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Decarbonising Aotearoa New Zealand's aviation sector hard to abate, but even harder to govern

Abstract

Aotearoa New Zealand ranks sixth in the world for total per capita aviation emissions. Our geographic isolation, our globally dispersed families and our large tourism industry make international aviation especially significant. Domestic aviation is also important, in part due to a lack of passenger rail services. We need to decarbonise aviation. Yet, uncertainties of future technologies and responses to prospective policies make it a challenge to prescribe a definite course of action. We suggest that a wide range of policies, including emissions budgets, a sustainable aviation fuel mandate, emissions trading and fuel tax reform, and a rethink of tourism are essential.

Keywords decarbonising aviation, sustainable aviation fuels, emissions reduction

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The challenge

Recent extreme weather events in New Zealand have brought renewed attention and urgency to mitigation of, and adaptation to, climate change. While 2022 saw the greatest weather-related economic losses on record (including the March 2022 North Island floods, insured losses \$120 million, and the August 2022 Nelson floods, \$67 million), these events were dwarfed by the record-breaking January 2023 Auckland flooding, followed two weeks later by Cyclone Gabrielle, with insured losses estimated at \$1.65 billion (Evans, 2023). Scenes of flooding in Auckland International Airport brought home the irony of air travellers making the problem worse – an extreme and tragic instance of the 'flyers' dilemma' (Higham, Cohen and Cavaliere, 2014).

For the big picture we can refer to the sober assessments of the Intergovernmental



Panel on Climate Change (IPCC) reports, including its latest in March 2023. These point out the stark difference between warming of 1.5°C and 2.0°C. Among many impacts, they see the potential for widespread impacts to ecosystems, people, settlements and infrastructure resulting from increases in the frequency and intensity of climate and weather extremes, and substantial damages, and increasingly irreversible losses, in terrestrial, freshwater and coastal and open ocean marine ecosystems. There is the potential for a 6m sea level rise at 2.0°C and 25m at 2.5°C. The latest report states that ‘[t]here is a rapidly closing window of opportunity to secure a liveable and sustainable future for all’

(IPCC, 2023). Tipping points, described as walking into an increasingly dense minefield, lie ahead (Kemp et al., 2022).

Or, we can refer to social commentary such as that of the New Zealand cartoonist Chris Slane.

Globally, aviation’s overall contribution to greenhouse gas emissions is currently smaller than that of sectors such as agriculture or road transport. It is estimated that aviation accounts for around 2.5% of global annual CO₂ emissions and 4% of current global warming (Klöwer et al., 2021). But aviation stands out as an extremely carbon-intensive form of travel, in which a very small proportion of the world’s population contributes a

disproportionate share of emissions (Erikson et al., 2022; Gössling and Humpe, 2020). In studies of how individuals in wealthy nations can reduce their emissions, avoiding flights, especially long-distance ones, is high on the list of recommendations. While aviation is already an important contributor to global warming, it is the global growth scenarios, potentially still mainly using fossil fuels, that are of particular concern.

Due to a number of factors, including our geographic isolation, being a country of migrants with families spread across the world, and our large tourism industry, international aviation is especially significant for Aotearoa New Zealand. Domestic aviation is also important, in part due to a lack of fast, affordable and frequent passenger rail services.

Not surprisingly, we have high emissions. Aotearoa New Zealand’s aviation emissions rose 116% between 1990 and 2019 to reach 4.9 MtCO₂, with international emissions tripling.¹ Aviation emissions rose from 8% to 12% of gross CO₂ emissions, faster than global growth. Pre-Covid, New Zealand ranked sixth in the world for per capita aviation emissions (i.e., including international and domestic emission), at 1 tonne CO₂, about ten times the world average. It ranked fourth for per capita domestic aviation emissions (more than Canada, a much larger country physically) and sixth for international emissions (Global Sustainable Tourism Dashboard 2022). On a per capita basis,

