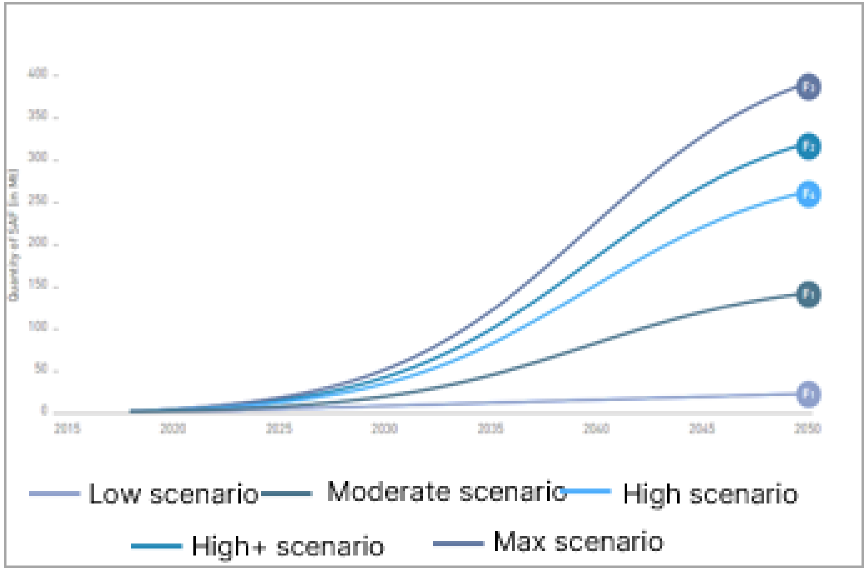
53%

10

Sources: improvements based on estimates by Bombardier engineering

SAF Assumptions

FORECASTED GLOBAL SAF PRODUCTION (Mt/y)

