Missed Targets

A brief history of aviation climate targets

May 2022

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Executive summary

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- We examined aviation industry climate targets starting and finishing within the period between 2000 and 2021, as well as assessing progress against some related longer term goals.
- Targets focused on CO_2 efficiency (or 'carbon intensity') and alternative fuel.
- Every alternative fuel target has been missed, in most cases by orders of magnitude.
- Unclear definitions, opaque monitoring and inconsistent reporting made many targets difficult to assess.
- Targets were commonly changed, replaced, or dropped within the study period.
- Targets were set within a context of industry advocacy for a wider framework of policies aimed at supporting ongoing aviation growth .
- Target setters never reported on the success or failure of the target in the original target end year.
- Targets lack public accountability.
- Efficiency targets are aligned with cost-reduction, as fuel consumption accounts for a high share of airline operational costs, but other business goals invariably take precedence over target progress in practice.
- The levels of ambition underpinning the targets were themselves generally insufficient, even if met, to reduce the absolute climate impact of aviation in the context of ongoing growth in demand.
- Business behaviour did not appear to be driven by environmental targets.
- We conclude that target setting appears to function principally as a tactic for giving an impression of progress and action to address aviation's environmental impacts to the public and policymakers, in order to prevent any policy barriers to ongoing growth in the industry.
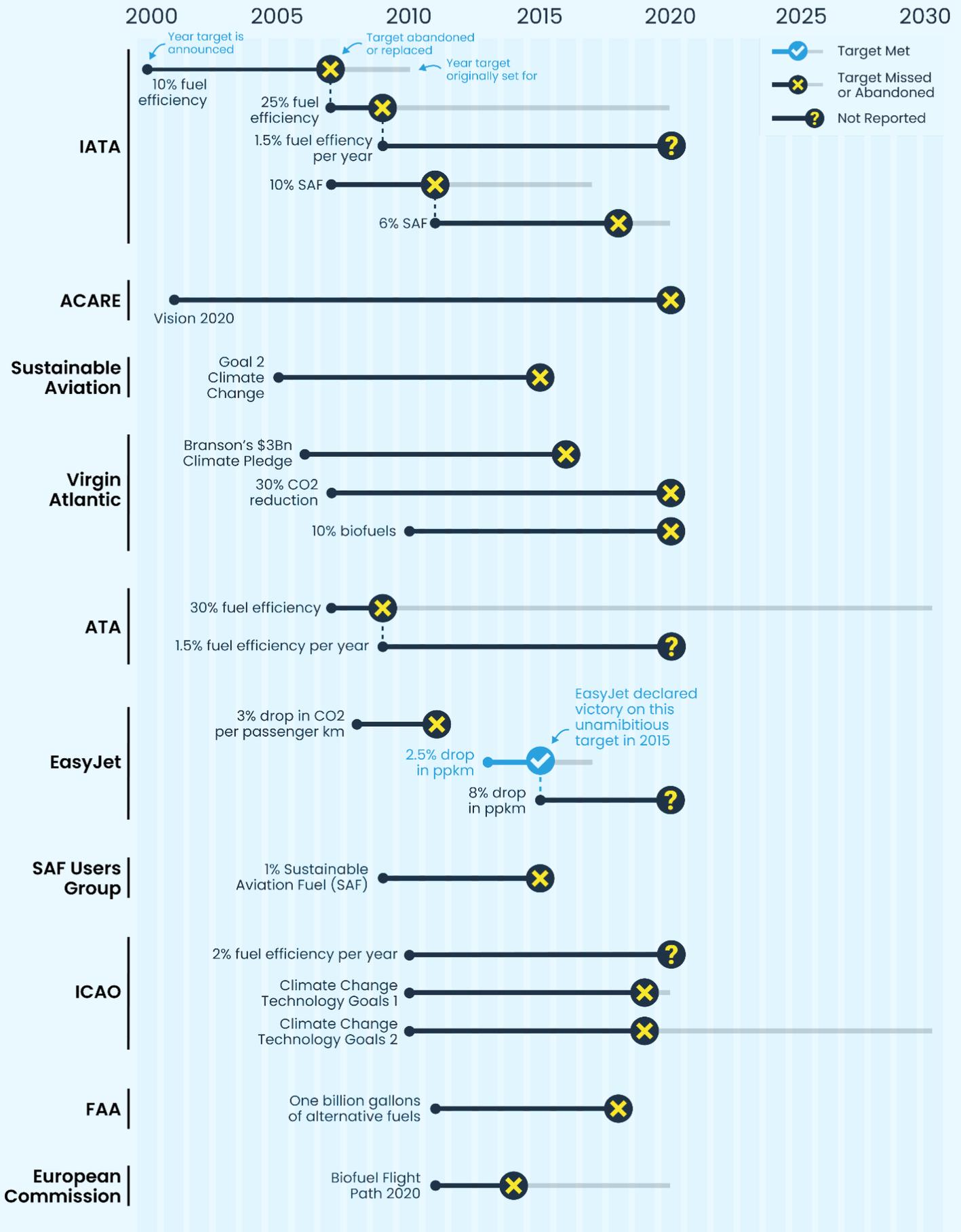
Foreword

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I have been part of the debate on aviation and the climate for so long now that I often experience a kind of wonkish deja vu; a powerful sensation that all of this has happened before. So the hairs stood up on the back of my neck as I read the government's Net Zero Strategy's new 'ambition': for 10% of the UK's aviation fuel to be Sustainable Aviation Fuel (SAF) by 2030.

The 'Jet Zero strategy' under development at the time of writing seeks to "decarbonise aviation whilst allowing … hardworking families to continue to enjoy their annual holiday abroad".[1] Fortunately, this is also exactly what the frequent flyer levy is designed to do, by placing a progressive tax on flights which increases as people fly more frequently.[2] By focusing demand reduction policy on the small minority of people who are responsible for almost all of the environmental damage from air travel, it will be possible to maintain access to some air travel for everyone, at the same time as keeping overall levels of flying within safe limits for the climate.

Every credible independent assessment of deep decarbonisation pathways through to the middle of the century incorporates some element of demand management: measures which reduce overall demand for air travel. But the government's new Transport Decarbonisation Plan does not. This is despite the fact that their own statutory advisors have been telling successive governments that, "Deliberate policies to limit demand below its unconstrained level are … essential if the target is to be met" since 2009.[3] So far, transport ministers are opting to place all of our decarbonisation eggs in the industry's technological innovation basket. Incubating these unicorns certainly looks expensive, but the real question is this: can the industry even hatch such mythical eggs? What happens if the basket breaks? And what happened to the last batch of eggs we gave them to look after anyway?

Leo Murray, director of innovation
May 2022

Two Decades of Missed and Abandoned Aviation Industry Sustainability Targets

2000   2005   2010   2015   2020   2025   2030

Year target is announced

Target abandoned or replaced

Year target originally set for

Legend:
- Target Met
- Target Missed or Abandoned
- Not Reported

IATA
- 10% fuel efficiency
- 25% fuel efficiency
- 1.5% fuel effiency per year
- 10% SAF
- 6% SAF

ACARE
- Vision 2020

Sustainable Aviation
- Goal 2 Climate Change

Virgin Atlantic
- Branson's $3Bn Climate Pledge
- 30% CO2 reduction
- 10% biofuels

ATA
- 30% fuel efficiency
- 1.5% fuel efficiency per year

EasyJet
- 3% drop in CO2 per passenger km
- 2.5% drop in ppkm
- 8% drop in ppkm

EasyJet declared victory on this unamibitious target in 2015

SAF Users Group
- 1% Sustainable Aviation Fuel (SAF)

ICAO
- 2% fuel efficiency per year
- Climate Change Technology Goals 1
- Climate Change Technology Goals 2

FAA
- One billion gallons of alternative fuels

European Commission
- Biofuel Flight Path 2020

Introduction

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> *The stressed-out air passenger belongs to aviation past, not present… Airports are no longer a test of the traveller's stamina and patience…. 99% of flights are within 15 minutes of schedule, and getting through the airport to board a short-haul flight takes no more than 15 minutes…. Aircraft noise is no longer a political and social issue. It has ceased to be an issue to people living close to airports…. Although demand has tripled over the last 20 years, aviation's polluting emissions have been reduced to acceptable levels, and the sector's contribution to a sustainable environment is widely understood and appreciated…*

The above is how an industry 'vision' document from 2000[4] described air travel and its impacts in 2020. By 2019, aviation had grown to 9.4% of the UK's CO_2 emissions,[5] and one of the fastest growing sources of greenhouse gas emissions in the UK, Europe, and globally.[6] Today, the aviation industry is painting another optimistic vision of a future where aviation has played its part in stopping climate change by becoming net zero by 2050, without the need for any measures to limit steeply rising growth in demand for flights. How realistic is that vision? This report seeks to provide some of the context for answering that question by examining previous voluntary climate targets that the aviation industry has set itself.

We looked for climate-relevant targets from industry bodies and a selection of UK companies (three of the largest UK airlines and the leading air traffic control provider) with target periods running between 2000 and 2021. While climate targets exist for airports and ground operations, we focused on targets relating to operating the planes themselves, which account for over 99% of aviation emissions. After identifying significant industry bodies and companies, internationally and in the UK, we searched through documents on their websites (including archived versions via the Internet Archive[7] and other search engines) for the setting of climate targets and updates on their progress. We do not seek to *verify* whether targets were met; our purpose is only to examine

which targets were set, and what was subsequently reported about their progress and success or failure.

Scientific and political context

Evolution of climate science and global targets

While the fundamental science of climate change was well understood by 2000 (the start of the period this report examines), there have been substantial developments over the study period in both the international policy consensus and the physical science with regards to what level society should aim to limit global warming to, and what level of greenhouse gas mitigation this requires.

During the 2000s, the high level goal was thought to be the stabilisation of atmospheric concentrations of greenhouse gases, but there was not yet international agreement on what that concentration should be, or on the upper global mean temperature limit.

In mid-2009, the G8 leaders agreed to the goal of reducing global emissions 50% by 2050 (the UK adopted a target of 80% by 2050 in recognition of the principle of differentiated responsibilities). That year, in the approach to COP15 in Copenhagen, the UK and EU pressed the need for global emissions to peak by 2020 at the latest, with the aim of limiting temperature increase to 2ºC. Around this time it became clearer that emissions needed not merely to peak and decline, but to fall to 'net zero' (where the amount of carbon humans remove from the atmosphere annually is equal to or less than the amount added) or below.