Table 1: Two scenarios for decarbonisation

Degrowth	Green growth
There are not enough minerals to build either renewable energy nor batteries and other technological advances needed for green growth projects.	There are enough minerals, especially as we switch to newer and cheaper processes (e.g. away from cobalt and rare earths).
We cannot build and maintain enough renewable energy to supply ever-rising demand.	We can build enough renewable energy to replace fossil fuels.
We will not have breakthroughs in battery technology any time soon that will allow large, longer distance regional electric planes.	Such breakthroughs are just around the corner.
Biofuels are an environmental disaster taking away valuable land for fuel production, relying on feedstocks that are unsustainable (e.g. palm oil) or in short supply such as used cooking oil.	Biofuels, from waste, wood, algae and corn are the answer for long distance flying and can be scaled up quickly.
Exponential growth of use of materials and energy is unsustainable.	Growth in demand for aviation is a natural response to economic growth, and society should plan to accommodate it.
Material and energy use should be minimized and should prioritize human needs.	Material and energy use should grow and be allocated in response to demand.
In an ‘Avoid/Shift/Improve’ framework, the focus is primarily on ‘Avoid’, but in some areas, ‘Shift’.	The focus is on ‘Improve’

New Zealanders emitted seven times more than people living in the UK and nine times that of Germany in domestic aviation (Ritchie, 2020).

Frameworks for considering decarbonisation of aviation

Scientific research can tell us much about the past and our current-day conditions. But while science can give us some signposts about the future, much is uncertain, especially when projecting out to mid-century, a date used in many emissions-reduction scenarios. Decision making is therefore often carried out within a framework of ideology and beliefs. This is especially important for aviation. Consider two quite differing frameworks for decarbonisation, 'degrowth' and 'green growth' (Boston, 2022; Millward-Hopkins et al., 2020) (see Table 1). We will keep these two belief systems in mind as we examine possible policy approaches to the decarbonisation of aviation.

Green growth is the dominant policy position around the world, at least insofar as efforts have been made to reduce emissions at all. To degrowthers, the green growth agenda – even if it could be realised – would still not constitute true sustainability, because of issues of overshooting planetary boundaries. Yet green growth risks sliding into the extremist fringes of eco-modernism and techno-optimism: namely, the belief that technology and economic growth will solve all environmental and human development challenges without fundamental changes to society or affluent lifestyles. These extremist positions we reject. There is, however, an intermediate position, which is becoming mainstream in the 'progressive climate' movement exemplified by, for example, Greta Thunberg (see Box 1).

There is a fundamental difference between land transport, where low-emission alternatives, from walking to electric vehicles, exist (but fast-enough adoption is still difficult), and air transport, where low-emission alternatives do not yet exist. The resulting uncertainties are a challenge to policy development and adoption. As long as there are no realistic low-emission aviation options, there is a risk of 'technologies of prevarication', promises of solutions in the future that act

Box 1 Greta Thunberg and the 'progressive climate' movement

"To have a chance of minimizing further irreparable damage, we have to choose: either we safeguard living conditions for all future generations, or we let a few very fortunate people maintain their constant, destructive search to maximize immediate profits. (<https://twitter.com/GretaThunberg/status/1625061065301151744>) [T]he idea that countries such as Germany, Italy, Switzerland, New Zealand, Norway, and so on will be able to achieve such enormous reductions within a couple of decades without major systemic transformations is naïve." (Thunberg, 2023, p.5)

"Until recently, you could argue that it was possible to save the climate without having to change our behaviour. But that is no longer possible. Our leaders have left it too late for us to avoid major lifestyle and systemic changes ... our number one priority must be to distribute our remaining carbon budgets in a fair and holistic way across the world as well as repay our enormous historical debts ... People keep asking us climate activists what we should do to save the climate. But maybe the question itself is wrong. Maybe, instead, we should start asking what we should stop doing?" (Thunberg, 2023, p.240)

to delay the adoption of known (behavioural, organisational, logistic) mitigation measures now. The prevention of greenwashing (United Nations, 2022) and rigorous technology assessment are therefore important, but there are limits to the latter's reliability.

'Making net zero aviation possible'

The aviation industry knows what the challenge is and has contributed to many decarbonisation studies. Here we focus on a major report, *Making Net-Zero Aviation Possible: an industry-backed, 1.5°C-aligned transition strategy* (Mission Possible Partnership, 2023). The report begins:

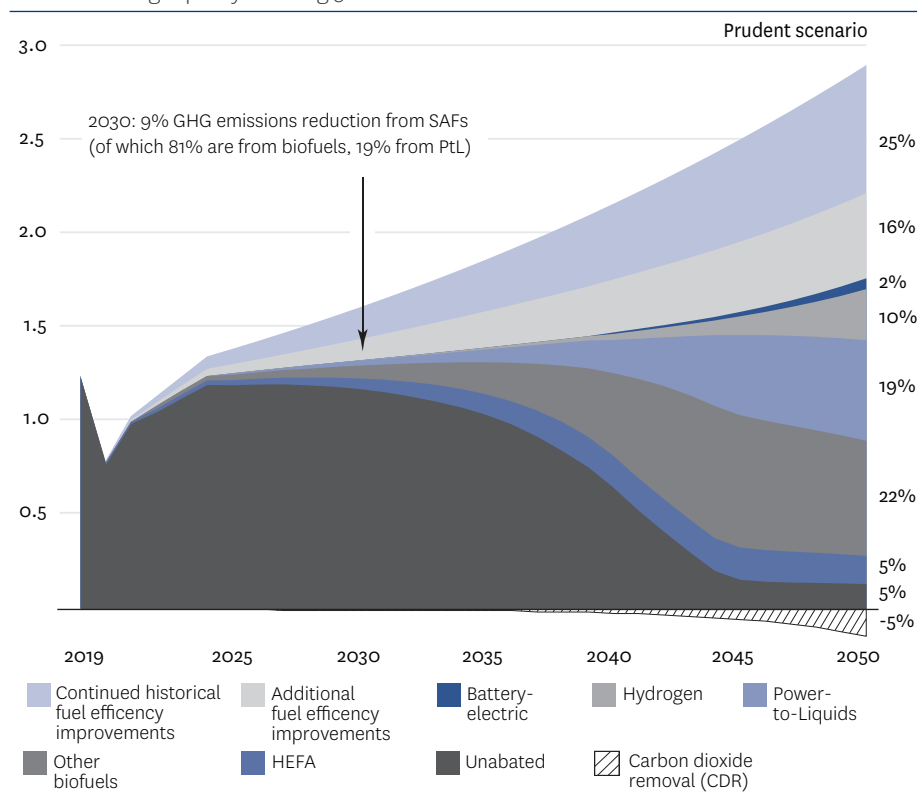
At current emissions levels, staying within the global carbon budget for 1.5°C might slip out of reach in this decade [the 2020s]. Yet efforts to slow climate change by reducing greenhouse gas (GHG) emissions run into a central challenge: some of the biggest emitters of greenhouse gases into the atmosphere — transportation sectors like aviation, shipping and trucking, and heavy industries like steel, aluminium, cement/concrete, and chemicals manufacturing — are the hardest to abate.

The collaborative report was backed locally by Air New Zealand and Sounds Air, as well as globally by a wide range of industry interest groups, including oil companies and producers of alternative fuels. The report works within the concept of a net zero goal for 2050. The authors see two components of net zero. One, which we will not focus on, is reducing aviation emissions by 5–10% by direct air capture of carbon dioxide. However, most current emissions (90–95%) in each sector need to be reduced by in-sector measures: this is 'in line with the Science Based Targets initiative, which prescribes "long-term deep decarbonization of 90%–95% across all scopes before 2050" as the single most important target for a net-zero world' (ibid., p.31).

The report studies four major levers that the authors suggest will move the industry towards net zero emissions. These are:

- reduction in air travel demand (from videoconferencing, from a shift to rail, from consumer education, and from pricing measures);
- efficiency improvements;
- sustainable aviation fuels; and
- novel propulsion (hydrogen, battery-electric and hybrid) aircraft.

Figure 1: The ‘Prudent’ scenario from *Making Net-Zero Aviation Possible*, showing 135% traffic growth over 2019–50 combined with a pathway to net zero. This scenario requires 100% sustainable aviation fuels by 2050 worldwide, of high quality enabling 90% well-to-wake emissions reductions.



Source: Mission Possible Partnership, 2023, p.10

The novel propulsion aircraft have almost no impact until 2040, and are expected to contribute only 12% of total emissions reductions by 2050.

The technology pathways in *Making Net-Zero Aviation Possible* are a useful guide. However, we emphasise that there is considerable uncertainty over their capacity to be realised, even in a narrow engineering context. They would require New Zealand to invest an estimated NZ\$36 billion by 2050 in new aircraft and sustainable aviation fuels; 29 terawatt hours (TWh) of new renewable electricity, which would likely come from wind and solar (ten times our current amount); and enormous amounts of biomass.

The scenarios for efficiency improvements, at 2% per year, are ambitious. For reference, consider the Airbus A320/321/neo family of aircraft. (Air New Zealand has just begun operating the A321neo domestically). The A320neo, introduced in 2016, uses 15–20% less fuel than the A320, introduced in 1988. This constitutes a rate of improvement of only 0.6% per year. The next major aircraft design from Airbus is expected in the early 2030s, pending the success of engines now

under development. Thus, there is potential for only one further aircraft upgrade cycle before 2050. In addition, the current fleet will need to be upgraded to the most efficient available models, and this process takes time.

