Building The Future Airport Now:
Christchurch Airport's Green Transition

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1. Introduction

The climate crisis is upon us. We are in the midst of accelerated, anthropogenic planetary change - so significant is the human impact upon planetary systems that a new, stratigraphically-discernible, geological epoch has been proposed: The Anthropocene[1]. We have become a terraforming force threatening the means of our own survival, exceeding multiple planetary boundaries crucial for preserving a safe operating space for humanity[2]. Decisive political leadership on climate change is now emerging in New Zealand though[3], prompting more businesses to further embrace sustainability. However, Christchurch International Airport Limited (CIAL) has been proactively focused on the challenges of climate change and environmental responsibility for a long time.

Christchurch Airport is New Zealand's second largest airport. It sits on 1000 hectares of land, has around 7,000 people working in 250 companies across the campus and hosts around 120,000 members of the public each week. It is one of eight subsidiary companies of Christchurch City Holdings Limited, which has a balance sheet of $4.8billion – of which the airport comprises 30%.

In 2007 it was the world's first airport to conduct an independently-verified carbon audit, performed by Enviro-Mark (now Toitū Envirocare). In 2015, airport shareholders challenged the organisation to sustain commercial returns while delivering on sustainability objectives. In 2016 it launched a Sustainability Strategy founded on the Māori concept of Kaitiakitanga, - care, responsibility, and guardianship. In 2017 the airport benchmarked itself against 24 airports considered leaders in airport sustainability. This informed the Green Transition Plan (GTP), an ambitious framework for advancing initiatives, developing future-thinking, and integrating sustainability decision-making in all planning and operations. In 2019 the airport appointed a Sustainability Transition Leader to oversee its GTP, possibly the first such role in New Zealand's corporate sector.

In 2020, having reduced its direct and indirect carbon emissions by 54% since 2015, Christchurch was the first airport in the world to achieve Level 4 (transformation) in the Airport Carbon Accreditation (ACA) scheme administered by Airports Council International (ACI)[4] .

Christchurch Airport is pursuing a decarbonised, green transition as a purpose driven corporate entity, with a mission to simultaneously build a stronger business, enhance customer journeys, and be great kaitaiki. While we may all be behind the curve in addressing climate change, the airport is ahead of the game.

All this from an airport required to operate with balance sheet separation and governed by a board of professional independent directors tasked with delivering a commercial return on capital. In other words, a purpose driven corporate entity, with a mission to simultaneously build a stronger airport and enhance customer journeys and be great kaitaiki.

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[1] See, for example, "Anthropocene now: Influential panel votes to recognize Earth's new epoch" (2019) https://www.nature.com/articles/d41586-019-01641-5

[2] For an introduction to the nine planetary boundaries framework see: https://www.stockholmresilience.org/research/planetary-boundaries/the-nine-planetary-boundaries.html
- For a report on the planetary boundaries as they apply to New Zealand see: https://environment.govt.nz/publications/a-safe-operating-space-for-new-zealandaotearoa-translating-the-planetary-boundaries-framework/
- For a recent appraisal, see: Biermann, F & R Kim. 2020. The Boundaries of the Planetary Boundary Framework: A Critical Appraisal of Approaches to Define a "Safe Operating Space" for Humanity. Annual Review of Environment and Resources 45 pp.497-521. https://www.annualreviews.org/doi/full/10.1146/annurev-environ-012320-080337?fbclid=IwAR02n0cxJajbaTKV8L4PDQlDKq5lQE6JCCferllrYczqJD3M_NOi3XUUGrA

[3] This is evident in the passing of the Climate Change Response (Zero Carbon) Amendment Bill in 2019, the establishment of He Pou a Rangi, The Climate Change Commission, development of an Emissions Reduction Plan, and a raft of new legislation addressing mitigation, adaptation, and just transition.

[4] See: https://www.internationalairportreview.com/news/145761/christchurch-airport-aci-airport-carbon-accreditation/

2. Investigating airport sustainability

Air travel is frequently invoked as an activity with a carbon cost too high to be justified if we are to mitigate the worst effects of climate change. Carbon dioxide emissions from aviation are estimated at 2-3% of the global total (though other effects of high altitude air flight further increase the contribution to global warming)[5]. This is not cause for complacency, but it would be unrealistic to imagine a cessation of air travel, particularly for a geographically isolated island nation with a global market-based economy. Christchurch Airport began looking at how to decouple flight from fossil-fuels.

Four years on from initiating its Green Transition Plan, Christchurch Airport is recognised as a world leader in airport decarbonisation and sustainability. It shares its knowledge and expertise with other airports and organisations, works with stakeholders and tenant companies to reduce environmental impacts, and exercises leadership on climate change at national and international levels. Its efforts are helping consolidate an increasingly shared agenda for airport sustainability[6].

This report interrogates the airport's green transition by asking:

1. **How has the GTP been developed and implemented?**
2. **What kinds of innovative change has this involved?**
3. **What structures, processes, and collaborative relations has this required?**
4. **How significant are its sustainability achievements, and how might they stimulate change at other airports, businesses, and organisations?**

To answer these questions, an exploratory research programme was conducted. Methods included operational immersion, interviews, analysis of internal and public reports, and investigative review of airport sustainability issues, nationally and internationally.

[5] The United Nations' International Civil Aviation Organisation (ICAO) cites a figure of 2.4%, as reported, for instance, in their 2019 environmental report, available from: www.icao.int/environmental-protection/pages/envrep2019.aspx
- This figure excludes other greenhouse gases like nitrous oxide. For more on the non-CO2 factors in the global warming effects of aviation, which include contrail-cirrus, nitrous oxides, stratospheric water, and aerosols of soot and sulfate, see pages 20-21 of 'Aviation in Norway. Sustainability and social benefit' (October 2020). Available from: https://avinor.no/globalassets/_konsern/om-oss/rapporter/en/aviation-in-norway-sustainability-and-social-benefit-2020.pdf

[6] In 2015 a report from the Airport Cooperative Research Programme (ACRP) noted that airport sustainability mainly involved ad hoc initiatives, was poorly reported, lacked verification, and required greater information and improved implementation. By 2020 however, a comprehensive academic review from the Airport Design Studio at Berkeley, reported significant improvements in reporting and verification while documenting best practice, the majority of which are evident at CIAL. And for an indication of CIAL's role in promoting a shared agenda, consider the panel it led at the 2021 Airport of The Future Conference on Sustainability: No More Excuses, featuring representatives from five airports in North America and Europe.
See:
- Martin-Nagle, R & Klauber, A. 2015. Lessons Learned from Airport Sustainability Plans: A Synthesis of Airport Practice. Washington DC: The National Academies Press. See: https://crp.trb.org/acrpwebresource2/acrp-synthesis-66-lessons-learned-from-airport-sustainability-plans/
- Greer, F et al. 2020. Airports and environmental sustainability: a comprehensive review. Environmental Research Letters 15 https://doi.org/10.1088/1748-9326/abb42a
- Sustainability: No More Excuses, see: https://www.youtube.com/watch?v=CPv8rfs5Z1s

3. Foundations for a Green Transition

Christchurch Airport is 25% owned by the New Zealand government and 75% owned by Christchurch City Holdings Ltd (CCHL), a council-controlled company. Comprising eight subsidiary companies, CCHL serves Christchurch through key infrastructure assets that must operate commercially. With the City Council as primary shareholder, dividend profits are delivered back to the city[7]. Under the Local Government Act of 2002, the airport is designated as 'strategic infrastructure', and under the Civil Defence and Emergency Management Act of 2002 as a 'lifeline utility'.

How does an organisation transform itself to secure business viability by making a genuine transition toward sustainability? Christchurch Airport quickly understood this would require instituting a vision, establishing values, and rethinking purpose. Christchurch had been devastated by the 2010/11 earthquakes, seriously impacting the business of the airport, and denting the confidence and aspirations of staff. The ambition to become world-class in sustainability represented a goal that could reignite imagination and inspire staff.

Balancing profit with purpose

In 2016, when the airport launched its Sustainability Strategy, it adopted the triple credo of Enhancing Customer Journeys, Building a Stronger Business, and Being Great Kaitiaki (environmental guardians). These aspirations for excellence, attentiveness, and responsibility have come to motivate staff ambition and inform business planning as core principles. In 2021, ardently pursuing a Green Transition vision, the airport more explicitly embraced a version of the Triple Bottom Line, albeit with one crucial variation, consistent with the intent of its originator John Elkington. Profit was replaced by Prosperity (*see Figure 1*)[8].