The Paris Agreement in 2015 increased the agreed global ambition, aiming to limit warming to *"well below 2ºC above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5ºC above pre-industrial levels"*.[8] Following the IPCC Special Report on 1.5ºC in 2018,[9] countries began pledging to reach net zero emissions by 2050, with the UK updating its climate legislation in 2019 in line with this understanding.[10]

Historical understanding of mitigating the climate damage of aviation

Emissions from international aviation reside outside of our regular democratic accountability frameworks. When the Kyoto Protocol was negotiated in 1997, agreement could not be reached on how to assign responsibility for emissions from international aviation, so it was decided that the sector should be excluded from national obligations and that instead countries would work through the International Civil Aviation Organization (ICAO) to control emissions from non-domestic air travel.[11]

The IPCC's 1999 Special Report on Aviation and the Global Atmosphere[12] estimated that aviation was responsible for 3.5% of the radiative forcing from human activities, with the total effect (including the effects of contrails, cirrus cloud formation and other non-CO_2 impacts) being 2 to 4 times greater than that of the CO_2 emissions alone.[13]

The report is also clear that, unchecked by restrictions on airport expansion or other policy measures, aviation's contribution to global warming would increase rapidly, with forecasted demand growth of 5% per year outpacing expected efficiency improvements of 2% per year between 1990 and 2015. The authors projected a 20% improvement in fuel efficiency by 2015 and 40-50% improvement by 2050 relative to aircraft produced at that time. The policy options to limit aviation emissions discussed in the report include "more stringent aircraft engine emissions regulations, removal of subsidies and incentives that have negative environmental consequences, market-based options such as environmental levies (charges and taxes) and emissions trading, voluntary agreements, research programmes, and substitution of aviation by rail and coach."

In 2006, a report from the Tyndall Centre for Climate Change Research warned that, "Aviation growth must be curbed until sufficient steps are taken to ensure fuel efficiency gains balance growth in activity, or until there is widespread use of alternative fuels that significantly reduce the industry's carbon emissions".[14] It suggests that emissions growth might be limited by halting airport expansion, increasing load factors, and flying slower.

The 2007 IPCC report warned that efficiency improvements "are expected to only partially offset the growth of aviation emissions", and that further mitigation is needed to account for non-CO_2 impacts of air transport,[15] with estimates of aviation emissions in 2050 reaching between 1.5 and 5 times greater than in 2000.

In 2009, the UK's Climate Change Committee (The CCC) reported on options for the UK government to mitigate aviation emissions out to 2050[16]. Unconstrained airport expansion and lack of carbon pricing could see demand triple from the high point of 2005 by 2050, whereas limiting airport expansion and a rising carbon price would limit demand growth to 115%. Efficiency improvement of 0.8% per year was likely over the period, with up to 1.5% a year possible if technology innovation in the sector accelerated. Biofuels would be viable, but due to sustainability and land-use concerns, it would be prudent to rely on no more than 10% of 2050's aviation fuel coming from biofuel. The non-CO_2 effects of aviation, although not part of the UK government's target at that time, would need to be accounted for in the future as scientific understanding developed. The committee recommended allowing for a maximum of 60% in demand growth above 2005 levels by 2050.

When the CCC reconsidered aviation mitigation against the UK's tougher target of net zero by 2050,[17] the maximum demand growth by 2050 was rebased to 25% above 2018 levels, baseline and accelerated efficiency assumptions had fallen slightly to 0.7% and 1.4% per year, with the role of alternate fuels rising to 25% of liquid fuel by 2050 (in part reflecting the prospect of synthetic jet fuel, along with a smaller projected demand).

A consistent thread in expert advice on aviation mitigation has been that expected growth in demand exceeds expected efficiency gains, and that there is a finite capacity to produce lower carbon alternative fuels without increasing unsustainable land use. Demand management is therefore necessary to hold the climate damage within predefined limits, and can be achieved by limiting airport expansion and pricing mechanisms.

Efficiency Targets

Overview

A wide variety of aircraft efficiency targets have been set by airlines over the last two decades. These efficiency targets are sometimes expressed in terms of a quantity of fuel burn or CO_2 emissions per passenger-km, but most are expressed in terms of a quantity of fuel burn (in mass or volume of fuel, depending on the target) per available tonne-km (ATK) or per revenue tonne-km (RTK).

One tonne-km is a measure of transportation activity that represents moving one tonne of mass a distance of one km. As aircraft transport both passengers and freight, it is possible to use ATK and RTK-based metrics to combine these two different types of transportation activity into a single metric that allows year-to-year comparisons of the industry's total activity.

In order to convert passenger movement into tonne-km, a mass of around 100kg for an average passenger plus their baggage is usually assumed, so a single passenger being transported 1,000km would equate to 100 tonne-km (0.1t x 1000km).

The available tonne-km (ATK) metric is calculated by taking the aircraft payload available to be used and multiplying it by the distance travelled. The revenue tonne-km (RTK) metric is calculated by taking the actual revenue-generating payload of passengers, baggage and cargo uplifted by the aircraft and multiplying it by the distance travelled. So if an aircraft could carry a payload of 20t on a flight of 1,000km then the ATK would be 20,000 tonne-km, but if in reality it only carries 15t over the same distance then the RTK would be 15,000 tonne-km.

The target reduction in fuel burn (or CO_2 emissions) is usually expressed as an annual percentage reduction such as 2% per year. Due to the compounding effects of annual percentages, this means that a 2% reduction per year over 10 years leads to an 18.3% $(1-0.98^{10})$ reduction in fuel burn rather than a 20% reduction in fuel burn.

Efficiency Targets

Advisory Council for Aviation Research in Europe

The Advisory Council For Aviation Research and Innovation in Europe (ACARE) is an organisation that comprises "public and private stakeholders" in the aeronautics and air transport sectors in Europe, collaborating on a shared research agenda.

In 2001 a group of representatives from these stakeholders published what the foreword describes as "a landmark report in the history of European aviation". *European Aeronautics: A Vision for 2020* predicts a 2020 where flying is cheaper, safer, more comfortable and more convenient, and where, despite a 200% growth in activity, the industry's externalities (noise pollution, air pollution, and climate impacts) have been minimised or eliminated.

Vision for 2020 also contains targets for achieving some of these aims. In particular, backing the ambition that by 2020 "the range and volume of damaging emissions has been substantially reduced", they set these targets:

- "A 50% cut in CO_2 emissions per passenger kilometre (which means a 50% cut in fuel consumption in the new aircraft of 2020)" and

- An 80% cut in emissions of nitrogen oxides (NOx).

It should be noted that if the volume of passenger-kilometres tripled by 2020, as they predicted, a 50% cut in fuel consumption of new aircraft in 2020 would still see a large increase in the total volume of emissions, not the substantial reduction which the report authors aspire to. It is not clear if the 50% cut in emissions per passenger kilometre is intended to apply only to new aircraft in 2020, or how the sets of new aircraft in 2000 and 2020 would be defined and compared. Another part of ACARE's vision is for an increase in options for extra legroom and office facilities; if the average space efficiency of passengers fell, a 50% more efficient airliner would not reduce CO_2 per passenger-kilometre by 50%.

The ACARE Vision 2020 targets were also adopted by UK trade group Sustainable Aviation after it was launched in 2005,[18] and ACARE targets feature prominently in Action Plans submitted by European states to ICAO.[19]

In 2010, halfway through the target period, ACARE produced a report entitled Towards 2050, which described their environmental targets as "extremely challenging",[20] presenting "significant engineering challenges", requiring "a doubling of the historic rate of improvement", and "hard work and further step-change technologies in order to succeed".

ACARE's website states that, in the 2001-2011 period, "a number of boundary conditions changed that prompted ACARE members to reconsider the sufficiency of the existing Vision 2020 with the view to extend it to a new horizon towards 2050", and in 2011 they published a new document, *Flightpath 2050*, which set new targets:

> "In 2050 technologies and procedures available allow a 75% reduction in CO_2 emissions per passenger kilometre to support the Air Transport Action Group [ATAG] target [Carbon-neutral growth from 2020 and a 50% overall CO_2 emission reduction by 2050] and a 90% reduction in NOx emissions. These are relative to the capabilities of typical new aircraft in 2000."

Flightpath 2050 does not report on the progress towards the original *Vision for 2020* goals.

An EU project called *OPTICS*, although focused on evaluating aviation safety research, examined progress towards ACARE's environmental targets in 2014 and features a chart showing a 29% gap between foreseeable progress from ongoing projects and the 50% reduction in CO_2 intensity target.[21]

In ACARE's 2014-2015 *Annual Report* (apparently their only "annual" report), they state: "To reach the very challenging ACARE 2050 CO_2 reduction objective, it is essential to pursue a tremendous effort at the aircraft, engine and ATM & flight operation levels."[22]

In ACARE's *Strategic Research & Innovation Agenda Update 2017*[23] they mention that "in 2015 the ACARE working group on energy and environment estimated that we had secured an

overall 38% reduction in CO_2 per passenger kilometre against a goal of [a] 50% reduction goal for 2020.[…] Whilst this represents significant progress, effort must be further strengthened to meet the even more challenging goals for CO_2, noise and NOx emissions set for 2050".

The assessment mentioned seems to have been done by an EU project called FORUM-AE, which produced a report showing a small amount of progress towards the CO_2 target, and some confusion around the NOx target.[24] The 38% reduction "secured" includes improvements foreseen by ongoing projects. The reduction that had actually been achieved by the time of the assessment was only 24%.

We have been unable to find further progress reporting or assessment of whether the target was met by 2020. A review of aviation CO_2 targets was also unable to find a further assessment of the 2020 targets by ACARE.[25] An aviation consultancy's blog post, *ACARE Vision 2020: How Well Have We Done?*[26] considers progress towards the target and suggests that CO_2 per passenger-kilometre of a new airliner in 2020 might be around 40% lower than a new airliner in 2000 if operational improvements are included. This is broadly consistent with the 24% gap foreseen in 2015.

In 2020, ACARE published a brochure *Time for change: Rethinking Flightpath 2050*,[27] which, despite promising "an overview of major aviation achievements", does not report on the *Vision for 2020* targets. It recommends "fully revising the FlightPath 2050 vision in alignment with the Paris Agreement (2015) and the new European Green Deal (2019)", but does not (yet) change the targets for 2050.

International Air Transport Association

One of the most significant efficiency targets has been promoted by the International Air Transport Association (IATA), the trade association for the world's airlines. This target is currently described on the IATA website as "an average improvement in fuel efficiency of 1.5% per year from 2009 to 2020."[28]

Untangling the genesis of this target proved challenging as it is one of a number of different efficiency targets which IATA

has promoted since 2000 according to captures of the environment pages of the IATA website made by the Internet Archive's Wayback Machine.