Even with these assumptions, it is hard to reconcile the *Making Net-Zero Aviation Possible* scenario with a safe future. In the ‘Prudent’ pathway (Figure 1), global aviation emits 25 GtCO₂ over 2020–50, while the aviation carbon budget for a 67% chance of limiting warming to 1.75°C is 22.5 Gt, and for 1.5°C, 12 Gt (Graver et al., 2022).

The following thought experiment illustrates the limitations of the modelling approach used in *Making Net-Zero Aviation Possible* and many other similar studies. Imagine running the model under a requirement of even more rapid decarbonisation: instead of net zero in 2050, ask for true zero in 2040, say, or 2030. The model would tell you how much sustainable aviation fuel of what types would be needed, and how efficient the aircraft would need to be. But it would not tell you whether those outcomes would be achievable.

Growth

Traffic volumes form a fundamental input to aviation emissions pathways. A common approach to modelling traffic volumes is to assume that growth will continue in an almost unrestrained fashion, based on past behaviour and on the principle identified by Schafer and Victor (2000) that widely diverse groups of people spend a constant proportion of their time and income on travel. Rising incomes and falling ticket prices therefore lead to faster travel modes: i.e., to more flying. Projections of global GDP doubling by 2050 lead to 135% growth in air traffic in the *Making Net-Zero Aviation Possible* study. Most of this growth is expected to take place in developing nations, indicating faster traffic growth in those regions.²

Predictions of faster traffic growth lead to an anticipation of more inputs (sustainable aviation fuel plants, feedstock plantations, new aircraft, hydrogen, electricity, airports, land use etc.), which can act as a spur to their development; but it also leads to greater total carbon emissions, other things being equal. Further, it creates a risk that some parts of the system may materialise (more passengers, airports and aircraft) but not others (sustainable aviation fuels and zero-tailpipe-emission aircraft), thereby missing emissions-reduction targets.

Inequality

As noted earlier, air travel is highly unequally distributed. Ivanova and Wood (2020) found that the lowest-emitting 90% of EU households have air travel emissions averaging 0.1 tonnes CO₂ per person (compatible with a ‘1.5°C lifestyle’); 9% of households average 0.8 tonnes; and the remaining 1% average 22.6 tonnes. Its high income elasticity of demand classifies air travel as a highly carbon-intensive luxury. At the global level, Gössling and Humpe (2020) found that in any given year (pre-Covid), 1% of the world’s population are extremely frequent flyers, emitting 10 tonnes of CO₂ each on average and causing half of all aviation emissions; another 10% fly less and emit 1 tonne of CO₂; and the remaining 89% do not fly at all.

We do not have complete data on the distribution of air travel in Aotearoa New Zealand. The Household Economic Survey

asks people if they have an overseas holiday at least once every three years: over all households in 2019, the proportion is 43%, while the range is from 5% in the bottom decile of material deprivation to 80% in the top decile. (Overseas holidays are not considered relevant to deprivation and are not a component of the deprivation index.) Thus, roughly 2.8 million New Zealand residents did not holiday overseas in a given three-year period, but a total of 9 million overseas trips were made by the other 2.1 million residents.

The New Zealand Household Travel Survey yields information on domestic travel emissions. The highest-emitting 20% of households fly domestically 25 times as much as the lowest-emitting 20%, while their emissions from private cars are only 1.6 times higher. Emissions from private cars are regressive, given that both the wealthy and the poor are heavy car users; emissions from aviation are progressive, given that it is the well-off who fly the most (Shaw, 2022).

Climate justice

Equity is written into the Paris Agreement, and a broad wing of climate action considers equity to be essential to addressing the existential crisis of climate change. Procedural equity concerns the process of decision making and the engagement of affected communities. Distributional equity deals with the spread of costs and benefits across society. Structural equity recognises historical, cultural and institutional structures that advantage some groups and disadvantage others. Transgenerational equity considers the balance of costs and benefits between present and future generations.

All four types of equity are relevant to climate change, and especially to aviation, which features marked distributional differences across and within countries. It is clear, however, that not everyone will agree on exactly what is a fair distribution of costs and benefits. Hall (2022), in a study of adaptation finance, assesses policy proposals under four allocative principles: polluter pays, beneficiary pays, taxpayer pays and ability-to-pay.