While profit matters as an obligation to provide dividends to shareholders, prosperity matters socially and environmentally to ensure economic wellbeing now and into the future – aligning with the company's intertwined principles of Being Great Kaitiaki, Building a Stronger Business, and Enhancing Passenger Journeys. Not one at the expense of another. In 2020, with a balance sheet of about $2bn to manage, the airport made planning for climate change a matter of fiduciary duty as well as social responsibility. This formally instituted more than financial purpose in the governance of CIAL.

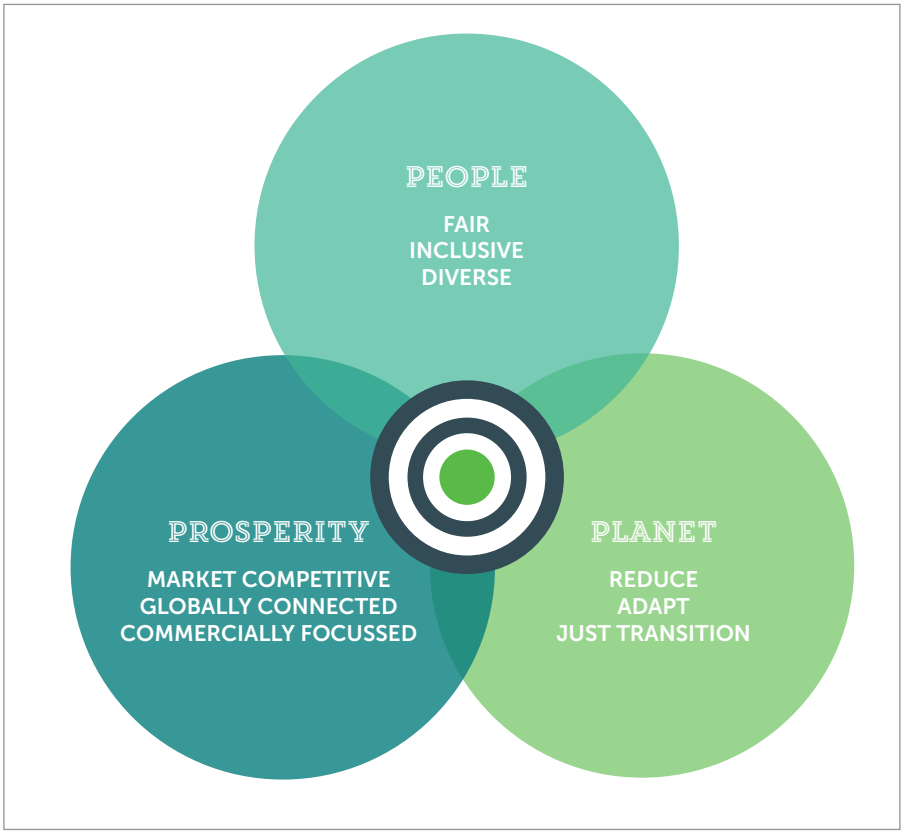

Figure 1: Christchurch Airport's conception of People, Planet, and Prosperity

[7] Between 2014 and 2019, CIAL achieved a more than fivefold increase in annual dividends to its shareholders, rising from $7.6m to $43.3m.
[8] People, Planet and Prosperity appears on page 4 of the 2022 Statement of Intent. See: https://www.christchurchairport.co.nz/globalassets/about-us/who-we-are/financial-reports/2022-statement-of-intent.pdf

4. Implementing a Green Transition - leadership and organisational change

From the outset, the ambition was not to merely add a green gloss to business-as-usual. The organisation recognised the gravity of the climate crisis and the urgent imperative to make meaningful change for a decarbonised future. This would require organisational change to both staff culture and operational activity.

The Sustainability Strategy was launched in March 2016. It represented the inception of an exploratory process to produce a methodology for instituting change, while the subsequent Green Transition Plan of 2018 represented a framework for ongoing implementation and heightened ambition. Brainstorming seminars enlisted staff commitment and understanding of the sustainability challenges for the airport. From this priority concerns were specified, enabling initiatives developed, and a programme for staff engagement formulated.

Priority concerns

CIAL's Sustainability Report for FY2017 reveals those priority concerns initially took form as five pillars with key objectives:

- Energy (increasing efficiency, shifting to renewables)
- Waste (diverting from landfill, measuring waste per passenger)
- Land (continued remediation of contaminated land, wildlife management, conservation of sites of ecological significance)
- Noise (measuring, managing, and mitigating)
- Water (reducing passenger consumption)

Initially, carbon was treated as a by-product of energy and waste operations, but in the 2018 Sustainability Report it had been installed as a pillar in its own right . With the stated objective of phasing out fossil fuels, the carbon pillar provided greater clarity of commitment, reflecting greater ambition in the context of ongoing operational development, technological innovation, and sustainability leadership.

Enabling initiatives

Ensuring priority concerns translated into concerted effort for the airport's journey toward sustainability involved:

- establishing working groups and advisory panels
- setting measurable targets
- submitting to independent sustainability assessment
- applying the UN's Sustainable Development Goals (SDGs).

At this stage, before the formulation of the GTP, the airport established an internal Sustainability Working Group of staff with expertise and responsibility related to each of the pillars. Sustainability was always subjected to measurement, verification, and expert input. An external panel of sustainability professionals was also established to review efforts. With targets becoming policy objectives, a reporting and assessment structure was produced, alongside a mandate for authorising operational innovations. For instance, the objective of reducing water consumption provided impetus for upgrading the terminal infrastructure with water meters, enabling data collection from June 2017.

Measurement relates not only to the mobilising power of targets, but also to benchmarked standards, hence the importance of independent verification. CIAL had already engaged Toitū Enviro-Care to conduct annual carbon audits, providing externally validated data on the airport's carbon footprint according to the Greenhouse Gas Protocol (GHG). These are divided into Scope 1 emissions (from directly controlled sources), Scope 2 emissions (from indirectly purchased energy), and, more recently, also Scope 3 emissions (from activities within a value chain, and therefore those of stakeholder partners) - for Scope 1, 2 and 3 emissions at airports (*see Figure 2*) .

The airport wanted to verify a broader index of sustainability measures and benchmark them against businesses in similar industries. The airport engaged Earth Check, a benchmarking certification service for travel and tourism . Later, it would conduct a more thorough benchmarking exercise, and switch to a different, airport-specific carbon auditing scheme.

In 2015 the member states of the UN signed up to Transforming our world: the 2030 Agenda for Sustainable Development. Comprising 17 goals with 169 targets, the SDGs represent an ambitious agenda for peace, prosperity, and environmental viability to be achieved by 2030 . The SDGs are not merely endorsed by governments, some incorporating them into policy , but are being taken up by many civil society organisations and purpose-driven businesses.

Christchurch Airport mapped relevant SDGs to the core objectives of its pillars (*see Figure 3*), and used them for staff engagement.

[9] See: https://www.christchurchairport.co.nz/about-us/sustainability/energy/
[10] See: https://www.christchurchairport.co.nz/about-us/sustainability/waste/
[11] See: https://www.christchurchairport.co.nz/about-us/sustainability/land/
[12] See: https://www.christchurchairport.co.nz/about-us/sustainability/noise/
[13] See: https://www.christchurchairport.co.nz/about-us/sustainability/water/
[14] See: https://www.christchurchairport.co.nz/about-us/sustainability/carbon/
[15] For a helpful infographic illustrating the difference between Scope 1, 2, & 3 emissions in general, see: https://www.ghgprotocol.org/sites/default/files/ghgp/standards_supporting/Diagram%20of%20scopes%20and%20emissions%20across%20the%20value%20chain.pdf
[16] See: https://earthcheck.org/
[17] See: https://sdgs.un.org/goals The goals recognize the need to; end poverty and deprivation, reduce inequality, improve health and education, manage energy, infrastructure, and supply systems, conserve forests and oceans, and take action on climate change.
[18] For a report on the New Zealand government's preparedness to implement the SDGs, see: https://oag.parliament.nz/2021/sdgs
- The Auditor-General notes that there is not yet dedicated leadership in government on implementing the SDGs, that there is a lack of data to inform targets (with the exception perhaps of wellbeing data available through the Living Standards Dashboard), and that stakeholder involvement needs to improve.
[19] The SDGs do though endorse economic growth, which many analysts see as incompatible with sustainability. For example, see: Hickel, Jason. 2019. The contradiction of the sustainable development goals: Growth versus ecology on a finite planet. Sustainable Development 27 (5) pp.873-884. Available from: https://static1.squarespace.com/static/59bc0e610abd04bd1e067ccc/t/5cb6db91a4222f60ea156798/1555487636747/Hickel+-+The+Contradiction+of+the+SDGs.pdf

Figure 2: Scope 1, 2, and 3 emissions at airports from the 2020 Airport Carbon Accreditation Application Manual

Figure 3: The five sustainability pillars and their alignment with the Sustainable Development Goals (from the FY17 Sustainability Report)

Staff engagement

The airport understood a sustainability strategy should not be limited to policy directives and operational activities. It should also strive for organisational transformation among staff implementing change – addressing their attitudes, dispositions, and understandings. The SDGs provided an ideal framework with which to educate, engage, and enthuse staff.