Figure 1: ICAO's Annual Reports show that Passenger growth is significantly outpacing aircraft CO2 efficiency improvements. Source: ICAO Annual Reports.
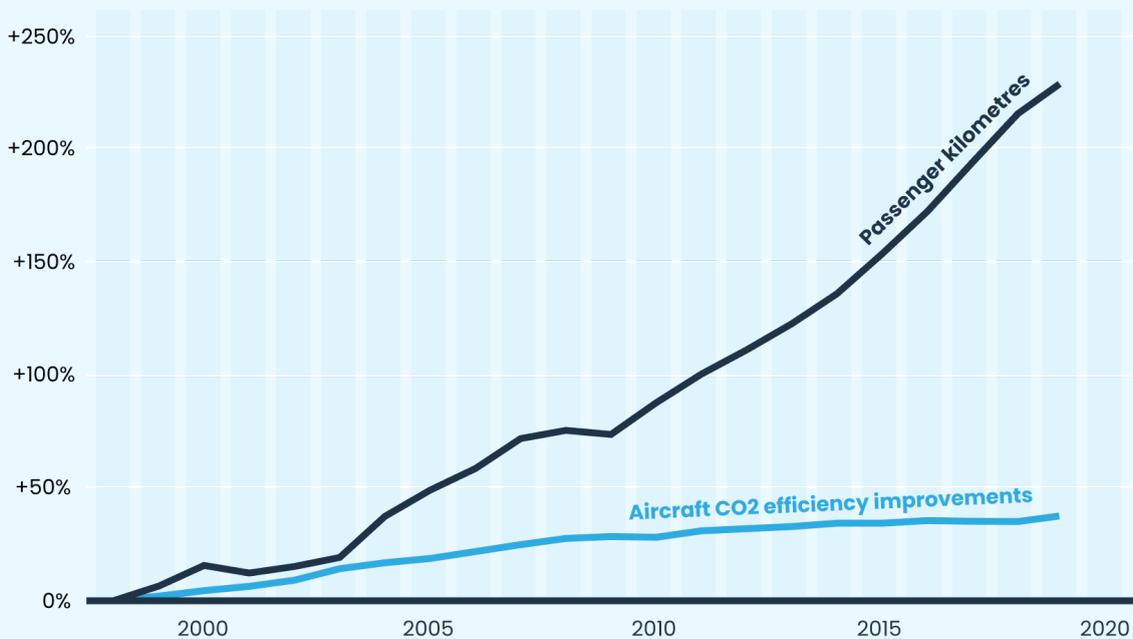
Sometime after 2000, IATA member airlines "adopted a voluntary goal and committed to improving their fuel efficiency by 10% between 2000 and 2010".[29] The earliest evidence we can find for this target is from September 2004 but two years later, the IATA website was claiming that "IATA airlines are on track to beat this goal and are planning to develop a more ambitious one" and that "the industry is aiming for a further 50% fuel efficiency improvement by 2020."[30]

This 50% target did not last long and by April 2007 had been reduced to a 25% improvement by 2020.[31] Then in 2008, director general and chief executive officer of IATA Giovanni Bisignani delivered a speech at the 2008 IATA Annual General Meeting[32] which confirmed that this target covered the period running from 2005 to 2020, and therefore represented an average improvement of 1.9% per year.

The footnotes to the speech indicate that "the 25% fuel efficiency goal was developed by IATA's Environment Committee and accepted by the IATA Board in June 2007", and stated that the goal was expected to be an average figure for the IATA member airline fleet and was to be measured in terms of litres of fuel consumed per revenue tonne-km (RTK).

This goal was referenced in the ICAO document of the resolutions in force at the end of the 36th ICAO Assembly (the organisation's triennial meeting) in September 2007 under an appendix describing ICAO's Programme of Action on international aviation and climate change.[33] This target of an improvement in fuel efficiency of 25% by 2020 proposed by the airline industry is likely to have influenced the development of ICAO's own efficiency target (see below).

A further complication to this picture can be found in IATA's 2009 annual report[34], which features a table summarising industry goals relative to 2005, including fuel efficiency improvement goals of 15% by 2012, 29% by 2020 and 50% by 2050. In the course of this research we were unable to find any further evidence of these three goals so the origin of these and the reasons for including them in the annual report, just before the final 1.5% target was announced, are unclear.

Speaking in February 2008, Bisignani had claimed that he was "absolutely confident" that the industry would make the target to improve fuel efficiency by 25% by 2020,[35] and at the first meeting of ICAO's Group on International Aviation and Climate Change (GIACC) in the same month, the 25% goal was still being promoted by IATA.[36]

By May 2009 that confidence had clearly been shaken, as the origins of the weaker target which IATA subsequently ended up switching to emerged in an Information Paper presented to ICAO by IATA titled "Development of a Global Sectoral Approach on Economic Measures for Addressing Aviation CO_2 Emissions".[37] This paper proposed a short-term goal of a 1.5% per annum reduction in fleet-wide fuel burn to 2012 and a medium-term goal of a 1.5% per annum reduction in fleet-wide fuel burn from 2013 to 2020. Both of these targets were proposed to be measured in litres of fuel burnt per revenue tonne-km (RTK) and in June 2009 IATA published a

press release stating that "a 1.5% average annual improvement in fuel efficiency from 2009 to 2020" target had been set.

The rationale behind the selection of a 2009 baseline for the IATA fuel efficiency target is not clear. Given that the previous 10% fuel efficiency target ran to 2010, it would make sense for the subsequent target to run from that year. Even well after the 2009 announcement, at ICAO's 37th Assembly in Montreal in October 2010, a group of aviation industry bodies[38] led by IATA proposed "an ambitious set of collective targets and associated principles to address aviation CO_2 emissions" in an ICAO Working Paper titled "Development of a Global Framework for Addressing Civil Aviation CO_2 Emissions".[39] This group of aviation industry associations recommended "adoption of an ambitious but realistic target to improve fuel efficiency by 1.5% on average per year between 2010 and 2020"[40] rather than the previously announced timeframe of 2009 to 2020.

Ultimately, the choice of a 2009 as the baseline certainly made a helpful contribution to achieving the 2020 target thanks to the 6.8% improvement in efficiency which the global airline fleet saw between 2009 and 2010.

International Civil Aviation Organization (ICAO)

The UN body tasked with regulating the global aviation industry, the International Civil Aviation Organization (ICAO), has two distinct efficiency goals running in parallel. The highest profile efficiency goal focuses on the efficiency of the in-service fleet of aircraft, while a less well-known goal relates to improvements in the efficiency of new aircraft coming into service.

In-Service Fleet Efficiency

The origins of ICAO's in-service fleet efficiency goal can be found in the resolutions which were in force at the end of ICAO's 36th Assembly in September 2007. In this document is a request from the Assembly to ICAO's Council to form "a new Group on International Aviation and Climate Change…for the purpose of developing and recommending to the Council an aggressive Programme of Action on International Aviation

and Climate Change, based on consensus, and reflecting the shared vision and strong will of all Contracting States"[41]. This was ten years after Kyoto had handed over responsibility for aviation emissions to ICAO.

This Group on International Aviation and Climate Change (GIACC) was tasked with the "identification of possible global aspirational goals in the form of fuel efficiency for international aviation… and reporting progress resulting from the actions implemented by Contracting States and Stakeholders". GIACC was composed of 15 senior government officials from developed and developing states and held four meetings which culminated in the publication of its final report in June 2009.

This report proposed that the goal should be measured on a revenue tonne-km basis and should have a baseline of 2005, with a short-term goal running to 2012, a medium-term goal running to 2020 and a long-term goal running to 2050. In each goal's case the recommendation was for an average 2% improvement per year. This "would represent a cumulative fuel efficiency improvement of more than 13% in the short-term" and would result in improvements of "about 26% by 2020" and "about 60% by 2050 relative to 2005.[42]

GIACC's Programme of Action was accepted by the ICAO Council in June 2009 and the High-Level Meeting on International Aviation and Climate Change (HLM-ENV/09) was convened in October 2009 to review it. HLM-ENV/09 welcomed the decision of the council to fully accept the Programme of Action and approved a Declaration and Recommendations on international aviation and climate change, which was fully accepted by the council in November 2009.[43]

The short-term target to 2012 was dropped from the Declaration, which set out the target to be "a global annual average fuel efficiency improvement of 2 per cent over the medium term until 2020 and an aspirational global fuel efficiency improvement rate of 2 per cent per annum in the long term from 2021 to 2050, calculated on the basis of volume of fuel used per revenue tonne kilometre performed." It also noted that "such fuel efficiency improvements or other

aspirational emission reduction goals would not attribute specific obligations to individual States."[44]

At the close of the ICAO Assembly's 37th Session which took place in September and October 2010, the organisation adopted Resolution A37-19, which declared that states and relevant organisations "will work through ICAO to achieve a global annual average fuel efficiency improvement of 2 per cent until 2020 and an aspirational global fuel efficiency improvement rate of 2 per cent per annum from 2021 to 2050, calculated on the basis of volume of fuel used per revenue tonne kilometre performed." No report assessing the outcome of this 2% target has ever been published to our knowledge. However, we know from data published in ICAO's annual reports that the medium term target was not met.

New Aircraft Efficiency

In addition to the in-service fleet efficiency targets, ICAO has a Technology Goals programme, which aims to provide "stretch yet reasonable targets for industry R&D to aim at". These goals are set by a panel of "independent experts" in order to "ensure transparency and involvement from all stakeholders.[45] In November 2010 the Independent Experts reported to the CAEP Steering Group with their proposals for the level of future improvement in new aircraft efficiency.[46]

The 7th meeting of ICAO's Committee on Aviation Environmental Protection (CAEP) held in 2007 requested advice on the potential for reduced aviation fuel burn from a group of Independent Experts over the coming two decades, which became known as the Fuel Burn Reduction Technology Goals.

Rather than considering the whole fleet, these medium and long-term goals relate to improvements in fuel burn for new aircraft coming into service and are calculated on the basis of kg of fuel burnt per available tonne-kilometre (ATK). The reasoning behind the selection of ATK as the metric to define these goals was because the remit of the exercise was the potential for aircraft technology improvements to reduce fuel burn and specifically excluded wider system and operational effects (such as airspace efficiency gains or increases in load

factor) which would have an impact on fuel burn per RTK but not on fuel burn per ATK.

As the aircraft of the day were considered to be made using technology from around the turn of the millennium, the baseline for the Fuel Burn Reduction Technology Goals was therefore considered to be new aircraft entering into service in 2000 and the target years for the completion of the goals were 2020 and 2030. Two aircraft types were considered: a single-aisle aircraft (the examples given were a Boeing 737 or Airbus A320) and a small twin-aisle aircraft (such as a Boeing 777 or A330).

Workshops involving a range of industry actors were undertaken in 2009 and 2010 to define the impact of technologies which could contribute to reductions in fuel burn in the coming decades and the Independent Experts then undertook a modelling exercise to quantify the potential impacts of these technologies on fuel burn and used this to define the goals. The Independent Experts predicted the following percentage reductions in fuel burn per ATK under different technology scenarios:

Table 1: Estimated percent reduction in fuel-burn metric relative to 2000 baseline

Technology Scenario	2020		2030	
	Single-Aisle	Small Twin-Aisle	Single-Aisle	Small Twin-Aisle
TS1	23%	19%	29%	26%
TS2	29%	25%	34%	35%
TS3			41%	41%

The Independent Experts developed three technology scenarios. TS1 represented a continuation of the existing trend in improvements, "what would happen with continued and consistent funding and dedicated programs, and without additional pressure other than market forces", while TS2 and TS3 represented the effect of increasing pressure on the

industry to reduce fuel burn. According to the 2010 report, "the goal will be said to have been achieved in 2020 if the fuel burn reduction relative to the 2000 baseline exceeds 29% for the single aisle reference aircraft and exceeds 25% for the small twin-aisle aircraft… In 2030 the goal will be achieved… if the reduction exceeds 34% to 35% relative to the 2000 baseline."

In 2019, CAEP again called together a group of Independent Experts to review the technological advances which could be expected in the coming decades.[47] As part of this work the Independent Experts also reviewed progress towards the technology goals set in 2010. Only the single-aisle aircraft type was analysed as the Independent Experts considered that the data to conduct the same exercise for the twin-aisle aircraft was not available. Aircraft entering into service in 2017 were chosen as representative of the new aircraft technology that was available to airlines at the time (the A320-neo).