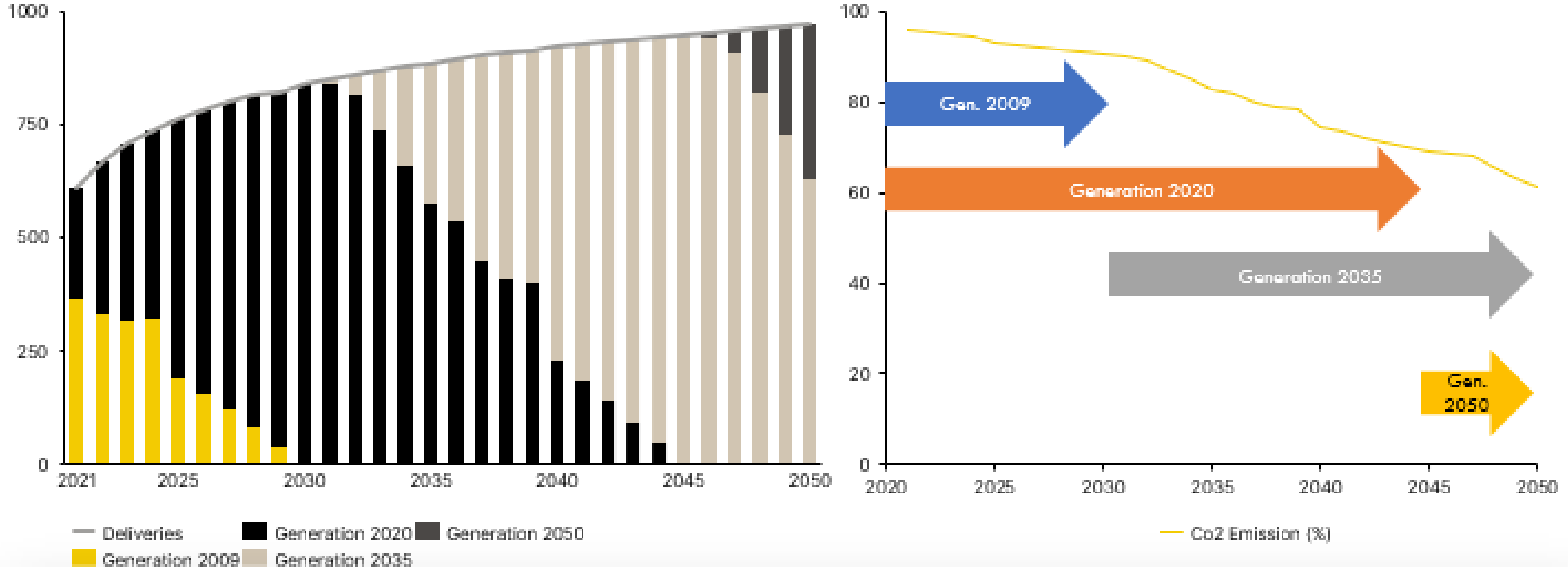


Estimated %replacement ratio (neat SAF available vs. Total aviation fuel used)		2020	2025	2030	2035	2040	2045	2050
Total neat volume of SAF per year (Max scenario)		0.01%	7.80%	27%	46%	57%	77%	87%
Total neat volume of SAF per year (High+ scenario)		0.01%	4.17%	12%	26%	44%	66%	81%
Total neat volume of SAF per year (High scenario)		0.01%	2.49%	6%	13%	26%	43%	66%
Total neat volume of SAF per year (Moderate scenario)		0.01%	0.56%	2%	3%	5%	11%	24%
ERF (Emission Reduction Factor - CO2)	80%							
Expected CO2 emissions reduction		2020		2035			2050	
CO2 reduction (Max scenario)		0.01%	6%	22%	37%	46%	62%	70%
CO2 reduction (High+ scenario)		0.01%	3%	10%	20%	35%	53%	65%
CO2 reduction (High scenario)		0.01%	2%	4%	11%	21%	34%	53%
Average CO2 reduction		0.01%		15%			59%	

Sources: ATAG Waypoint 2050

Technology Improvements

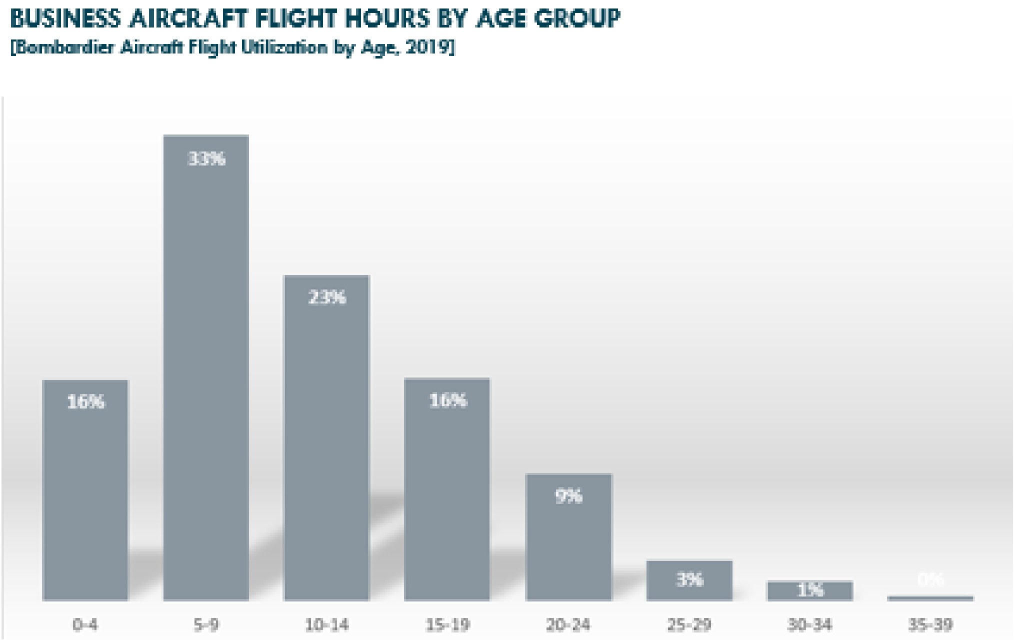
Fleet ramp-up for technology improvements



Total deliveries are composed of old generation aircraft and gradual ramp-up of new technologically advanced aircraft

Aircraft Retirement

Retirement age assumption : 17-year retirement rationale



Rationale for Retirement Age

- 72% of the flight utilization is obtained from aircraft under the age of 15 years, and 88% from aircraft under the age of 19 years
- Median of age group 15-19 (**17-year**) is used in the model as the retirement age to avoid over-representing the older aircraft in the fleet

Source: Bombardier Internal Flight Hours Data