In 2017 the airport hired a Sustainability Champion whose brief was to help embed the SDGs into the organisational culture of the airport. In interactive workshops staff were encouraged to consider the SDGs in relation to existing airport strategy, improving airport operations, and their own lives as citizens and family members. The challenge was to generate an authentic culture of sustainability[20]. A variety of events, campaigns, communicative tools, and incentives were deployed, which, crucially, made sustainability everyone's responsibility. Everyone received a native kōwhai tree to plant at home, and since then staff have participated in annual native tree plantings held during work time, thereby contributing to the national One Billion Trees Programme[21].

SDG-related discussions proliferated across the airport team and a group of particularly passionate staff members formed a team of 20 Sustainability Ambassadors from across the business, meeting regularly to boost engagement within teams and discuss effective messaging. The IT team collected two tons of e-waste for reusing and recycling, followed by a retail promotion for sustainably-produced reusable shopping bags (before single use plastic shopping bags were banned), and the procurement team required sustainability to be considered in all purchases (a precursor to a more rigorous approach covering goods, services, and contractors).

The greatest innovation though was Planet One (P1), the Sustainability Dashboard, an interactive, bespoke online tool enabling staff to submit ideas relevant to the six pillars and track the outcomes (see Figure 4). Anyone could make a suggestion and within four weeks, 143 ideas had been submitted.

Staff were successively polled to self-assess their sustainability understanding, engagement, and efforts, with marked progress demonstrated one year on. In 2021, the positive effects of this programme on staff were evident in climate-literacy displayed, environmental commitment expressed, and enthusiasm for their purpose-driven workplace.

From strategy to roadmap

The core aspects of the Sustainability Strategy - priority concerns, enabling initiatives, and staff engagement - built institutional momentum for the next step. This was the Green Transition Plan, representing an evolutionary advance in the airport's approach to kaitiakitanga. While sustainability refers to a desired but indeterminate condition[22], green transition suggests activity required to forge a path toward a specific outcome - nothing less than a new energy regime, finding a way to replace fossil-fuelled services and infrastructures with assets and technologies operating on renewable energy.

Christchurch Airport made this its mission in 2018, instituting a governance and reporting structure obligating it to pursue the goals of net zero GHG emissions by 2030, and absolute zero emissions for Scope 1 and 2 emissions by 2050. Before the Zero Carbon Act of 2019, organisations had no formal obligation to reduce their greenhouse gas emissions[23]. However Christchurch Airport had already begun its 'Race to Zero'[24].

The GTP took the airport from strategy to roadmap. The airport engaged in a new benchmarking exercise that was much more detailed, rigorous, and airport-specific. It comparatively analysed the performance of Christchurch against 24 other airports in relation to air quality, carbon, energy, noise, water, waste, and also governance. This final pillar was crucial to provide data on how airports can be managed to optimise positive environmental achievements. Drawing on the expertise of a consultant who has worked with almost 100 airports in 23 countries, CIAL could be confident benchmarking was conducted rigorously, and provided a reliable data-set with which to assess performance and possibility across the sector. The results were presented to the board, which tasked airport staff with investigating opportunities to become world-class in carbon, waste, and water – including adding sustainability performance measures for every role.

The airport was organisationally primed to mobilise working groups for carbon, waste, and water, and to identify and evaluate opportunities across these pillars. Twelve months later a recommendations report was produced, with

Figure 4: The Sustainability Dashboard tool allowing staff to submit suggestions and track their outcomes

[20] New Zealand's Sustainable Business Council hs produced a report about the airport's experience applying the SDGs. See: https://www.sbc.org.nz/__data/assets/pdf_file/0006/172815/CIAL-SBC-CASE-STUDY_V01_03_WEB.pdf

[21] See: https://www.nzstory.govt.nz/stories/the-country-on-a-tree-planting-mission/

[22] The most commonly cited definition for sustainability comes from the UN's 1987 Our Common Future or Brundtland Report, as meeting the needs of the present without compromising the ability of future generations to meet their own needs. See: https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

[23] Indeed, while businesses could choose to implement policies for climate change mitigation, councils were expressly prevented from considering climate change in making rules or granting consents. This was overturned by the 2020 amendment to the Resource Management Act, which made it mandatory for RMA decision-makers to consider climate change mitigation plans. See: http://www.adderleyhead.co.nz/updates/2020/rma_amendment_climate_change_mitigation

[24] See: https://unfccc.int/climate-action/race-to-zero-campaign and for CIAL announcing its formal commitment, see: https://www.christchurchairport.co.nz/about-us/who-we-are/media/2021/our-race-to-zero/

22 opportunities identified and assessed in relation to expenditure, return on investment (ROI), and strategic outcomes. They were given priority rankings:

1. Transformative project (high impact, able to deliver significant improvement to sustainability performance)
2. Medium project (may require capital investment, but aimed at changing operations or introducing disruptive forces)
3. Minor project (may be implemented in house, with minor disruption and resource allocation)
4. Monitor and review (because emerging technologies may not be sufficiently developed or economically viable)
5. Not recommended (not feasible due to operational incompatibility).

A bounty of initiatives

The GTP considers the status, timeline, and further prospects of ongoing initiatives such as the rollout of LED lighting, the transition to electric vehicles[25], the electrification of aircraft ground power, and the extension of ground source heat pump (GSHP) technology into the old terminal building. Complementing the pioneering installation of GSHP technology in the new terminal building completed in 2013, this award-winning technology has been responsible for the airport's most significant gains in energy efficiency and carbon reduction[26]. The report also provides updates on experimental projects like the 3-D printed autonomous shuttle, part of a plan for reduced emissions from ground transport[27]. It approves new experimental projects, including a pilot project for hydrogen electrolysis and fuel cell generation, and new initiatives including a campus water telemetry system. Now fully operational, this initiative is one component in a suite of smart tech innovations integral to the airport's green transition.

The due diligence of the GTP is especially evident in initiatives not recommended, or subject to monitor and review. For instance, rainwater harvesting is not desirable due to low rainfall and the importance of stormwater draining into the aquifer that serves the needs of the city. Similarly, an onsite forest for carbon sequestration is not desirable due to poor soil quality, fire risks, increased bird strike threat, predictions of low rainfall due to climate change, and the indeterminacies of carbon credits likely earned. Wind turbines are also considered, but data on average wind conditions revealed conditions at the airport would be unsuitable for year-round energy generation.

There are also exciting ideas the airport plans to invest in, when the time is right. The consideration of solar energy, batteries, and micro-grids exemplifies this. CIAL had been engaging in regular discussions with solar providers for years, monitoring technological and industry developments plus shifting cost trajectories. In 2021 the airport has gone much further in renewable energy initiatives, launching Kōwhai Park, a renewable energy precinct, set to be New Zealand's largest solar array, alongside complimentary technology including battery storage solutions and green hydrogen. These examples demonstrate the rigour with which logistical feasibility, environmental benefit, and economic cost are assessed together.

Also notable in the GTP is the airport recognising the need to revise its thinking and change direction in the face of global change. The airport had developed a recycling programme credited with one of the highest rates of waste diversion in Australasia, and been recognised for its efforts addressing coffee cup contamination in its waste streams. But in January 2018, China banned the import of most plastics, completely disrupting a recycling industry upon which North American, European, and Australasian nations had long relied[28]. Southeast Asian nations quickly followed suit, forcing the rest of the world to take responsibility for its plastic, and triggered an urgent review of the airport's approach. The airport realised phasing out single use plastics had to become a policy priority, as it has since become at the national level[29] and has begun working with waste minimisation consultants[30], considering circular economy thinking to move beyond recycling by designing waste out of operations.

Collaborative coordination

The GTP is also testament to coordination across organisational units, bringing together staff concerned with business information systems, environmental compliance, facilities infrastructure, finance, passenger services, property development, and sustainability and planning. Intimate collaboration across departments was operationally crucial for identifying, assessing, and pursuing the projects of the GTP, and remains integral for its ongoing implementation and further development. One initiative emerging from this culture of collaboration has been Gateway Zero, enabling staff to develop proposals and turn ideas into business cases through the assistance of colleagues.