In the 2010 technology goals report the expected reduction in fuel burn by 2017 relative to 2000 under Technology Scenario 1 (a continuation of the current trend of improvement) was around 20%. The goal itself (defined as matching or improving on Technology Scenario 2, which represented an increased pressure to reduce fuel burn) would have implied around a 25% reduction in fuel burn in new aircraft by 2017.

According to the Independent Experts the typical single-aisle aircraft available in 2017 had reduced fuel burn compared to the equivalent aircraft available in 2000 by just 15%. This means that the outturn technological development fell short of the expected technological development from only 7 years earlier by 25% and fell short of the actual goal by 40%. The Independent Experts' solution to this problem was to re-baseline the goals to 2017 aircraft, slightly increase the ambition of the targets and then push them out by 7 years, to 2027 and 2037.

Figure 2: Goals from the 2010 Independent Expert Fuel Burn Review and Goals from the 2019 Independent Expert Independent Technology Goals Assessment for Single-Aisle aircraft
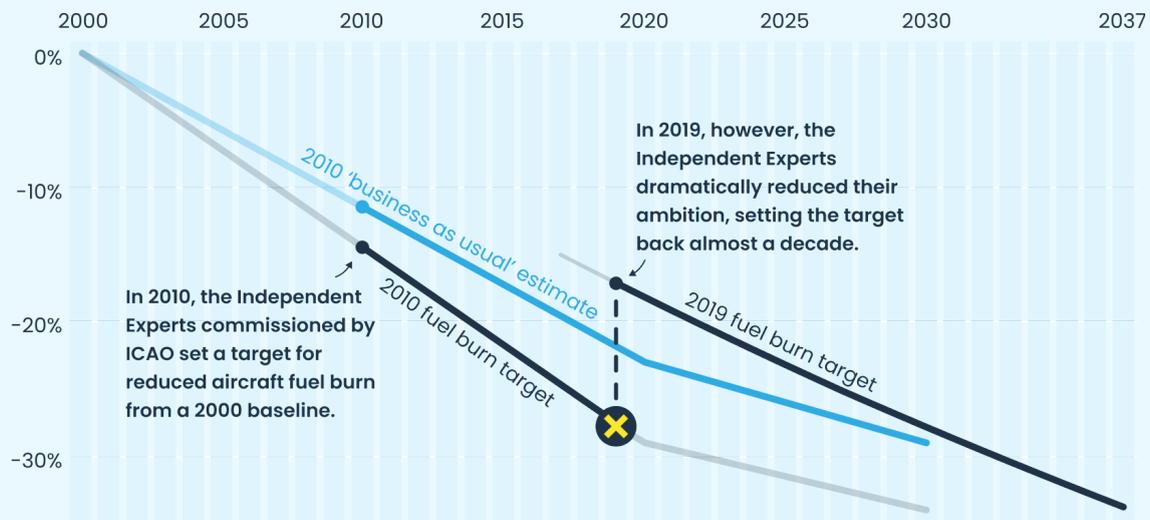
In 2019 the Independent Experts suggested that Technology Scenario 1 of the 2010 review "considerably over-estimated the reduction by 2017; whilst TS2, which was used for the goals of the review, was far too optimistic when compared to recent achievements" but went on to say that "the goals from the current [2019] review continue at about the same gradient as TS1 in its early years [and] from this, there is no reason to suspect that the present goals lack ambition." Not only was the target missed, fuel burn from new aircraft in 2017 even exceeded 'business as usual' projections from 2010.

Airlines for America (A4A)

In 2007, Airlines for America (formerly called the Air Transport Association of America), "approved a comprehensive plan to further limit aircraft emissions with a commitment to improve fuel efficiency another 30 percent through 2025 [from a 2005 baseline]".[48] The ATA frequently characterises aviation's efficiency improvements over time in terms of a number of cars taken off the road. They claim this target is equivalent to taking 13 million cars off the road every year through 2025, however we note that the number of light-duty vehicles in use in the USA rose by 17.4 million between 2007 and 2020.[49]

In 2009, they reported being on track for the target, but in 2010's report they did not mention their 30% target, and

instead said that "as part of our overall commitment, we have joined airlines around the world in adopting an ambitious set of targets to mitigate emissions associated with climate change under a global framework" which included the IATA target of a 1.5% improvement in efficiency per year.

It is not clear if they have abandoned their 2009 target for the wider global targets, but it seems to represent a reduction in ambition from 30% over a 20 year period, to 26% over a 20 year period (1.5% a year).

In 2020, the ICCT examined whether A4A airlines had met the 1.5% efficiency target adopted in 2009, and found that 5 out of the 7 major A4A airlines they looked at had not met the target, with an average efficiency improvement across the 7 of 1.3% improvement a year.[50]

Sustainable Aviation (UK)

Sustainable Aviation is a UK aviation trade group founded in 2005 with members from UK airports, airlines, manufacturers and navigation service providers. Their website describes their purpose as "finding collaborative ways of improving our environmental performance and creating a balanced debate to ensure sustainable growth of our industry".[51] They state that they have "set a range of goals and commitments covering climate change" and "regularly report on our progress towards these objectives".

Their first Progress Report in 2006[52] sets a goal to have "aviation incorporated into a global policy framework that achieves stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous man-made interference with the climate system", and makes a number of related commitments. Primarily, they adopt the ACARE 2020 targets, including the 50% cut in CO_2 per passenger kilometre between 2000-2020 (see the ACARE section above). They allow a contribution from air traffic management improvements of up to 10%, and aim, by 2012, to propose mechanisms for mitigating aviation's non-CO_2 effects.

It is also interesting to note that Sustainable Aviation made a commitment to raise passenger awareness of the climate

impacts of air travel, for which they see offering voluntary carbon offsets as a "practical short term measure". Describing British Airway's introduction of voluntary carbon offsetting, they say "the scheme's primary aim is to raise passenger understanding of the climate impacts of air travel, and is not claimed to be a substitute for international policy action." By their 2015-2017 Progress Report,[53], their position had evidently changed. They state: "UK airlines took a leading role in securing global progress to establish the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) to enable aviation to meet its climate change goals of carbon neutral growth from 2020". Carbon offsetting had gone from being no substitute for international policy action, to constituting almost the totality of international climate policy on aviation.

Their 2009 Progress Report describes (as yet unquantified) advances in aviation technology towards achieving the ACARE 2020 target, but signals a lack of progress towards their commitment to mitigate air travel's non-CO_2 climate damage. While in 2006, their view on the non-CO_2 impacts was "scientific uncertainty is not a reason for inaction and we must continue to seek the most appropriate ways to address all of these impacts", in 2009 they said "in view of this uncertainty, our conclusion is that these effects should be considered separately from the impact of CO_2, rather than being treated as equivalent CO_2 emissions." After this 2009 Report, they no longer reported on the ACARE 2020 target, presumably judging it had been replaced by ACARE's 2050 target set in 2011.

In their 2005-2015 Progress Report,[54] Sustainable Aviation announced that they had revised their original goal for a "robust global policy framework that achieves stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous man-made interference with the climate system". Their post 2015 climate change goal was now: "To identify, create and develop opportunities to reduce UK aviation climate change emissions and enable sustainable growth." While the goal to stabilise atmospheric concentrations came from a context of a lower level of climate ambition prior to COP15 in Copenhagen, the revised goal is less specific and less ambitious still. A robust global

policy framework that aligns aviation with stopping climate change has yet to be achieved.

They note also that, between 2005 and 2014, Sustainable Aviation airlines had improved their efficiency on average by 1.9% per year since 2009, outperforming the 1.5% per year target set by IATA. (However, this underperforms against the 2% per year target set by ICAO in October 2010, according to Sustainable Aviation's 2011 Progress Report[55]).

In their Key Facts on Aviation CO_2 leaflet from 2019, they stated: "Sustainable Aviation airlines have improved their fuel efficiency by 13.7% since 2005"; a 1.5% annual improvement would have amounted to over 19% improvement for the same period.

Virgin Atlantic

During 2007, Virgin Atlantic set a target of a 30% reduction in CO_2 per revenue tonne kilometre by 2020.[56] In their 2010 Sustainability Report, they say "It's a big target and we're sticking with it". By that point, their efficiency had worsened for much of the period since 2007, which they explain as the effect of the recession on their load factors, but was beginning to improve. The 2013 Sustainability Report shows that their efficiency figures, while better than 2007, had been rising back up to the baseline for the last two years. With the planned delivery of new jets in 2014, Virgin Atlantic said "we're confident we'll hit our 2020 target."[57] But in the 2014 Sustainability Report, with a reduction in CO_2/RTK of only 8% from baseline, they admit "we're nearly half way through our target period, and know we have to pick up the pace."[58]

In their 2015 Sustainability Report,[59] Virgin Atlantic noted their CO_2/RTK was now 10% below baseline, and again conceded they were off target, but claimed "thanks to our new 787s and fuel efficiency initiatives we're on track to get there". The 2016 Sustainability Report[60] however, saw their improvement drop back to 9%, saying "we realise that with 5 years to go, it's going to be tough".

By their 2017 Report,[61] they had more optimistic results to report, with a decrease of 8% to 17% below baseline, which they ascribe to the introduction of new planes. They also state

that this has now taken them ahead of the IATA 1.5% per year target, and how much more ambitious their own -30% target is (1.5% year on year from 2007 to 2020 amounts to a little under 18%). In 2017, Virgin Atlantic also responded to the Scottish Government's consultation on cutting Air Departure Tax by 50%, citing the 30% by 2020 target as part of their argument that taxes on long haul flights can be cut since the aviation industry is dedicated to reducing its environmental impacts[62].

Although the 2018 Report saw CO_2/RTK fall another 1.8% to 18.2%, it accounts for the target's prospects with a note of pessimism: "at this stage we're not sure how close we'll get to our 2020 target."[63] In their 2019 Report, Virgin Atlantic postponed their 2020 end date to 2021: " To allow for the industry wide engine supply issues and to align with the timeframe of our new three year business plan we have extended our 30% CO_2 per RTK reduction target from 2020 to 2021."[64] They note that progress had stalled over the previous year (in fact their figures show a slight regression), citing engine supply issues and a decision to delay retiral of older planes. Virgin Atlantic's 2019 Annual Report (written in 2020) declares "a new interim target to reduce aircraft CO_2 emissions by 20% per Revenue Tonne Kilometre (RTK) between 2019 and 2030".[65]

Virgin Atlantic's Annual Report for 2020[66] does not mention the 2020 target (which by then had been extended to 2021), and refers to the impact of the pandemic on their operations, resulting in lower passenger load factors and an increase in their CO_2/RTK.

A press release in 2021[67] describes the airline's new interim targets to chart a pathway to net zero:

- By 2026: 15% gross reduction in CO_2/RTK achieved through continued fleet transformation and operational efficiency
- By 2030: 15% net reduction in total CO_2 emissions, including 10% of fuel sourced from sustainable aviation fuel
- By 2040: 40% net reduction in total CO_2 emissions

These targets, say Virgin, build on the "18% reduction in CO_2/RTK already achieved by 2019"; the press release does not mention the 30% target set for 2021 (previously 2020), nor the interim 2030 target they had set in the previous year, or their seemingly abandoned goal of sustainable biofuel being 10% of their fuel mix by 2020.