For aviation, equity points to 'polluter pays' as the preferred principle, although costs borne by the polluter (the airline)

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would likely be passed to beneficiaries (the passengers). However, there are other beneficiaries which could be considered: the tourism industry, and (for business travel) the employer. Proposals for frequent flyer levies cross into 'ability-to-pay' territory.

Without a just approach, the aviation industry globally risks damaging or losing its social licence to operate. Indeed, the extreme unsustainability of 'business as usual' has finally prompted a renewed sense of urgency and the emergence of a coalition behind the goal of net zero aviation by 2050. New Zealand has contributed to this process, first as a founding member of the International Aviation High Ambition Coalition at COP26, then in the negotiations at the International Civil Aviation Organization (ICAO) that resulted in its own net zero 2050 resolution, and also through the sustainability work programme of Air New Zealand.

Science-based targets

Extensive work is underway charting courses for the world, for various

economic sectors, for nations and for companies. Of particular relevance here is the guidance provided by the NGO Science Based Targets initiative (SBTi) for aviation. While some corporate targets are based on the 'absolute contraction' method – grandfathering in emissions from some reference date, along with a specified rate of reduction – for aviation, SBTi guidance is based on the sectoral pathway approach, specifically the pathways of the International Energy Agency (IEA) Sustainable Development Scenario. These allow aviation 2.9% annual passenger growth and a doubling of its present share of the global carbon budget. Targets for individual companies are based on industry-wide emission intensities needed to meet this global budget.

Air New Zealand's SBTi target is a '28.9% reduction in carbon intensity by 2030, from a 2019 baseline. This equates to a 16.3% reduction in absolute emissions over the period' (Air New Zealand, 2022). Such a target is far better than the status quo and the overall initiative is extremely positive.

However, there are some concerns about the SBTi process in general.

- The IEA Sustainable Development Scenario involves enormous amounts of carbon dioxide removal and storage (10 Gt a year), a technology which is unproved at scale and which is itself energy intensive.
- It requires other sectors (e.g., land transport) to decarbonise far more rapidly, which is not easy.
- The modelled passenger growth is a global figure, most of which is expected to be in developing nations, not wealthy nations.
- The global pathway involves gross CO₂ emissions from fossil fuels falling 10% over 2019–22 and 25% over 2019–30; in reality, emissions have not fallen at all over 2019–22. The IEA net zero 2050 pathway, which leads to a 50% chance of limiting warming to 1.5°C with no overshoot, involves CO₂ emissions falling 36% between 2019 and 2030.
- The pathways will only be achieved in a sector if all companies meet the targets. In reality, there will be some laggards, and the most ambitious

Table 2: Terms of reference of the leadership group Sustainable Aviation Aotearoa*

Provide industry leadership on efforts to deliver Aotearoa capabilities for net zero aviation, integrating best practice.	Promote and mobilise private sector efforts to decarbonise aviation, while keeping the network safe and reliable.	Identify and optimise the strategic, economic, and international benefits for the industry, while overcoming the barriers and constraints the industry may face in achieving this goal.
Consider what barriers, including regulatory and investment barriers, need addressing to enable a smoother decarbonisation pathway.	Work to accelerate and enable the commercial operation of zero emission aviation systems in Aotearoa, including SAF, zero emission aircraft, and innovation.	Foster greater collaboration across sectors, such as between airlines, airports and enabling infrastructure, like electricity providers and generators.
Contribute to and identify opportunities to take forward in updating Aotearoa’s State Action Plan, submitted as a voluntary ICAO report.	Consider the Climate Change Commission’s review, under clause 5R of the CCRA, of the inclusion of emissions from international aviation in the 2050 target.	Accelerate the design, manufacture, testing, certification, infrastructure and commercial operation of zero emission aviation in Aotearoa through sustained investment in research and development, and fostering of greater collaboration across sectors.

* Sustainable Aviation Aotearoa includes representatives from Te Manatū Waka, the Ministry of Business, Innovation and Employment, the Ministry for the Environment, the Civil Aviation Authority, Airways, Ngāi Tahu, Tainui, three airlines and the airline body BARNZ, four airports and NZ Airports.

companies and sectors should aim higher.