In 2019 the role of Sustainability Transition Leader was established. The brief of the Sustainability Champion was to inculcate the values necessary to embark on a green transition, but the brief of the Sustainability Transition Leader is to extend green transition thinking, help implement green transition plans, and ensure the airport meets its environmental objectives and zero-carbon goals.

The airport also developed an open-source and open-dialogue approach to sustainability - committing to providing assistance and sharing expertise, inviting interest groups to come in to discuss environmental concerns[31]. This stimulates critical discussion of the challenges of transition, steering the airport toward a more integrated conception of social, economic, and environmental sustainability - particularly evident in its recent turn to Just Transition thinking[32]. This represents recognition the energy transition cannot be treated purely instrumentally in terms of assets, infrastructures, and technology, but must also be considered socially and behaviourally.

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[25] In 2018 the airport sign up to the Climate Groups's EV100, a global initiative for companies to switch their fleets to electric vehicles and install charging infrastructure by 2030. See: https://www.theclimategroup.org/ev100

[26] Developed with Beca engineering, the airport's GSHP technology has received the following awards:
- Building and Construction winner at the 2014 New Zealand Engineering Excellence Awards
- International Project of the Year at the 2015 Chartered Institute of Building Service Engineers (CIBSE)
- Energy Efficiency Champion at The Sustainable Business Network's 2017 awards
- Low Carbon Future Award at the 2021 New Zealand Energy Excellence Awards (recognising the further advancements made as the airport installed additional GSHPs and further improved its energy efficiency)

https://www.buildmagazine.org.nz/assets/PDF/Build-147-88-Innovation-Tapping-Into-Natures-Gift.pdf
https://www.christchurchairport.co.nz/about-us/who-we-are/media/2017/christchurch-airport-wins-coveted-award-for-energy-efficiency/
https://www.energyawards.co.nz/content/christchurch-airport-%E2%80%93-innovation-and-aquifers

[27] See: https://www.christchurchairport.co.nz/about-us/innovation/automation/

[28] For analysis of the impact of China's National Sword policy on global plastic recycling see: https://e360.yale.edu/features/piling-up-how-chinas-ban-on-importing-waste-has-stalled-global-recycling

[29] See: https://www.theguardian.com/world/2021/jun/28/new-zealand-to-ban-most-single-use-plastics-by-2025
- And for the Ministry for the Environment's declarations on phasing out single-use plastics, see: https://environment.govt.nz/what-government-is-doing/areas-of-work/waste/plastic-phase-out/

[30] See: https://www.sustainably.co.nz/

[31] In 2021, CIAL hosted conversations with representatives from Generation Zero, School Strike 4 Climate, and Extinction Rebellion.

[32] The first instance of Just Transition appearing in CIAL reports is on page 9 of its March 2021 submission to the Climate Change Commission: "We want ambitious climate action, decoupling of aviation from fossil fuel, the realisation of a just transition for Aotearoa, and to ultimately contribute to a climate action plan that speaks to our global commitments and responsibility"

Leading on carbon

The shift from sustainability to green transition involved the elevation of carbon as a priority concern. It is also the issue to which CIAL has devoted greatest leadership effort. The airport is closely involved with the Sustainable Business Council (SBC) and was a founding signatory of the Climate Leaders Coalition[33]. Formally launched in 2018, and now comprising 105 signatory organisations, its mission is for business leaders to build irreversible momentum for a low emissions economy. In 2019 a high ambition pledge was developed, of which CIAL was a key signatory committing to:

- Pursuing efforts to limit warming to 1.5 degrees above pre-industrial levels
- Adopting science-based targets (SBTs) for New Zealand to achieve carbon neutrality by 2050[34]
- Independently verifying greenhouse gas emissions
- Assessing and disclosing climate risks (now to become a legal obligation for large asset organisations from 2023).

The SBT inclusion is actively endorsed by the airport in its support of other organisations on their emissions reduction journeys (*see Figure 5*).

The inclusion of Scope 3 GHG emissions from value-chains and activities of stakeholder partners has made carbon accounting more demanding in terms of data collection, and more accurate by recognising footprints reveal paths that exceed organisational boundaries. Airports must consider emissions from flights, from ground transport access, from tenants' business activities, from waste to landfill, from engine testing, and more. CIAL collects full carbon data for flights to and from the airport, and in sharing the aviation industry's incentive to reduce emissions, it recognises it must work with its partners to bring about a more sustainable aviation future[35]. This commitment informed the airport's decision to turn to a scheme specifically developed for airports.

The shift from sustainability to a decarbonising green transition involved the airport joining the Airport Carbon Accreditation (ACA) scheme in 2018, initially at Level 2. First developed in 2009 by Airports Council International (ACI), the ACA is an independently verified programme, providing airports with a common framework for active carbon management with measurable goalposts. Developed in line with the GHG Protocol and ISO 14064 (greenhouse gas accounting and verification), and consistent with setting SBTs, it has continued to evolve with ongoing achievements, higher ambitions, and further development of decarbonising strategies. By 2020 two new levels had been introduced, totalling six. The progressively stringent levels are:

1. Mapping (this requires measuring the carbon footprint and making a policy commitment on emissions reduction - 118 airports have mapped their carbon footprints in the past year)
2. Reduction (this requires developing a carbon management plan - 98 airports have actively reduced their CO2 emissions under direct control, i.e. Scope 1)
3. Optimisation (this requires third party engagement - 66 airports have achieved this level, including some prominent hub airports)
4. 3+ Neutrality (this requires offsetting - 61 airports have achieved carbon neutrality, representing 87% of global passenger air traffic).
5. 4 Transformation (this requires a transformation of airport operations and those of business partners in pursuit of absolute emissions reductions in alignment with global climate goals. Christchurch Airport was the first globally to achieve this)
6. 4+ Transition (this involves purchasing offsets for residual emissions).[36]

In November 2020, having exceeded its 2020 target for Scope 1 emissions by 52% and its Scope 2 target by 4%, Christchurch became the first airport in the world to achieve Level 4 (Transformation)[37], and was able to do so through evidence of genuine emissions reduction, without relying on purchased offsets.

With this recognition came opportunities for the company to extend its climate leadership[38]. The airport was soon mentoring airports including the Ports Authority of New York and New Jersey, UK Airports (including Bristol Airport which shares an ambition to be the most sustainable airport in the country), Asia Pacific Airports, Australian Airports including Perth and Hobart, and within the New Zealand Airports Association, including formally mentoring Hamilton Airport. In addition, CIAL was named one of the world's Top 5 'Airports of the Future'[39] by Traveller news and media website, and was asked to lead the panel 'Sustainability: No More Excuses' at the recent International Airports of The Future conference[40]. The airport's transition leader began to lead sustainability at CCHL, through a collaborative working group which convened a panel at the recent Aotearoa SDG Summit[41]. The transition leader was also invited to write the first article in a series on sustainability for International Airport Review[42].

Other airport staff represent the airport at events, while its Chief Executive chaired the APEC Business Council working group on Climate Change Leadership for Business, promoting energy transition as a business priority[43]. In 2021, about 1500 tons CO2e short of its Scope 1 and 2 targets for 2030, the airport decided to offset its emissions for carbon neutrality. This will enable the airport to achieve its 2030 net zero target of 2030, eight years ahead of schedule.