Virgin Atlantic's CO_2/RTK efficiency target, on the positive side, was well-defined and consistently reported upon, with setbacks often acknowledged and explained. On the negative side, when they decided that they could not meet it, they first extended it to 2021, and then neglected to report on it thereafter. Nor do they acknowledge dropping their biofuel goal, or the impact that slow progress there has made on their CO_2 efficiency target. They meet the IATA 1.5% per year target on average for the 2007-2019 period taken as a whole, but only began to note their progress on this when they started meeting the target. They fail to consistently improve efficiency, regressing several times. It is not clear that their target drove them to greater efficiency improvements than they would have if motivated only by cost reductions, whereas efficiency improvements are sometimes delayed to meet other business goals. Virgin Atlantic's most meaningful climate achievement is that between 2007 and 2019, they reduced their total flight emissions by 20%, which they managed to do by keeping flight activity (revenue tonne kilometres) flat while improving efficiency over the period (and their total emissions in 2020 were 58% lower than 2007 due to the drop in demand).

> **"It is important that the airline industry is being seen to do something."**
>
> **Steve Ridgway, Virgin's chief executive, 2007**

easyJet

In 2007, easyJet announced plans for an 'ecoJet' that it said would emit 50% less CO_2 than its current planes and could be

in service by 2015. The savings would come from a combination of a more efficient engine, lighter construction, changes to air traffic management, and a slower inflight speed.[68] The plans were described in a 2008 House of Commons research paper, *Aviation and Climate Change*,[69] written to inform policymakers ahead of the UK's 2008 Climate Change Bill while the exclusion of international aviation emissions was being debated. The airline's 2009 Annual Report states that they "continue to actively engage with both airframe and engine manufacturers in pursuit of this vision by 2017", and that appears to be the last time easyJet ever mentioned the ecoJet.[70]

easyJet's 2008 *Annual Report* says: "easyJet has set a target to reduce fuel burn per passenger kilometre by 3% (directly proportional to CO_2 per passenger kilometre) by 2011."[71] At ~1% reduction per year, this is less ambitious than the industry target of 1.5% per year that IATA would set in June 2009; it appears to have been met easily, but there is no mention of the target again after 2009. In the same period, senior executive bonuses are linked to targets for other business measurements, such as profits, customer satisfaction and on-time performance.

In 2012 they noted that efficiency had worsened slightly due to a business focus on shorter flights and primary airports with longer taxi times.

In their 2013 *Annual Report*, easyJet announced they had "set targets to reduce CO_2 g/km per passenger further, by 2.5% by 2017 and by 5% by 2022". The industry-wide IATA target of 1.5%/year would have implied targets of 5.9% (2017) and 12.7% (2022), so these targets were considerably less ambitious. By 2015, efficiency had improved 3%, and easyJet announced a new target of 8% reduction in CO_2 per passenger kilometre by 2020 (a 1.5%/year improvement would have implied a target of 10%).

In the 2017 *Annual Report*, the previous 2020 target was seemingly forgotten and a new target of a 10% reduction between 2016 and 2022 was announced. This was more ambitious this time than the 1.5%/year rate of improvement targeted by IATA. But in 2019, CO_2 per passenger kilometre had only fallen 3.5% since 2016; in 2020, due to decrease in

demand caused by the pandemic, efficiency worsened slightly (although less than might have been expected, as they were able to concentrate traffic on their newest planes). In 2021, the further fall in demand significantly worsened their efficiency metric and easyJet conceded that they no longer expected to meet their 2022 target.

Between 2008 and 2019, easyJet's CO_2 per passenger-kilometre fell 14.6% - close to IATA's 1.5%/year reduction (which would have meant a 15.3% fall). However, over the same period, their total annual emissions from fuel burn rose from 4.3 million tonnes of CO_2 to 8.2 million tonnes - a 90% rise, falling to 2.1 million tonnes in 2021 due to the collapse in demand resulting from the pandemic.

British Airways

British Airways set the earliest efficiency target we found, stating in their 1999 Annual Report that they had "responded to concern over climate change by adopting a 30 per cent target for improvement in fuel efficiency over 20 years".[72] Later reports make clear that the target period is 1990-2010, measuring fuel burn per Revenue Tonne Kilometre (RTK).[73] In 2001, British Airways entered the UK's trial Emission Trading Scheme, through which they received £2.6M from the Government over 2002-2003.

The British Airways 2006-2007 Environmental Overview[74] states that their efficiency has improved 28% over their 1990 baseline, that they are on track to meet their 2010 target, and that they will set a new target going forward. This target appears in their 2007-2008 Corporate Responsibility Report: a further 25% improvement in efficiency down to 83gCO_2/pkm (passenger kilometre) by 2025. The 2008-2009 Corporate Responsibility Report announced a new longer term target to cut net CO_2 emissions 50% by 2050, in line with the global emissions target identified in the Stern Review (2006); it also welcomes the government's approval of a third runway at Heathrow Airport. British Airways do not appear to have reported on their 1990-2010 target since the 2007-2008 Corporate Responsibility Report, which stated that their efficiency had improved 28% since 1990. Later reports use an

efficiency metric of CO_2 per passenger-kilometre, and it is not clear whether the 2010 target was met.

In 2021, the airline issued Sustainability Linked Bonds "to finance and support its activities of transitioning to a low carbon business model"[75] (enabling it to buy more fuel-efficient aircraft), where the interest the company has to pay on the bond is linked to a measurement of performance. In this case, British Airways is measuring CO_2 per passenger kilometre, and needs to achieve 88.3 gCO_2/pkm in 2025. Sustainability Linked Bonds[76] are a novel way for companies to raise investment needed to reduce their emissions and demonstrate commitment to a target; they will be penalised financially if they fail to meet the target, and the results are verified by a third party. This is the only meaningful accountability mechanism we identified during this research. The efficiency level British Airways has committed to financially, however, is less ambitious (at 88.3gCO_2/pkm) than the target it set for 2025 back in 2007 (83gCO_2/pkm).

NATS

NATS (originally *National Air Traffic Services*) is the main provider of air navigation services in the UK. In 2008, NATS set a target that "by March 2020, we will have co-operated with the industry in reducing ATM [air traffic management] CO_2 emissions by an average of 10% per flight (against a 2006 baseline)".

By 2013, they had achieved a 1.4% reduction.[77] Their 2015-16 Responsible Business Report stated "we have achieved a reduction of 4.3% so far and continue to identify new opportunities to deliver the remaining 5.7%"[78]. Their 2016-17 report records a 5% improvement but notes that "it will become increasingly difficult to meet our goals unless we can deliver further efficiencies by modernising UK airspace."[79]

In their 2018-2019 Responsible Business Report, with only one year to go, NATS recorded a 6.9% reduction in their efficiency figure from baseline, conceding that they did not expect to meet their target of a 10% reduction in ATM CO_2 per flight by 2020.[80] They also claim to have decoupled traffic growth from emissions: "the total distance flown by aircraft under our control has increased by 39%, while CO_2 emissions have

grown by 20%". (We note that the only relevant part of this as regards the climate change impact, is that overall CO_2 emissions from these aircraft had grown by 20%.)

2020's Responsible Business Report saw NATS reach a 7% reduction in CO_2 per flight and, they conceded, missing their "very challenging 10% target". They ascribe the failure to policy trade-offs made around prioritising a reduction in noise from aircraft and a delay to the "airspace modernisation" plans.[81]

Alternative aviation fuel targets

Overview

Described by the aviation industry as Sustainable Aviation Fuels (SAF), these alternatives to fossil kerosene are biomass or waste-derived aviation fuels that could potentially be less carbon intensive than conventional, fossil-derived fuel when considering the entire lifecycle of the fuel. The alternative aviation fuels which are being proposed are considered 'drop-in fuels' which means that they have similar performance to fossil-based fuels and can therefore be used without modification of the aircraft or engine.

According to ICAO's criteria for eligibility under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), minimum lifecycle greenhouse gas reductions of just 10% compared to conventional jet fuel are required[82] but the industry almost always quotes much higher reductions (usually "up to 80%"[83]) when promoting the technology,[84] although concerns have been raised that these reductions are not valid when considering system-level carbon stocks. The wider sustainability criteria concern factors such as soil carbon stock, water quality and capacity, biodiversity and food security, amongst others.

Alternative fuels can also be made from e-fuels (electrofuels) which, it is hoped, will be produced using renewable energy to split water into hydrogen and oxygen and then combining the hydrogen with CO_2 captured from the air to make hydrocarbons. This is at a very early stage of development and not yet in use.

Robust and recent data on alternative fuel production volumes is hard to come by. ICAO has published stocktaking data up to 2018, when nearly 7 million litres of alternative fuels were produced, representing less than 0.002% of global aviation fuel consumption.[85]

The International Energy Agency points[86] to an increase in alternative fuel production capacity in 2019 due to Neste's Porvoo refinery in Finland being upgraded to produce 100,000

tonnes (125 million litres) of alternative fuel per year, but it is currently unclear what proportion of that refinery output was actually used in that year. If all of the 100,000 tonnes per year capacity is used then 2019 global alternative fuel consumption might have reached 0.03%. As the Porvoo refinery has a total production capacity for all fuels of 12.5 million tonnes[87], the implication is that the majority of current alternative fuel production represents less than 1% of the output of a single refinery.

IATA's alternative fuel factsheet suggests that in 2021 production volumes amount to 100 million litres (80,000 tonnes) per annum or 0.02% of the aviation industry's pre-pandemic fuel consumption.

ICAO

In October 2017 ICAO proposed a Vision on Aviation Alternative Fuels, "a statement of developments contributing to a long-term vision of transitioning to an extensive use of alternative fuels in international aviation".[88] This Vision emerged from the Second ICAO Conference on Aviation and Alternative Fuels (CAAF2).

In the Vision ICAO defines a short, mid and long-term goal for alternative fuel use in international aviation:

	Short-Term Goal (2025)	Mid-Term Waypoint (2040)	ICAO Vision 2050
Alternative fuel use in international aviation (Mt/year)	5	128	285
Alternative fuel share in international aviation fuel demand	2%	32%	50%
% CO_2 reduction from alternative fuel use in international aviation	0.9%	12%	33%

ICAO's Vision was intended to "provide the inspiration that will be important to channel efforts in a unified way" and "will be a living instrument; progress towards achieving this vision will be regularly assessed through a stocktaking process which will allow the mid-term waypoint to be adjusted in light of the progress observed in the SAF industry."

International Air Transport Association (IATA)

IATA has promoted a series of alternative fuel targets over the last 15 years. The first emerged in 2007 when IATA set a target for 10% of the global aviation fuel supply to come from alternative fuels by 2017. In 2017 the aviation industry consumed around 90 billion US gallons of aviation turbine fuel so this target equates to a production capacity of around 9 billion US gallons or 34 billion litres per year.