- The submission and evaluation process is private, and the reporting, verification and responsibility for meeting the target lies with the company. At present, of all companies signing up to SBTi, 28% do not report their emissions and a further 26% report their progress only partially (Science Based Targets, 2022). A report from the New Climate Institute analysed the climate plans and actions of 24 multinational companies affiliated with the ‘Race to Zero’ (1.5°C-aligned) campaign. It found that most are of low integrity, further raising doubts about voluntary corporate initiatives and highlighting the need for independent scrutiny.

Finnegan (2019) has considered the role of institutions in promoting long-term climate policy. With data from the EU and North America, he found that proportional representation and concertation are both associated with more stringent policy. Concertation is a process of allowing peak industry bodies privileged access to the formation of government policy, ensuring their support both publicly and privately. It is also associated with costs falling more on consumers than producers and with compensation for producers. Unfortunately, experience in New Zealand so far with He Waka Eke Noa, a concertation-like process, has not seen these successes, while even simpler parts of the country’s first emissions reduction plan (2022), such as in the electricity sector, have seen pushback from producers.

At present, the aviation industry in New Zealand is not aligned behind progressive climate goals. The tourism industry, a significant beneficiary, is struggling to adapt to a new vision of fewer, higher-value tourists. The airport sector is focused on rapid growth: Christchurch Airport’s long-term strategy involves 175% growth in international passengers over 2015–40, as well as the construction of a new wide-body-capable airport at Tarras. The industry body NZ Airports submitted to government that ‘A positive narrative and greater public understanding are necessary to counterbalance the perceptions – often noisily promoted – that aerospace activities (including aviation) have generally poor outcomes for the environment’, followed by the straw-man argument that the alternative is no flying at all: ‘New Zealand without aviation is a distant, small, isolated society and economy with a rapidly deteriorating standard of living’ (Ward, 2022).

In contrast, Air New Zealand’s sustainability planning has long been world leading, and has now resulted in a net zero 2050 strategy as well as the adoption of their SBTi target for 2030. Air New Zealand had about 40% of the total New Zealand aviation market in 2019, and is majority state owned. The regional airline Sounds Air is hoping to shift to hybrid electric aircraft by 2028; even if that date is highly optimistic, it does demonstrate a commitment. These developments raise the prospect of an alignment of the wider industry (including tourism) behind sustainability.

What we are doing in New Zealand

Aotearoa’s first emissions reduction plan was released in June 2022. It aims to set the direction for climate action for the next 15 years. The plan has only a very short section on aviation. It acknowledges the role of aviation in moving both freight and people nationally and internationally, and suggests there is a need to improve its sustainability ‘alongside improving alternatives to interregional air travel in some places’ (Ministry for the Environment, 2022, p.189). Three key initiatives were set out: to develop and set specific targets for decarbonising domestic aviation in line with our 2050 targets; to implement a sustainable aviation fuel mandate; and to establish a public–private leadership body focused on decarbonising aviation. This body, Sustainable Aviation Aotearoa, has now been established (see Table 2). The members are heavily drawn from the industry itself, and there appears to be under-representation from the tourism industry (Parliamentary Commissioner for the Environment, 2021) and for the interests of the environment.

In the aviation sector, the emissions reduction plan has been somewhat overtaken by events, as the updated State Action Plan provided to ICAO will now need to be aligned with our ICAO net zero 2050 pledge and our other commitments under the High Ambition Coalition. (These cover both domestic and international aviation.) Unlike other sectors, aviation has not yet been given a target for mode shift or traffic reduction. Adoption of the ‘Avoid–Shift–Improve’ framework would remedy this.

Sustainable aviation fuel

Air New Zealand is aiming for a 10% biofuel share by 2030. The initial feedstocks are tallow and used cooking oil, which have a good life-cycle emissions reduction of around 80%, but are very limited in supply. Producing biofuel from oilseed crops is a mature technology (indeed, 10% of the world's grain is used for biofuel), but it impacts on the supply of food for humans and of feed for livestock, and increases the pressure to shift natural ecosystems to agriculture. In addition, the energy requirements for aviation are extreme. Consider, for example, diverting the entirety of New Zealand's current 134,000 ha of grain production to oilseeds for biofuel. This would produce about 134,000 tonnes of fuel – just one-fifteenth of our jet fuel consumption in 2019.