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[33] See: https://www.climateleaderscoalition.org.nz/

[34] See: https://sciencebasedtargets.org/ For the latest SBTi criteria and recommendations, see: https://sciencebasedtargets.org/resources/files/SBTi-criteria.pdf

[35] And in its submission to the Climate Change Commission the New Zealand Airports Association also recognises that aviation must become carbon free (section 4.1, p3). See: https://www.nzairports.co.nz/assets/Files/public/NZ-Airports-Submission-to-the-Climate-Change-Commission-Draft-Advice-FINAL.pdf

[36] For the most recent Airport Carbon Accreditation application manual, see: https://www.airportcarbonaccreditation.org/airport/technical-documents.html
- N.B. The United Nations' International Civil Aviation Organisation (ICAO) has a series of eco-toolkits for airports dealing with environmental management, waste management, water management, eco-design of airport buildings, and renewable energy generation. See: https://www.icao.int/environmental-protection/Pages/Ecoairports.aspx

[37] In addition to International Airport review (see footnote 2), this was also reported in Airport Technology: https://www.airport-technology.com/news/christchurch-airport-level-4-transformation/
Regional Gateway: https://www.regionalgateway.net/christchurch-airport-is-first-to-achieve-level-4-transformation-on-airport-carbon-accreditation-programme/
Green Air News: https://www.greenairnews.com/?p=154
And Passenger Terminal Today: https://www.passengerterminaltoday.com/news/airport/christchurch-attains-level-4-airport-carbon-accreditation.html

[38] A recent article by CIAL Chief Executive Malcolm Johns discusses the airport's sustainability journey, it's ACA level 4 achievement, and its work encouraging decarbonisation at other airports. See: https://www.internationalairportreview.com/article/164818/christchurch-airport-malcolm-johns-sustainability-net-zero-target-position/

[39] https://www.traveller.com.au/international-travel-after-covid19-the-future-of-airlines-airports-and-travel-overseas-h1ywyj

[40] See: https://www.internationalairportevents.com/airport-of-the-future/

[41] The full title of the panel was "How critical is collaboration in system change and the conditions necessary for success?" and it can be viewed here: https://www.youtube.com/watch?v=HPFQZSUSn-c

[42] See: https://www.internationalairportreview.com/article/151893/aviation-sustainable-christchurch-airport/

[43] The renewable energy transition was a topic at the 2021 ABAC meeting (APEC Business Advisory Council), co-chaired by Christchurch Airport Chief Executive Malcolm Johns. https://tradeworks.org.nz/abac-themes-and-priorities-for-2021/
- CIAL's CE was appointed to this role by the prime minister in 2019. https://tradeworks.org.nz/pm-appoints-business-leaders-to-apec-business-advisory-council/

Figure 5: Six Steps on Your Emissions Reduction Journey

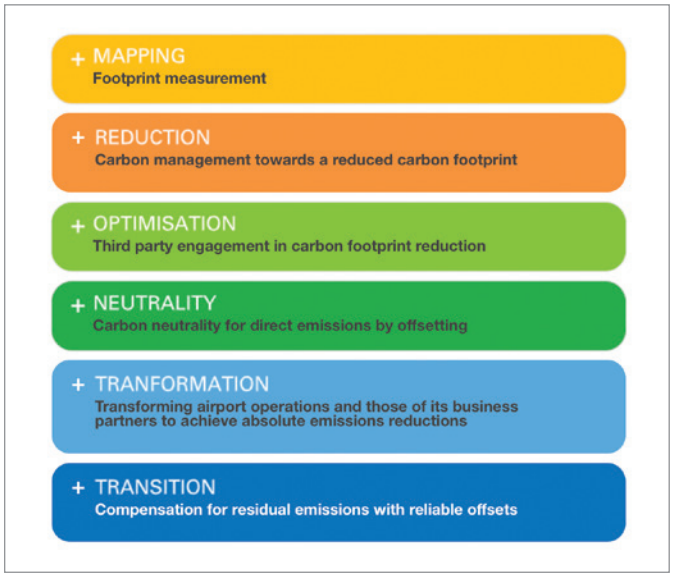

Figure 6: Main requirements of Airport Carbon Accreditation

Leadership from above, among and beyond

The airport's commitment to advancing the transition to a low emissions economy now informs all operational activity. Recognised as a business imperative upon which its future operations depend, this involved rethinking business purpose, transforming staff culture, stimulating ambition, and establishing a framework apparatus with which to advance projects and fulfil objectives. This organisational change has been made possible by taking a dynamic approach to leadership, not just from above, but also spreading among and extending beyond. Leadership from above is evident in the board and the executive establishing a structure of governance responsibility for the GTP - committing to globally-recognised standards, consulting with staff to set priorities and objectives, and authorising projects proposed by working groups. Leadership among is evident in staff feeling empowered to propose ideas and develop proposals, and feeling confident to participate collegially in collaborative projects. Staff know the executive trusts their expertise and commitment, that colleagues respect each other, and that the organisation is looking for ways to permanently change the way it does business[44]. Leadership beyond became possible as the airport established itself as a prototype transition organisation, recognised for genuine progress and authentic ambition.

[44] The most recent staff survey demonstrated that 93% of staff are proud of the organisation and 91% of staff believe in its purpose.

5. Realising a Green Transition - collaboration and technological change

Clearly, organisational transformation was crucial for making a green transition, but just as crucial are the initiatives by which the airport has reduced emissions, improved operations, and deployed new technologies. That is a story of innovation and collaboration. During research for this report it quickly became evident the airport is a lively space of technological development made possible by working with expert partners. This is an organisation that has learned how to learn and how to partner, to think and act with an intergenerational mindset, unafraid to embark upon challenging, transformative projects even when it doesn't have all the answers to hand.

The story of technological change for green transition begins with the installation of the first Ground Source Heat Pump (GSHP) in the new terminal building completed in 2013. Soon after, a special unit for innovation and digital transformation was established. This has proven crucial to the efforts to build the future airport now.

A better way to heat and cool airport terminals

Christchurch sits upon an aquifer that meets the city's fresh water needs, requiring the airport to exercise responsibility managing stormwater discharge and preventing contamination[45]. But the aquifer also presented an opportunity to replace costly, inefficient, and emissions-heavy use of diesel boilers to heat and cool terminal buildings. During the development of the new terminal, the engineering consultancy firm Beca proposed the installation of a new system using artesian water to provide geothermal energy. This ground source heat pump (GSHP) technology involves extracting, circulating, and reinjecting water from wells sunk into the aquifer. The extracted water is filtered to remove sediment, and passed through plate heat exchangers to both heat and cool the terminal through its air-conditioning system, after which the water is returned to the ground (*see Figure 7*). Operational demand is monitored through a Building Management System (BMS), a key strategic asset allowing automated management and efficiency improvements by collecting and processing data from sensors.

This first set of GSHPs immediately improved the energy efficiency of the new building by 20%. Within two years the airport was able to improve the coefficient of performance (COP) for its GSHP from 3.0 to 5.0. The COP describes the relationship between energy used and the amount of heating and cooling extracted, so every kwh input would provide three, then later, five times kwh output. By contrast, diesel power is far less efficient, with a COP of 0.75.

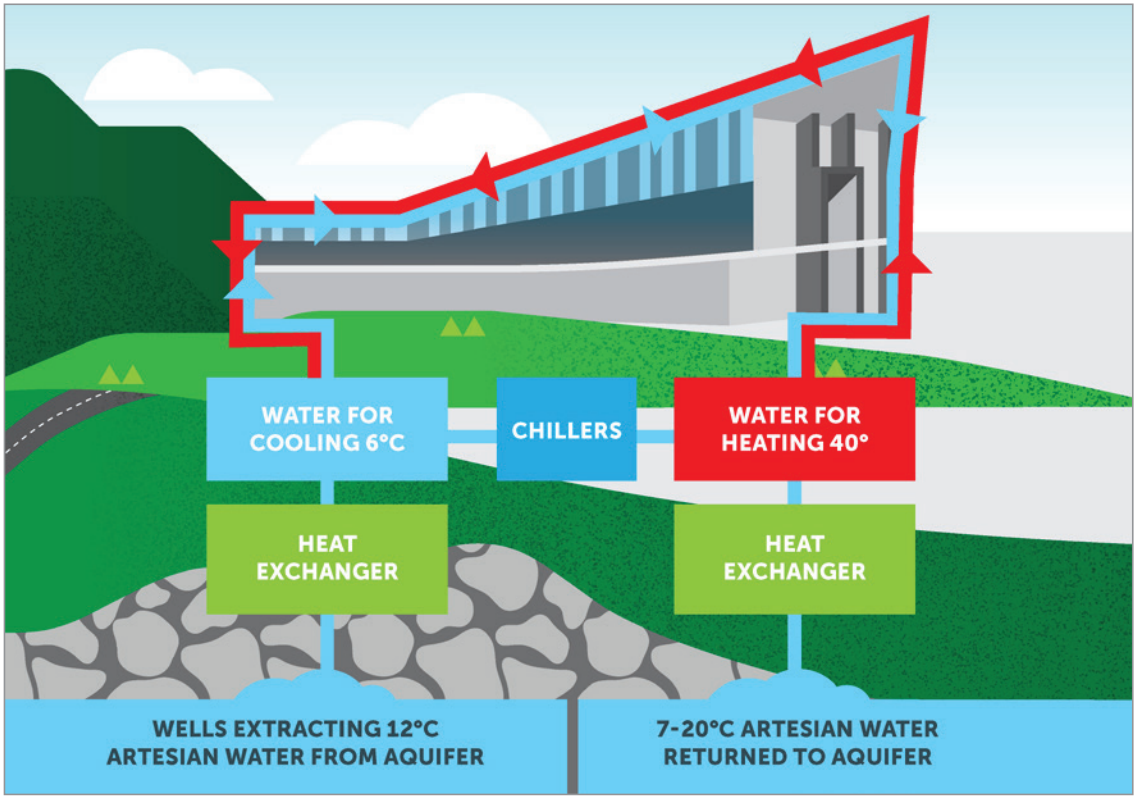

Figure 7: Use of GSHPs for Heating and Cooling

[45] The airport manages 1000Ha of land above unconfined aquifer, while sitting above confined aquifer, operating its own stormwater discharge network, with 1200 sumps, 70 stormwater treatment devices, and 500 soak pits. It also operates an Environmental Compliance and Monitoring Programme (ECMP) to ensure the airport and its tenants uphold water supply safety. Furthermore, in collaboration with City Care, another CCHL company, and Fulton Hogan, it also manages its own water supply system, with recently raised well-heads, and a UV and chlorine gas treatment programme.