IATA has disavowed this target on social media (and in private correspondence with Possible), stating that it was "never a formal target" and that it derived from "a speculative chart on potential SAF uptake"[89] but the available evidence indicates that this statement is untrue.

The IATA 2008 Report on Alternative Fuels references "IATA's goal of 10% alternative fuels of non-crude sources by 2017",[90] and the organisation's own annual report in 2009 states that "IATA set a target in 2007 for 10% airline alternative fuel use by 2017".[91]

Most significantly, in a speech at the World Business Summit on Climate Change in Copenhagen in May 2009, director general and chief executive officer of IATA, Giovanni Bisignani, stated in June 2007 at IATA's annual general meeting that he had personally "announced a vision to achieve carbon-neutral growth on the way to a carbon-free future" and that "working with ICAO, the UN's aviation agency", IATA had set "three challenging targets", one of which was "to be using 10% alternative fuels by 2017."[92]

This speech is the last evidence that we can find of the 10% target and by 2011, IATA's alternative fuel target had reduced substantially to 6% and pushed back to 2020. The Wayback Machine's capture of the IATA website from March 2011

contains IATA's position on biofuels which stated that "IATA thinks a 6% share of sustainable 2nd generation biofuels is achievable by 2020.[93]

In the same year, writing in a report published by lobbying group the Air Transport Action Group (ATAG), confidently titled "Powering the future of flight – The six easy steps to growing a viable aviation biofuels industry", IATA's then senior vice president of member and external relations, Paul Steele, wrote that "we are striving to practically replace 6% of our fuel in 2020 with biofuel. We hope this figure can be higher."[94]

Figure 3: IATA's Sustainable Aviation Fuel targets are getting less and less ambitious over time.
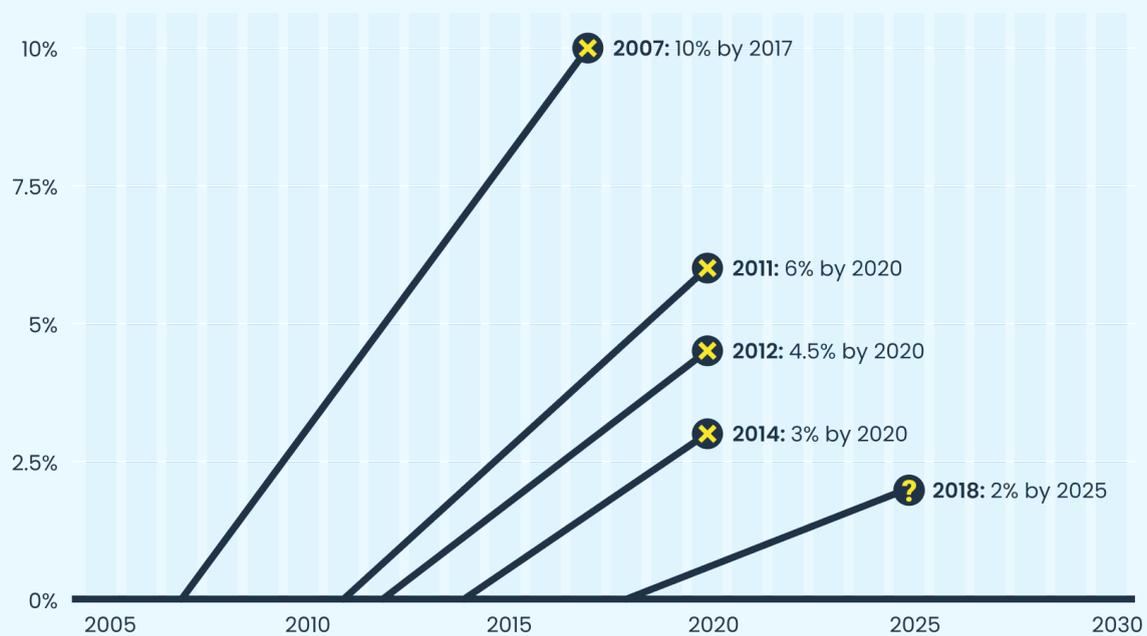
At the end of 2011 IATA updated their website, reducing ambition further with a new position that "IATA thinks a 3 to 6% share of sustainable 2nd generation biojet is achievable by 2020"[95] and by June 2014 it had become "roughly 3%" by the same year.[96] By July 2015 this page had been taken offline and the content moved to a pdf with no further reference to an alternative fuel target.[97]

In February 2018, IATA relaunched their alternative fuel ambitions with a fresh target for "one billion passengers to fly on flights powered by a mix of jet fuel and sustainable aviation fuel (SAF) by 2025.[98] We were unable to find the blend concentration which would qualify a flight to be

classed as operating on alternative fuel but IATA subsequently clarified that in 2025 "penetration should be approaching 2% (circa 7 billion litres)".[99]

This was followed up in 2021 by an announcement that IATA is targeting 65% of the greenhouse gas reductions needed in 2050 coming from alternative fuels. To achieve this they estimate that global alternative fuel supply will need to reach 449 billion litres[100]. Confusingly, the press release supporting IATA's announcement of this target in 2021 states that 449 billion litres represents "65% of total fuel requirement" in 2050[101], which would imply a technical maximum carbon reduction contribution of just over 50% if all alternative fuel produced in 2050 had the maximum greenhouse gas benefit quoted of 80%.

Sustainable Aviation Fuel Users Group (SAFUG)

The Sustainable Aviation Fuel Users Group (SAFUG) was an industry coalition, co-founded by Boeing, which formed in 2008 and was made up of 25 airlines along with airframe manufacturers and fuel supply.[102]

SAFUG developed a target "to see 1% augmentation of the global aviation fuel supply with sustainable biofuel by 2015. This target would translate into 500-600 million [US] gallons per year, globally." This goal dates back at least as far as December 2009[103] and as recently as February 2015 senior Boeing staff were still promoting a goal "to have sustainable aviation biofuels available to address 1% of global jet fuel demand, which is about 600 million gallons [2.3 billion litres]" by the slightly later date of 2016.[104]

Boeing has more recently been promoting a new near-term goal "to contribute to accelerate initial production and use of sustainable aviation fuels by 2025 to meet 2% of the total amount of global aviation fuel demand, and they believe this goal can be met."[105]

The last time the SAFUG website was available online was June 2020[106] which suggests that the group no longer exists.

US Government

In 2011 the US regulator, the Federal Aviation Administration (FAA), set "an aspirational target for use of 1 billion gallons [nearly 4 billion litres] of alternative jet fuel per annum by 2018."[107] This would have equated to nearly 4% of the 26 billion US gallons of aviation fuel consumed in the US.[108]

In the original 2012 version of the United States Aviation Greenhouse Gas Emissions Reduction Plan,[109] this FAA target was cited along with two others. The first was that the US Air Force had set "a goal of being ready to cost competitively acquire 50 percent of USAF domestic aviation fuel from domestically sourced 50/50 alternative fuel blends by 2016", while the US Navy had "a goal to have 50 percent of the Naval fleet's total energy consumption from cost competitive alternative sources by 2020."

All three of these goals were also present in the 2015 update of this plan,[110] but by the time of the 2021 update the 2020 FAA target had been dropped in favour of a commitment to "scaling up SAF production to at least 3 billion gallons per year by 2030"[111] and the US Air Force and Navy targets had been removed from the report.

European Union

In 2011 the European Commission brought together Airbus, European airlines and European biofuels producers to launch a programme aimed at accelerating the deployment of alternative fuels in Europe.

The European Advanced Biofuels Flight Path was intended to be "a roadmap with clear milestones to achieve an annual production of two million tonnes of sustainably produced biofuel for aviation by 2020" and "a shared and voluntary commitment by its members to support and promote the production, storage and distribution of sustainably produced drop-in biofuels for use in aviation.[112] Two million tonnes of alternative fuel equates to 1.6 billion litres, equivalent to around 3% of EU aviation fuel consumption and the target lasted until 2014 when the website was taken offline.

Aviation Initiative for Renewable Energy in Germany (aireg)

The aireg coalition was founded in 2011 with a goal to promote research, production and the use of alternative aviation fuels in Germany. Since at least 2012,[113] the group has promoted "measures to ensure that ten per cent of the jet fuel used in Germany will come from alternative feed stocks by 2025", equivalent to 1.1 million tonnes of fuel.[114]

While this old target still appears on live pages throughout the aireg website, the target appears to have been scaled back in ambition and pushed back by one year so that now they have a revised goal of a "2% blending obligation of sustainable, renewable fuels into aviation fuels" by 2026.

Clean Skies for Tomorrow Coalition

The Clean Skies for Tomorrow Coalition is a group of over 60 "Champions" made up of aircraft manufacturers, airlines, airports and fuel producers brought together by the World Economic Forum.

The aim of the coalition is to "address the chicken-and-egg scenario whereby producers and consumers are both either unwilling or unable to carry the initial cost burden of investing in new technologies to reach a scale where they are competitive with existing fossil fuel-derived options."[115]

In 2021 Clean Skies for Tomorrow released an ambition statement to "put the global aviation sector on the path to net-zero emissions by 2050 by accelerating the supply and use of alternative fuel technologies to reach 10% of global jet aviation fuel supply by 2030.[116]

Virgin / Virgin Atlantic

In 2006, Virgin Group founder, Sir Richard Branson, pledged to spend $3 billion (the estimated total of the next 10 years of Virgin Group's proceeds from its travel businesses) developing sources of renewable energy[117]. The pledge was high profile and attracted attention and admiration from UK politicians; a spokesperson for prime minister Tony Blair described it as "an extremely generous offer", and that, after

meeting with Branson and other business leaders, Blair had been "very impressed with the positive steps all the companies were taking to reduce their impact on global warming". Liberal Democrat environment spokesperson, Chris Huhne, described the pledge as an "extraordinarily generous and imaginative gesture on Sir Richard's part" (the emphasis on generosity is perhaps misleading; Branson was pledging to make investments, not donations). Branson's pledge was also cited several times in the House of Commons by members of parliament discussing energy, climate and aviation policy in the several years following[118].

Three years later, Virgin had invested only $260 million in total towards the pledge (far short of the $300 million a year implied by the headline figure).[119] "In a sense, whether it's $2 billion, $3 billion or $4 billion is not particularly relevant," Branson told *Wired* magazine.[120] Seven years into the pledge, the writer Naomi Klein calculated the cumulative pledged investment at still well under $300 million[121].

Although Branson characterised the pledge as investing "proceeds from our dirty fuel business" into stopping climate change, the *Wired* article reveals that over 90% of the money was from rail travellers via Virgin Trains. While Branson claimed that his failure to invest the billions he had announced is due to the lack of profits from his transport businesses, Naomi Klein's *This Changes Everything*[122] describes how this explanation is undermined by Virgin Group's expansion into other high carbon areas, including space tourism (Virgin Galactic), Formula One (Virgin Racing), and more airlines (Virgin Australia, Virgin America, Virgin Express).

In 2007 the pledge was featured prominently on Virgin Atlantic's Environment page alongside a quote from a climate NGO describing it as "the sort of initiative the airline industry needs at a time when emissions from this sector are growing at nearly 4% a year."[123] By late 2010, four years into the ten year pledge, the Environment page no longer mentioned the $3 billion pledge[124], nor did it appear in Virgin Atlantic's 2010 sustainability report.