The biofuel mandate for land transport has been dropped: the government was concerned about its impact on consumers, while environmentalists were concerned about its impact on food, animal feed and land use. The arguments are stronger for its use in aviation: it forms the greater part of all pathways, and its higher cost, if passed onto airfares, leads to a progressive, not regressive, impact on consumers. Concerns about the sustainability of feedstocks remain, however, leaving a major question for New Zealand as to the wisdom, timing and structure of investments in wood-based biofuel. The development of domestic biofuel industries is challenging even the most biomass-supportive countries, such as Sweden (Mossberg, Söderholm and Frishammar, 2021). The most viable pathway is to produce biocrude from wood (either waste wood or whole logs), which would likely need to be refined overseas (BioPacific Partners, 2021; Indufor, 2021).

Modelling for Channel Infrastructure NZ (the former Marsden Point oil refinery) (Channel Infrastructure NZ, 2022) forecasts jet fuel use (including efficiency improvements and new aircraft, but not sustainable aviation fuels) relative to 2019 levels to grow 16% by 2030 and 66% by 2050. Fossil jet fuel, based on a scenario from Air New Zealand, would remain steady until 2030 and fall 56% by 2050. The emissions savings associated with sustainable aviation fuels in this forecast

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are already quite ambitious: assuming sustainable aviation fuels with an 80% life-cycle emission reduction, 17% of all jet fuel must be sustainable by 2030. And still, these forecasts fall far short of net zero by 2050, once again illustrating the conflict between traffic growth and sustainability. A report from the Royal Society reaches similar conclusions as to the extreme land and energy requirements of alternative fuels (Royal Society, 2023). Channel Infrastructure has commissioned research into domestic production of biofuels and e-fuels made from renewable electricity, water and carbon dioxide. E-fuels are cleaner and can potentially require fewer resources than any other liquid fuel; they can be made anywhere. They form the main part of Peeters and Papp's (2023) net zero pathway for tourism.

Pricing

Emissions pricing is a core component of New Zealand's climate response. It is likely to remain so, even as complementary measures are added, most notably the Climate Emergency Response Fund. It is unlikely to be an effective tool to reduce aviation emissions if used in

isolation: first, aviation has high costs for technological abatement; second, this high price may be hard to implement, as was demonstrated early in 2023 when the government declined to follow the advice of the Climate Change Commission on Emissions Trading Scheme (ETS) settings; third, there are unresolved debates as to whether purely price-based measures can be effective (Alexander and Floyd, 2020; Hall and McLachlan, 2022). On the other hand, the underpricing of jet fuel relative to other fossil fuels has likely led to overinvestment in aviation, a situation that is unfair and unsustainable. Correcting it provides an opportunity to undo some of the regressive effects of carbon pricing. Similar remarks apply to the zero rating of international travel for GST, which should be removed. Because the increased demand due to rising incomes outweighs plausible levels of taxation, pricing is more about equity and levelling the playing field with other uses of fossil fuels, than reducing demand.

Any pricing mechanism must be carefully designed to both achieve and reward emissions reductions. Existing systems, like the New Zealand ETS and the EU's 'Fit for 55' package, are hybrids that combine pricing and quantity measures. 'Fit for 55' includes a sustainable aviation fuel mandate, a strengthened ETS with revenue recycling, and fuel tax reform. Although not yet compatible with ICAO's net zero goal, it shows a realistic forward path.

Quantity-based instruments must also be carefully designed. Simply bringing aviation into the existing multi-year carbon budgets, with no additional measures that directly reduce emissions, risks passing the responsibility for overall reductions to other sectors.

The way forward

Knowing the benefits brought to people by transport, policymakers are often reluctant in their efforts to mitigate the environmental damage it causes. This cannot continue ... Constraining demand immediately is essential to reducing aviation's climate impact – otherwise our [global] carbon budgets will be breached too soon. Various

mechanisms could be used to do this, including a moratorium on airport expansion in wealthy parts of the world, as well as a frequent-flyer levy. (Larkin, 2022)

There is no way around the fact that transport decarbonization means reducing the use of cars, trucks and planes and the simultaneous removal of fossil fuels from them. (Anable and Brand, 2022)

The uncertainties of both future technologies and the response to prospective policies make it impossible to prescribe a definite course of action for New Zealand at present. We suggest that it will be necessary to press on all levers and to learn from experience. However, our analysis of the global situation as presented above indicates that the following aspects are critical.