Diesel generators were retained for electrical power production for emergency supply and for load-shedding; those periods of high electricity demand requiring large-scale, commercial users to activate generators to provide supplementary power to the grid. Replacing this residual use of diesel generators remains a challenging problem the airport is keen to solve, potentially by means of hydrogen fuel cells.

The airport's partnership with Beca to install GSHP technology was pioneering for Christchurch and for airports. It won national and international engineering awards and paved the way for further projects in the city's post-quake rebuild, with GSHPs installed in multiple buildings, including those of regional council Environment Canterbury, Christchurch City Council, the Justice Precinct, and the University of Canterbury's new student union building Haere Roa[46]. Internationally, GSHPs have also been installed at airports in Tibet and China. Shigatse Peace airport, at an elevation of 3783m on the Tibetan plateau, has a solar-assisted system[47], while Beijing's new Daxing airport has GSHP technology on a formidable scale. Comprising eight units, it serves an incredible 2.5 million square metres of space (by contrast, Christchurch has 77,000), and is projected to save 15,800 tons of carbon emissions per year[48].

Since ground source heat pumps substitute for fossil-fuelled power, thereby reducing both energy costs and carbon emissions, it made financial and environmental sense for CIAL to proceed to install a GSHP system in the older section of the terminal building as well. This was done in 2019. While the new terminal building design allowed for hot water to circulate at 40 degrees, the older area was designed for hot water to circulate at around 70 degrees. This meant a COP of 5.0 would not be obtainable, although the airport continues to optimise (*see Figure 8*).

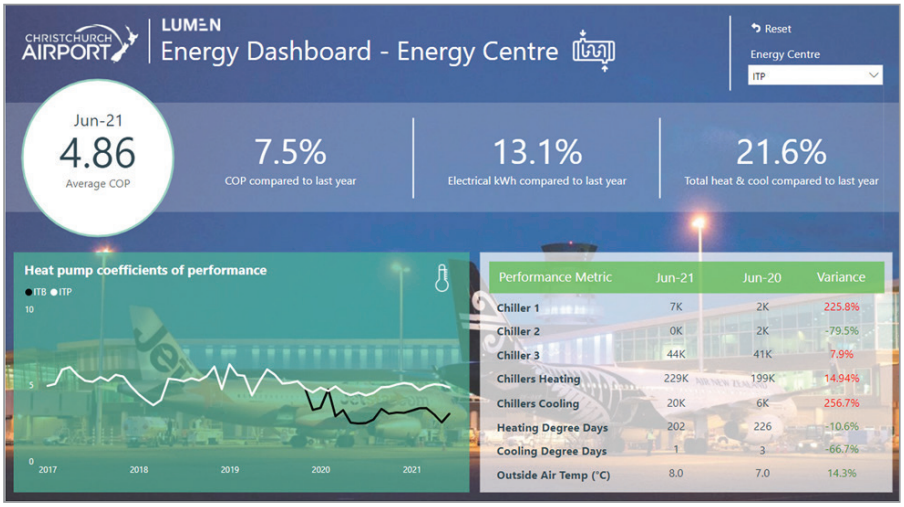

Figure 8: Heat pump coefficients of performance from the Energy Dashboard

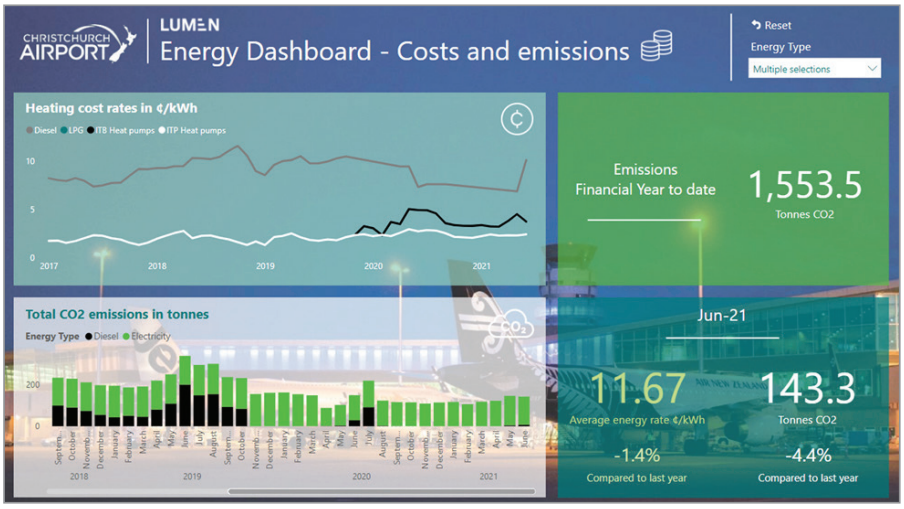

Figure 9: Heating costs and CO2 emissions from the airport's Energy Dashboard

The screenshot above shows optimising for energy efficiency is an ongoing process, and we need to consider the GSHPs as a component within a complex apparatus of terminal energy management. This apparatus not only includes the Building Management System and its expert operators, but now also an AI-powered (machine learning) system the operators are teaching how to make optimal decisions about energy needs, valve positions, and chiller settings. This also enables the airport to collect, process, and visualise data on key information like costs and emissions (*see Figure 9*). This is one of a suite of smart tech dashboards the airport's Business Intelligence team manages, producing data to drive the airport's green transition.

The airport has seized an opportunity presented by the hydrogeology of Christchurch and applied cutting-edge computing to transform its energy system in pursuit of its zero emission ambitions. This has enabled the airport to reduce its use of fossil-fuels by 85%, saving about 500,000 litres of diesel a year, representing the single-most significant project for reducing the airport's Scope 1 emissions. In 2021, the airport's Scope 1 emissions were confirmed at just 281 tons, a saving of 1469 tons since 2015 - an 85% reduction! The greater challenge lies with its Scope 2 emissions, primarily from purchased electricity, which in 2021 were confirmed at 1306 tons, a saving of 505 tons since 2015 (in spite of increased demand from plugging in planes and powering the GSHPs). Though New Zealand's electricity is low carbon, with 81% from renewable sources[49], purchased electricity constitutes the primary source of Scope 2 emissions[50]. This was a motivating factor for the airport to develop its own renewable energy precinct, Kōwhai Park.

[46] See: Seward, A et al. 2017. Rebuilding Christchurch- Using Ground Source Heat Pumps. 12th IEA Heat Pump Conference. http://hpc2017.org/wp-content/uploads/2017/05/O.2.9.4-Rebuilding-Christchurch-Using-Ground-Source-Heat-Pumps.pdf

[47] Zhen, J et al. 2017. Groundwater source heat pump application in the heating system of Tibet plateau airport. Energy and Buildings 136 pp.33-42. http://dx.doi.org/10.1016/j.enbuild.2016.12.008

[48] See: http://www.xinhuanet.com/english/2019-04/24/c_138004806.htm

[49] MBIE's annual reports reveal that the share of electricity from renewable sources between 2017 and 2020 has varied between 81.1 and 84%. For the latest MBIE Energy in New Zealand report see: https://www.mbie.govt.nz/dmsdocument/16820-energy-in-new-zealand-2021

[50] The Ministry for The Environment provides annual guides for organisations to measure emissions according to the GHG protocol. This includes the emissions factor for purchased electricity, which informs the airport's calculation of carbon emissions from electricity. For the latest report see: https://environment.govt.nz/assets/Publications/Files/Measuring-Emissions-Detailed-Guide-2020.pdf

Figure 10: Fixed Ground Power Unit for an A380

Reducing emissions by plugging in planes

Pursuing zero emission objectives of the airport's green transition also requires serious commitment to addressing Scope 3 emissions. This is why the airport works with stakeholder partners across its value chain to find mutually beneficial solutions. For example, the electrification of aircraft turnaround operations. Technologically, this has involved the installation of electrical ground power units for planes (GPUs) and the replacement of diesel-powered ground support equipment (GSE), the vehicles that load and service planes. Collaboratively, this has involved working with airlines, ground service providers, and with Beca for electrical engineering.