Virgin Atlantic also announced plans in 2007 for a test flight using biofuels in one of their airliners. One of the plane's four engines would run on a blend of 40% biofuel. Virgin's chief executive said: "If the industry is to keep growing it has to do what it can to look at new technology, whether it be lighter planes or new fuel. It is important that the airline industry is being seen to do something."[125] The flight took place in 2008, from London to Amsterdam, with one engine powered by 20% (not 40%) biofuel[126]. An Early Day Motion signed by 10 MPs congratulated Virgin Atlantic on "the first commercial flight powered partly by biofuel" and noted that "sustainable fuels such as biofuels will help reduce carbon emissions generated by air travel"[127].

Virgin Atlantic's 2010 Sustainability Report[128] presented a chart showing how they expect their efficiency target to be achieved, which includes a contribution from a biofuels target: lower carbon sustainable biofuels (goal 10% of our mix by 2020).

Virgin Atlantic's 2011[129] and 2012[130] Sustainability Reports show the same chart, and a similar chart appeared in the 2014 Report, but this time the sustainable fuel contribution does not have the specific 10% of fuel mix by 2020 goal attached to it. This appears to be the last time Virgin Atlantic mentioned this sustainable biofuel target.

Virgin Atlantic's 2019 Sustainability Report says: "After 10 years of development the technology is now close to jet fuel production on a commercial scale [...] we're now actively seeking UK government and investor commitment to making this fuel a commercial reality".

In 2021, a press release from Virgin Atlantic announced a new target for alternative fuels: 10% of their fuel mix by 2030.

ACARE

In addition to the efficiency targets set by ACARE, the organisation also set targets for sustainable alternative fuels as part of its Strategic Research and Innovation Agenda.[131] In 2012 these targets aimed for at minimum 2% alternative fuels by 2020, 25% by 2035 and 40% by 2050,[132] but by the time of the 2017 update of ACARE's *Strategic Research & Innovation*

Agenda Volume I, the ambition for 2050 had been downgraded to "sustainable alternative fuels are widely used contributing to a substantial reduction in aviation's impact on climate change."

Other alternative fuel targets

According to the IATA Sustainable Aviation Fuel Roadmap[133] a number of other smaller regional and national alternative fuel targets were launched including:

Entity	Coverage	Target
NISA	Nordic Countries	3 to 4% of Scandinavia aviation fuel supply by 2020
SkyNRG/BioPort Holland	Netherlands	1% of KLM's fuel consumption by 2015
	Netherlands	Producing 1 million tons of bio jet fuel in 2020
Mexico-Spain Partnership	Mexico & Spain	1% use of biofuels by the year 2015
	Mexico & Spain	15% use of biofuels by the year 2020
Indonesian Government	Indonesia	2% by 2016, 3% by 2020, 5% by 2025
Fuel Choice Initiative	Israel	20% by 2025
Norwegian Government	Norway	0.5% blend mandate by 2020
	Norway	30% by 2030

Discussion

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Over the last two decades, a broad range of actors in the aviation industry (including airlines, airframe manufacturers, regulators, industry associations and governments) have produced a blizzard of goals and targets. Many of these goals had a target date of 2020 and it might be thought that in assessing the aviation industry's target-meeting, industry reports produced for 2020 would be a helpful starting point, perhaps even listing previous targets already met.

Instead we were obliged to search through two decades of reports, working papers and archives of the organisations' websites in order to piece together a picture of the often convoluted evolution of each target. In doing so we found targets which were extended, replaced, or silently abandoned, even when (in a very small number of cases) the limited evidence available points to them likely to have been met.

IATA was the biggest culprit for this kind of behaviour, setting a range of shifting efficiency targets in the run up to 2009 when it settled on the least ambitious option, and setting a series of alternative fuel targets of gradually reducing ambition during the ten years running from 2007.

The targets that we found fall into two broad categories: aircraft fuel (or CO_2) efficiency, and alternative fuel use.

Efficiency targets

Efficiency targets were often poorly defined, or the original definitions were uncovered only after extensive research, and it was not clear how they were supposed to be assessed. For example, only after extensive research was it possible to ascertain that the ICAO 2% efficiency target was to be measured on a fuel burn per revenue tonne-km basis. Even the team of Independent Experts commissioned by ICAO to develop fuel burn reduction technology goals wrote in their 2010 report that it was "noteworthy that the metric for efficiency [for the 2% target] was not defined" and this was written shortly after the target had been agreed. The baseline

for the ICAO target is also not entirely clear, with the balance of evidence pointing towards the 2% per annum target commencing in 2005, but it is far from clear and we could find no reference to the baseline year since the fourth GIACC report in 2009.

Another example of poor target definition can be found in ACARE's Vision 2020 which set a target of "a 50% cut in CO_2 emissions per passenger (which means a 50% cut in fuel consumption in the new aircraft of 2020)", however on further investigation ACARE appeared to consider the target to include operational considerations such as load-factors and savings from changes to air traffic management alongside the designed efficiency of the planes.

The choice of metric is also an important factor in assessing the impact of targets. The efficiency metric widely adopted by the aviation industry, fuel burn per revenue tonne-km (RTK), does not represent the fuel efficiency of the aircraft alone. While fleets are gradually replaced by more efficient aircraft, a significant contribution to the efficiency gains achieved by the industry has come from increases in load factors (the proportion of an aircraft's potential payload taken up by revenue-generating passengers and freight) with passenger load factors increasing from around 70% in 2000 to more than 82% in 2019.[134]

Increased load factors are a viable means to increase the efficiency of the aviation system, but the potential to increase load factors is finite and the easiest gains have already been achieved. This means that these operational benefits will gradually diminish and it will be necessary for the rate of improvement in aircraft efficiency to increase substantially in order to achieve a sustained reduction in fuel burn per RTK over the coming decades.

When considering just the improvement in aircraft efficiency on an available tonne-km (ATK) basis, as ICAO's group of Independent Experts did, reductions in fuel burn have been considerably harder to achieve than was expected. In their 2019 report, the Independent Experts framed this as being because their 2010 review "considerably over-estimated the reduction by 2017" and the goal which they set "was far too optimistic when compared to recent achievements". Another

way of looking at this is that the industry fell well short of what was expected of them and has struggled to deploy the technologies needed to achieve the expected fuel burn reductions.

This does not bode well for the Independent Experts' second report in 2019, which set a target of a 21% improvement in fuel burn per available tonne-km for single aisle aircraft and a 24% improvement for small twin aisle aircraft by 2037. Not even three years later, ICAO's Committee on Aviation Environmental Protection (CAEP) reported that "new technology, including advanced traditional and new unconventional airframe configurations were also expected to contribute to efficiency improvements of up to 21%".[135]

The implication of this statement is that CAEP is now of the view that the Independent Experts' target is not going to be met. It also suggests that ICAO's 2% per annum reduction target between 2020 and 2050, which equates to a 45% reduction in fuel burn per RTK over that period, cannot be met. This is confirmed in CAEP's *Report on the feasibility of a long-term aspirational goal (LTAG) for international civil aviation CO_2 emission reductions* which finds that the efficiency improvements under all three scenarios studied range from 1.2% to 1.7% per annum.[136]

Another kind of efficiency improvement exists in the form of airspace modernisation. This strategy of airspace reform is a core part of the aviation industry's net-zero plans and the UK government claims that modernising airspace will "help to reduce aviation's carbon emissions, contributing to ambitions such as the global industry goal to reduce net emissions by 50% by 2050" but that it will also "increase airport capacity, providing more choice and better value for passengers."[137]

The UK Civil Aviation Authority's Airspace Change Masterplan states that "without significant changes to the system, increased congestion, vectoring and arrival holding will lead to a further degradation in environmental efficiency as traffic levels grow, with average per flight CO_2 emissions expected to rise by between 8% and 12% by 2030 compared to current levels."[138] The use of "average per flight CO_2 emissions" in that report is important as the Masterplan also goes on to state that "traffic levels are predicted to continue growing to 3.3

million flights per year in 2040 – a net 28% increase on the 2019 peak."

In Europe there is a similar programme of airspace reforms underway called Single European Sky. Launched in 2004, the European Commission set a number of High-Level Goals for the Single European Sky programme. One of these goals was to "enable a 10% reduction in the effects flights have on the environment", while another was to "enable a 3-fold increase in capacity".[139]

These programmes therefore only reduce emissions relative to a baseline in which aviation demand grows without airspace capacity being increased so it is extremely important to view any claims of emissions reduction from a suitably sceptical perspective.

'Sustainable Aviation Fuel' targets

Targets for Sustainable Aviation Fuel (SAF) began to appear in 2007 and at first were extremely bullish about the potential for biofuels to be deployed at scale in the run up to 2020. Over time these targets have been replaced with progressively less ambitious ones, while the original targets were quietly abandoned, as alternative fuel supplies remained multiple orders of magnitude lower than required by these original targets.

After this period of diminishing ambition, as it dawned on the industry that there were no "easy steps to growing a viable aviation biofuels industry"[140] using fuels that in 2030 are expected to cost two to five times as much as jet fuel costs in 2020,[141] a flurry of highly ambitious new targets and mandates have recently been set.

These envisage a rapid expansion in alternative fuel production to supply greater than 50% of aviation fuel in under three decades (with the bulk of the expansion taking place in the 2030s. IATA has set a target that 65% of the greenhouse gas reduction in 2050 should come from alternative fuel use, and they estimate that global alternative fuel supply will need to reach 449 billion litres to achieve this - an increase of nearly 450,000% on the 100 million litres which IATA believes are currently produced[142]. This extraordinary

increase is demanded by the industry's own net-zero pathways and is fundamentally driven by the desire to sustain passenger growth at all costs.

It may be that climate targets do little to make aviation more sustainable because airlines and other industry organisations have little control over whether they meet them. Airlines rely on burning jet fuel to fly planes to generate revenue; a competitive market without significant climate regulations drives airlines to seek fuel efficiency improvements while also discouraging significant uptake of costlier cleaner fuels.

Efficiency improvements have always been a focus for the aviation industry, driven by the pursuit of cost-savings, and targets do not seem to have made a material difference. As the Air Transport Association (now called Airlines for America) wrote in their 2009 Economic Report, "whether or not scientific and policy concerns were prevalent years ago, our members were doing the very things needed to address GHGs – conserving fuel and shepherding it to its most productive use. Given that fuel burn, which is the source of GHG emissions, is our largest cost center – accounting for 30 to 40 percent of our costs – our environmental and economic interests are perfectly aligned".

Efficiency improvements align especially well with the business model for fast-growing carriers, who can improve overall fleet efficiency when they add newer planes to their fleet, and again when they eventually retire older planes. However, efficiency improvements are not the primary business motive, and in practice the efficiency figures sometimes regress due to more compelling business motives (such as adding older planes to the fleet, or through the practice of "tankering", where airlines sacrifice fuel efficiency for lower fuel costs by uplifting excess fuel at airports where it is cheaper[143]), or wider economic fluctuations (most dramatically, the current pandemic).