- There should be consistency with our obligations as members of the High Ambition Coalition.
- International and domestic aviation should be considered together.
- There should be a sequence of emissions-reduction targets for both domestic and New Zealand-related international aviation to 2050 and beyond, either decade by decade or aligned to the domestic carbon budget periods.
- There should be regular monitoring and reporting to ensure that progress is on track to meet the targets. Equity considerations imply that the targets should follow stricter pathways than for sectors where emissions are more evenly distributed or are essential for basic human needs.
- The right to development and the need for international equity suggest that a relatively lesser burden should be placed on aviation between New Zealand and small island developing states.

Possible policies

Some combination of emissions budgets, a sustainable aviation fuel mandate, emissions trading, and fuel tax reform are essential. Beyond these, we can consider the following.

Although many challenges around technology and scalability remain, ... a fuel mandate with strict sustainability criteria is the best prospect to lower emissions of long-haul flights.

The tourism industry is a beneficiary of aviation. A renewed tourism strategy, focused on reducing emissions and building on the report of the Parliamentary Commissioner for the Environment (2021), needs to be a component of our plan. Simon Upton's practical suggestion of a departure levy, modelled on that which exists in the UK, is a small step towards a solution and could be phased out as emissions reduce and/or alternative mechanisms are implemented. (See also Peeters and Papp, 2023.)

Frequent flyer schemes increase the price of essential goods such as food in order to subsidise flying. They also normalise frequent flying and incentivise the more emissions-intensive classes of travel. They should be prohibited (Callister and McLachlan, 2023). Or different options to implement them should be explored. Frequent flyer *levies* have resonated with the public in surveys and citizen's forums, and are progressive (Zheng and Rutherford, 2022) and appear to appeal to a common sense of fairness. How they might actually operate is the subject of debate.

Communication and education on the environmental impacts of aviation, and the challenges of technological solutions, can build support for an overall plan. Our experience agrees with that of Upton, who encountered widespread denial and cognitive dissonance.

An agreement with the industry to a shared commitment to a sectoral pathway is essential. For example, airlines operating in New Zealand would need to be required to be SBTi-1.5°C compatible.

Fuel efficiency standards can encourage the uptake of more efficient aircraft, by either banning or penalising the least efficient models.

Public investment in the industry (e.g., in airport expansions) should be tied to a commitment to reduce emissions and a mechanism to ensure its delivery. Until this is in place, there should be a moratorium on airport expansion.

Voluntary action plays an important role in climate change mitigation, especially in the early stages of mitigation of a sector. Individuals and organisations can reduce their aviation emissions either by travelling shorter distances, taking fewer flights, reforming their travel policies, or by 1.5°C-aligned procurement. Three important examples are the public service, which, through the Carbon Neutral Government Programme, is to become carbon neutral by 2025; the tertiary sector, which has already markedly reduced staff air travel; and companies that have net zero targets in place (certified, for example, through Toitū Envirocare). Those that are acting now already feel an obligation to do so, which can in time influence norms of behaviour more widely (United Nations, 2022).

While all aviation can be reduced by avoiding air travel (e.g., by holidaying closer to home), domestic aviation is also influenced by shifts to other modes. One reason that New Zealand has such high domestic aviation emissions compared to other similar-sized countries is the poor state of passenger rail. The long-term development of passenger rail offers co-benefits in connecting communities, addressing equity for non-drivers, making travel more pleasant, and lowering energy use, pointing to a role for out-of-sector funding.

Research into wood-based biofuel and e-fuel should continue. Although many challenges around technology and scalability remain (Callister and McLachlan, 2022), a fuel mandate with strict sustainability criteria is the best prospect to lower emissions of long-haul flights.

Conclusion

In Aotearoa New Zealand there has been a strong emphasis on international tourism for several decades, many exporters are dependent upon air travel for freight and visiting foreign markets, many people think a regular overseas holiday is their right, and a significant part of the

population has close relatives who live overseas. Yet, as for all other parts of the economy, decarbonising of aviation needs to happen and ambitious reduction targets are essential.

Technological abatement of aviation is difficult and uncertain and, even if possible, is unlikely to come quickly. But the governance issues may be even more difficult. While international action will be vital, locally there will be a significant political challenge in building a cross-party agreement and a broad social licence for the large emissions reductions that are needed. If the new technologies do not come quickly to the rescue, reducing

international and domestic air travel in this part of the world will be required. This means moving away from the 'Improve' strategies and adopting the 'Avoid' and 'Shift' policies. Demand management solutions will be required if targets cannot be achieved in other ways.

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1 International aviation emissions are reported to the UNFCCC by the country of departure of flights, but are not generally included in national emissions reporting and targets.

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