When jet aircraft are parked at the gate during turnaround operations the functional requirements of electrical power and air conditioning are usually provided by an auxiliary power unit (APU), a non-thrust, jet-fuelled engine located at the rear of an aircraft. This is fuel that need not be burned, and is a source of greenhouse gas emissions, other air pollutants, and particulate matter. The solution is plug-in power. Similarly, vehicular, diesel-powered GSE can be replaced by EV alternatives. Christchurch Airport began transitioning to electric GPUs in 2016, and of the gates servicing jet aircraft only two remain to be electrified (turbo-prop planes do not run APUs). The provision of GPUs is more than 85% complete, while the electrification of GSE is 70% complete[51]. Achieving this has involved installing transformer stations, GPUs either fixed, mobile, or attached to the underside of passenger airbridges, and charging units for EV ground service equipment (*see Figures 10 & 11*).

Figure 11: Mobile Ground Power Unit

A recent study by the Airport Design Studio at the University of California, estimates 10-12 million tons of GHG emissions could be saved if most airports electrified their gate operations[52]. For example, daily use of the domestic A320 can save 730 tons of carbon emissions a year, with a saving to the airline of US $124,000. This shows electrification is feasible and affordable. Airlines save fuel, which is costlier than electricity, and while the airport invested in the infrastructure, the costs are shared through user charges. Clearly this requires greater electricity usage and combined with the energy demands anticipated for electric aircraft, this also provides cause to consider renewable energy generation.

Data, Dashboards, and Digital Transformation

The credo "what you measure you can affect" has become commonplace over the past decade as digital data, machine learning, and internet capability have driven a flurry of technological transformations. If an airport knows how much water and energy is used, how much GHG emission its operations produce, the rate at which runways are degrading, or how crowds develop in terminal spaces, it can optimise or transform operations - doing things better or differently. Christchurch Airport has done this by embracing the technological opportunities including embedding sensors, applying software, and aggregating data for multiple purposes.

[51] A further challenge in airfield electrification would be the extension of plug-in power for the US Antarctic Programme, which flies out of Christchurch using the large C-17 Globemasters and Hercules LC-130- https://www.christchurchairport.co.nz/about-us/who-we-are/gateway-to-antarctica/

[52] Greer, F, Rakas, J & A Horvath. 2021. Reduce aviation's greenhouse gase emissions through immediately feasible and affordable electric gate electrification. Environmental Research Letters 16 https:doi.org/10.1088/1748-9326/abf7f1

Things can be done differently, for example, with an app for foreign object debris (FOD) on the airfield that allows ground support staff to take pictures using their mobile phone. GPS coordinates, date, time, and person reporting are logged automatically. Machine learning enables the app to recognise objects, and a pattern of data accumulates about their type and occurrence by which one may make inferences about FOD-producing airfield practices. A clear airfield apron and runway are imperative for operational safety. This is big data without bureaucracy, automating the task of logging FOD, while also producing an easily interrogated database to inform modifications to operational practice.

A similar technological approach is being applied to data from CCTV cameras, in order to optimally manage services as passenger numbers accumulate at key points, to data from sensors for terminal cleaning, and for maintenance of runway tarmac. The airport has designed a virtual reality system to improve firefighter training, to reduce the environmental impacts of costly, real-world simulations in burning fuselages[53]. This is another innovation made possible by collaboration, this time with Corvecto, a Christchurch-based virtual-reality design company.

And things can be done better when you not only maximise data gathering but apply tools to use data intelligently. The data visualisation of 'dashboards' is now integral to the airport's green transition. Designed and managed by the airport's Business Intelligence unit, these interactive tools enable users to set the parameters with which to collate and represent information. For example, the Carbon Dashboard utilises 150 data gathering processes, automatically acquiring information from energy bills, waste bills, aircraft travel and the like, brought together in a data warehouse in order to perform calculations of their CO2 emissions outputs. This information can then be visualised, allowing granular interrogation down to the level of particular staffed departments and operational units to reveal the most carbon intensive activities. This information can inform decisions for revising operational activity and behaviours to reduce carbon impacts. See Figure 12, a screenshot from the Carbon Dashboard showing the airport's Scope 1, 2, and 3 emissions for financial year 2021 (the green bars represent 2020, the blue bars represent 2021).

Just as the Energy Dashboard visualises data acquired and processed from sensors embedded in state-of-the-art energy infrastructure, the Water Dashboard processes data from a telemetry system that is part of an upgraded water infrastructure system. The airport manages its own artesian water network, supplying potable water to terminal buildings and tenant companies across its campus. The airport's water infrastructure was upgraded to comply with latest regulations, involving the raising of well heads, UV and chlorine treatment, and smart-tech monitoring, with on-site maintenance provided by City Care and Fulton Hogan. This water telemetry system provides live leak detection, monitors for compliance, and autonomously alerts asset managers to maintenance needs. Again, automation for efficiency removes the need for frequently scheduled checks. Crucially though, it also drives sustainability by monitoring water use, allowing the airport and its tenants to understand patterns of water consumption precisely – to help identify, correct, and improve water use.

Also significant for airport sustainability are dashboards for noise, waste, and bird strikes. Globally, this shift toward sensor technology, machine learning, and digitised maintenance is by no means unprecedented, and may be seen as indicative of a new kind of industrial revolution harnessing digital technology for green transitions[54]. The airport's commitment to digital transformation, and data analytics informing actionable recommendations is being progressively applied across the full range of airport operations. Further tools are anticipated, such as one to enable the Property Development team to calculate the embodied emissions of construction projects[55].

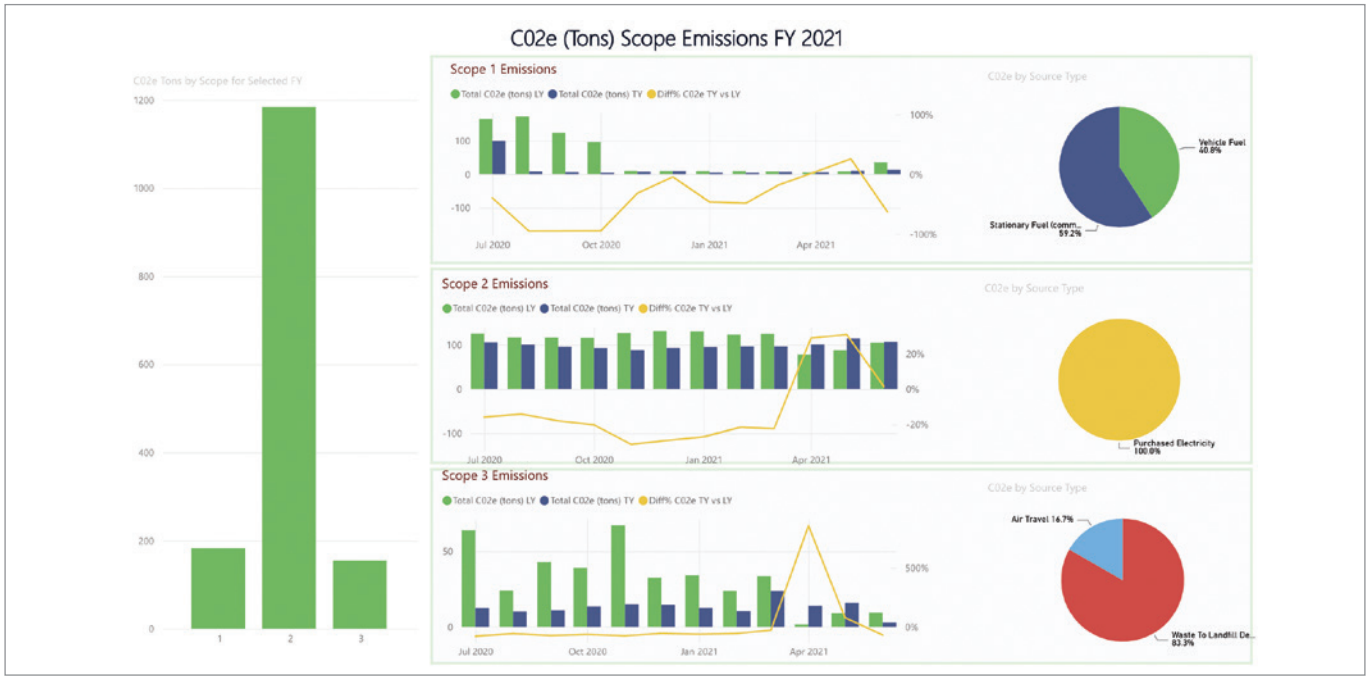

Figure 12: CO2e (tons) Scope Emissions FY 2021 from the Carbon Dashboard

[53] See: https://www.christchurchairport.co.nz/about-us/innovation/mixed-reality/