Although there are substantial differences in efficiency between airlines, these are best explained by the markets they operate in (lengths of routes and space per passenger), rather than their environmental policies. Recent analysis by the International Council on Clean Transportation found that

"no one carrier consistently deployed aircraft with lower fuel burn than its peers across the four route groups."[144]

Figure 4: The contrasting environmental impacts of easyJet and Virgin Atlantic here likely reflect their market position rather than differences in their environmental policies. An ICCT white paper[145] found the same pattern in US airlines, where the low cost carriers were more efficient, but their growth in traffic greatly exceeded their efficiency improvements. The low cost carriers were responsible for most of aviation's growth in greenhouse gas emissions. Network carriers (such as Virgin Atlantic and British Airways) were not as efficient but the growth in total emissions was less extreme compared to the low cost carriers.
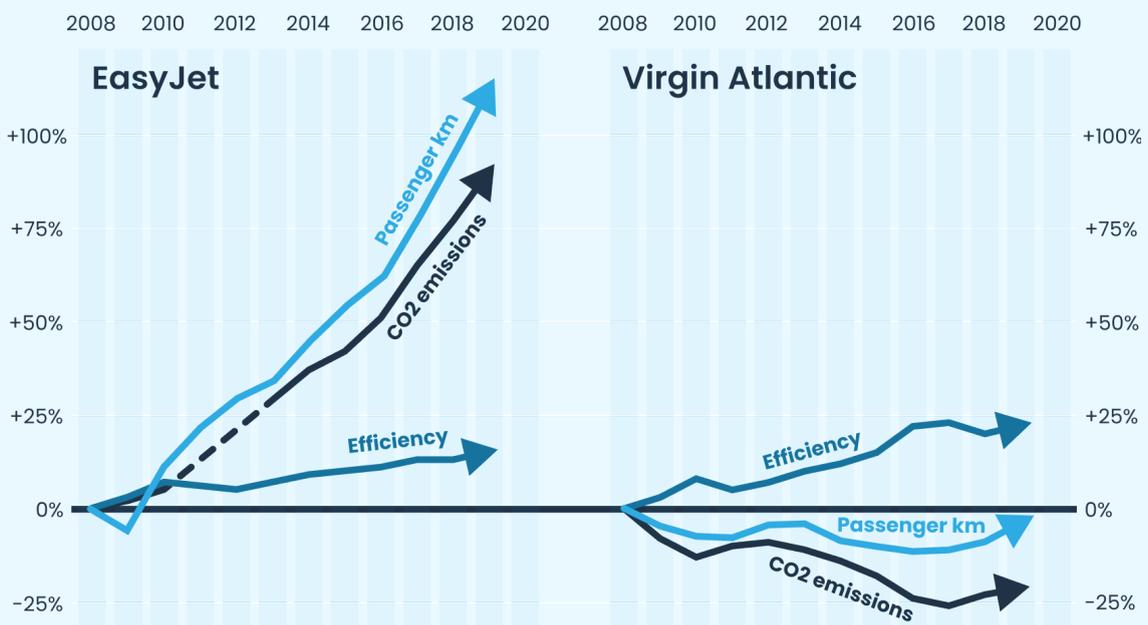
"We believe that the main environmental challenge facing the industry is to ensure that emissions are put on a downwards path.
There is a real risk that if the industry does not achieve this on its own, it will have growth constraints placed upon it."

EasyJet's annual report 2010

In the same way, alternative fuel targets do not materially change conditions in a way that could facilitate uptake. The cost-saving motives that align with efficiency targets work strongly against replacing a significant percentage of kerosene with an alternative that may be two to five times as expensive. The sourcing of alternative fuels by airlines has also depended upon agreements with nascent startups who have struggled to scale up production (and stay solvent) in line with airlines' publicly announced expectations.

As Dan Rutherford, aviation director at ICCT, told the magazine Marketplace: "I've been watching this space for about 10 years and really haven't seen the needle move. It's because voluntary goals don't work. They don't drive markets."[146] IATA appears to agree: "It's important to stress that it is not IATA, nor even the airline sector, that can drive production of SAF. It has to be done by the big oil majors, or by new innovative companies coming to the market."[147]

Alternative fuel targets have become particularly important for those parts of the industry eyeing a resurgence in supersonic flight, as a way of reconciling their pledges of climate responsibility with a fuel burn per passenger-km 7-10[148] times greater than conventional subsonic aircraft. This renewed interest in a technology which was in part abandoned due to its exceptionally high fuel costs seems fundamentally at odds with an industry which supposedly aims to achieve sustained year-on-year improvements in efficiency out to 2050. Questions must also be asked about whether using a scarce fuel source (which could come with its own adverse impacts) in such an inefficient way is a sound environmental strategy or whether the economics of supersonic aviation stack up when the intended fuel costs multiple times conventional jet fuel.

Wherefore aviation climate targets?

Aviation climate targets have changed over time to reconcile the industry's desire for unconstrained growth with the global and national climate targets and ambitions of the time. In the early-mid 2000s, targets focused simply on improving efficiency, at a level which, when combined with the sector's projected growth, would still result in a substantial increase in

emissions. ACARE's Vision 2020, for instance, sets a relatively ambitious goal of a 50% reduction in CO_2 per passenger km by 2020 which, combined with their projected tripling of demand, would have still resulted in a 50% increase in aviation emissions.

ICAO has been slow to respond to increasing demands for action on aviation's environmental impacts in the 2000s, with a record of continued opposition to fuel taxes, the rejection of the establishment of emission standards for new aircraft (which meant that these were not finalised until 2016, with implementation not being enforced until 2028 and the average new aircraft being delivered today already complying with the 2028 standard[149]), the opposition of a closed emission trading scheme for aviation and the opposition of the inclusion of foreign carriers in regional emissions trading schemes.[150]

In late 2009, ICAO set an "interim target to stabilize net CO_2 emissions from aviation from 2020 onward (carbon-neutral growth)" and "a long-term aspirational goal to reduce aviation net carbon emissions by 50 per cent in 2050 compared to 2005 levels",[151] reacting to a growing consensus that global emissions must peak by 2020 at the latest, and fall to at least 50% of 1990 levels by 2050.[152] ICAO's targets mirror the 50% cut and the 2020 peak, giving the appearance of aligning with the leading global ambition of the time, but the 2005 baseline (the date of aviation's peak emissions thus far) and the "net" rather than an absolute emissions cut (achievable through carbon trading and offsets), allow room for the industry's goals of growth ("carbon-neutral-growth").

The industry's qualms over climate concern's threat to its social licence for unrestricted growth are illustrated by these remarks from the Risks section of easyJet's 2010 Annual Report[153]:

> "Over the last ten years, global aviation traffic has grown by over 5% a year, while efficiency gains have been about 2%. [...] This is clearly unsustainable and needs to change going forward. [...] There is a real risk that if the industry does not achieve [emission reductions] on its own, it will have growth constraints placed upon it. We have already seen suggestions of

this in the UK, where the Committee on Climate in its December 2009 report on aviation emissions suggested the growth of the industry would need to be limited to 60% over the next 40 years to control UK emissions. To ensure the industry does not face any artificial constraints we need to significantly improve the efficiency of flying."

(Despite these concerns, by 2019, although easyJet's CO_2 per passenger-km had fallen 8.7%, its total CO_2 emissions had increased 82% from 4.5 million tonnes to 8.2 million tonnes.)

The 2018 IPCC Special Report on 1.5°C[154] triggered a wave of public concern about climate change, followed by many countries setting targets for net zero emissions by mid-century. The aviation sector again followed suit (albeit less quickly than in 2009). In early 2020 Sustainable Aviation UK updated their road map with a potential path to net zero in 2050;[155] that December, United Airlines also promised to be net zero by 2050,[156] and in October 2021, IATA announced an industry wide commitment for net zero by 2050[157].

The industry targets we found are always set in the context of allaying environmental concerns about continued long term growth in aviation, and the targets always allow for real emissions to grow unconstrained over the short-medium term. Although Sustainable Aviation have a target for net zero emissions by 2050, their 2020 CO_2 Roadmap[158] has real emissions climbing steeply with the forecast opening of Heathrow's third runway in 2026, peaking only in about 2035, where the efficiency improvements from still-unknown future aircraft types,[159] and larger quantities from alternative fuels come online.

We found that, although industry's efficiency targets were insufficient to control growth in emissions resulting from a growth in activity, they have been consistently used to ease policymakers' environmental concerns. For example, British Airways responded to a consultation on airport expansion in the South East of England in 2003 referencing ACARE's Vision 2020 targets as reassurance that technology improvements were coming that would reduce emissions.[160]

Targets from ACARE and British Airways were cited again in a 2008 Commons Research paper written to inform a debate on aviation's exclusion from the UK's climate change targets[161]. When the Scottish Government consulted on cutting air travel taxes in 2017, several responses cited targets; Airlines for America responded: "this projected increase in emissions must be seen against the backdrop of the industry's commitment to improve efficiency and reduce emissions through global agreement, industry targets, new technologies, sustainable fuels and operational improvements."[162]

Yet the industry has often replaced or abandoned its commitments and targets without explanation, and, since the targets are voluntary, faced no consequences for doing so. High profile examples are ICAO's 2% per year efficiency target, ACARE's Vision 2020 target, and IATA's targets for 10% SAF by 2017, then 6% SAF by 2020. In some cases we have even encountered outright denial that the targets ever existed in the first place, such as in correspondence with Possible when IATA claimed that the organisation had "never had specific targets for SAF production or use." A recent small innovation counter to this pattern is British Airways issuing bonds linked to its fleet efficiency, yet even here, the efficiency improvement the airline has made themselves accountable for achieving is less ambitious than the public target they announced.[163]

The problem of absence of accountability at the highest levels is compounded by how these targets flow down through the industry, with supranational organisations such as ACARE, ICAO or IATA setting targets which are then adopted by national governments and organisations, and included as inputs into models or into action plans. For example the ACARE Strategic Research and Innovation Agenda targets, including the alternative fuel target of 2% by 2020, have appeared in many of the State Action Plans to ICAO[164] and global and regional targets are sometimes adopted by national bodies, for example UK lobbying organisation Sustainable Aviation (UK) adopted targets from ACARE's Vision 2020, and latterly ACARE's Flightpath 2050 targets when ACARE dropped the Vision 2020 targets.

Conclusion

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What is the explanation for this pattern of setting impressive-sounding targets and then quietly abandoning or revising them? Our hypothesis is that targets present an impression of action, of direction, of the existence of a plan to address aviation's impacts. These targets therefore serve to reassure policymakers that the industry has the problem under control and that other – more politically difficult – measures, such as demand management, are not needed.

This pattern of, at times almost compulsive, target setting raises some critically important questions around credibility. The industry is asking us to believe that radically greater ambition for 2050 is plausible without any changes to aviation's growth trajectory. Two of the main components of their plan for net-zero carbon emissions are sustained, ambitious efficiency improvements and the production of enormous quantities of genuinely sustainable fuels between now and 2050. Their track record with respect to setting, achieving and reporting on targets connected to both of these measures does not inspire confidence that either of these goals will be met, and casts a shadow of profound doubt over the ability of the industry to achieve their net-zero ambitions without deliberate policies to manage demand for flights.

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