[54] For instance, Jeremy Rifkin has argued for a 'Third Industrial Revolution' by which new communication technologies may facilitate a shift to a new energy regime. See Rifkin, J. 2011. The Third Industrial Revolution: How Lateral Power is Transforming Energy, The Economy, and The World. Palgrave Macmillan or the 2017 Vice documentary The Third Industrial Revolution: A Radical New Sharing Economy. See: https://www.youtube.com/watch?v=QX3M8Ka9vUA
- Others, like Klaus Schwab of the World Economic Forum, present this in terms of a 'Fourth Industrial Revolution'. See, for example: https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/
- Yet others simply frame this in terms of a 'Green Industrial Revolution'. See for example: Clark, W & G, Cook. 2013. The Green Industrial Revolution. In Clark, W (ed) Global Sustainable Communities Handbook: Green Design Technologies and Economics. Butterworth Heinemann. All of these are relevant to the industrial strategy of recent formulations of Green New Deal thinking, currently informing EU policy and prospective US legislative programmes. Green New Deal thinking and its relevance to the airport's green transition is discussed in the final section of this report.

[55] For the latest research analysing the carbon footprint of office buildings' construction and lifetime use in relation to carbon targets, see: Bullen L et al. 2021. Absolute sustainability of New Zealand office buildings in the context of climate targets. Building and Environment 205 https://doi.org/10.1016/j.buildenv.2021.108186

6. Anticipatory planning, new ideas, and further challenges

Managing an airport well has always involved planning for future contingencies, pursuing strategies to sustain business, and exploring opportunities for upgrading infrastructure. But in this time of climate crisis, bolder, more integrated thinking is required. At Christchurch Airport this is evident in a commitment to simultaneously imagining, anticipating, and shaping the prospects for transition to a resilient, low carbon future. This not only involves new projects to meet the needs of technological transformation, and new frameworks to plan for disrupted futures, but also new ideas for an energy and behavioural transition. In pursuit of this, the airport is embarking on a mega-project for self-sufficient, renewable energy generation, alongside investing and advocating for sustainable, decarbonised aviation. It is also further developing its approach to anticipatory governance with climate risk planning and intergenerational future-thinking. And it is also expanding its perspective to develop its thinking on Just Transition, as the third principle in the airport's climate crisis agenda, alongside mitigation and adaptation. Finally, consistent with these values and objectives, it is exploring the possibility of a new, low carbon airport in Central Otago.

Renewable energy futures

One might have expected COVID-19 to put a dent in the sustainability ambitions of Christchurch Airport, but as an organisation that remained profitable and avoided core staff redundancies, this has not been the case. In 2018, the original Green Transition Plan document made recommendations for rooftop solar power. In 2021, a much more ambitious agenda emerged to develop a large-scale renewable energy precinct. Having made great gains in its Scope 1 emissions, the airport is now looking at how to address Scope 2 and Scope 3 emissions. This objective, along with the decarbonisation of aviation, makes zero emission renewable energy generation a priority objective. This will not only enable the airport, CCHL, and even the country to reduce its carbon emissions, but also enable the airport to further diversify its revenue and increase its resilience.

Utility-scale solar farms are only just being established in New Zealand, and the solar energy sector may be deemed incipient[56]. For an organisation intent on leading on carbon while delivering profit with purpose, this has presented an exciting challenge. In recent years the airport has increased its revenue base through extensive property development, playing a significant role in the economic recovery of Christchurch after the devastating earthquakes that began in 2010. This scale of endeavour has equipped the airport with the confidence to embark on its most transformative project yet- to generate solar power on hundreds of hectares of land, in order to become zero-carbon, energy independent, and support New Zealand's decarbonisation.

The Sustainability and Planning unit mobilised airport staff to collectively scope out possibilities for developing large-scale renewable energy generation. An internal project team was formed with expertise in asset management, law, finance, procurement, project management, and sustainability. As with so many airport projects, this also involves the consulting services of external partners[57].

Supported by $100 million from Solar Bay, a renewable energy impact investment fund, Kōwhai Park renewable energy precinct will start with the airport as landlord to multiple renewable energy generators via long term leases[58]. It will entail a three phase programme, beginning with development of 220 hectares west of the airfield, sufficient to generate 180MW of electricity, enough to power 50,000 homes. This will make a major contribution to New Zealand's energy transition, providing a reliable source of clean energy for the airport and the grid, as well as meeting future needs for charging electric aircraft and producing green hydrogen. Independent energy generating capability is also a resilience strategy because seismic activity in the Canterbury region has the potential to disrupt electricity transmission networks.

[56] MBIE's 2021 Energy in New Zealand report (cited in footnote 45) has a section on the development of utility-scale solar (p38), which also includes a link to a forecasting report it commissioned.
See: https://www.mbie.govt.nz/assets/Uploads/utility-scale-solar-forecast-in-aotearoa-new-zealand-v3.pdf
- For a summary of the 20 largest solar power projects in New Zealand as of October 2021, see: https://www.solarfeeds.com/mag/biggest-solar-projects-in-new-zealand/
- Todd Energy opened the Kapuni solar power plant in South Taranaki in July 2021. Comprising 5800 photovoltaic panels, and capable of generating upto 2.1MW of electricity (enough to power about 500 homes), it is New Zealand's first solar farm to produce electricity for the grid.
Meanwhile, Far North Solar Farms has commenced work on a solar power station on 12 hectares comprising 32,000 panels capable of generating upto 16MW of electricity (enough to power more than 3000 homes).
In addition, Lodestone Energy is developing five solar farms in Dargaville, Kaitaia, Edgecumbe, Whakatane, and Whitianga. The total energy capacity is projected at 400GW, enough to power 55,000 homes.
See: https://www.stuff.co.nz/taranaki-daily-news/news/300341373/new-zealands-largest-gridconnected-solar-farm-now-open-in-taranaki
And: https://www.nzherald.co.nz/northern-advocate/news/work-starts-on-nzs-biggest-solar-farm-at-pukenui/5QUQASWLUBMVLZ4GKUUCA4UMJM/
And: https://www.stuff.co.nz/business/125090584/300m-plan-for-five-solar-energy-farms-providing-1pc-of-countrys-supply (accessed September 2021)
- Furthermore, it should be noted that Hawkes Bay Airport is also developing airfield solar. See:
https://hawkesbay-airport.co.nz/sustainability/sustainability-solar-farm-project/ (accessed September 2021)
On November 1st, drawing on the Reserve Bank's Funding for Lending Programme (FLP), ASB announced its first Sustainability Linked Loan (SLL) for Hawke's Bay Airport, allocating them $23 million, which will help fund their solar farm. See: https://www.asb.co.nz/documents/media-centre/media-releases/asb-and-hawkes-bay-airport-partnership.html

[57] Lumen, the company that works with the airport on energy management, was brought on board to advise on the New Zealand solar energy market. The law firm Chapman Tripp has confirmed the airport's consenting ability to use land for solar. Worley, an industrial engineering solutions company, has also been involved. With expertise developing renewable energy projects around the world, it has worked with the airport team to think through risks and opportunities, helpful for development of an activation plan that has been approved by the board.

[58] See: https://www.christchurchairport.co.nz/about-us/sustainability/kowhai-park/

Alongside solar power generation, the airport is investigating green hydrogen generation. This is hydrogen produced from the electrolysis of water, where electricity powering the reaction comes from a zero-emission renewable source, such as solar[59]. Hydrogen may be stored in fuel cells and may be used as a source of clean power for future aviation, heavy transport, and manufacturing. In a recent report, the International Energy Agency (IEA) argues technologies need to be scaled up to bring costs down, noting hydrogen is a leading option for storing energy from renewables, offers ways to decarbonise a range of sectors, and represents a way to improve air quality and strengthen energy security[60]. The airport also recognises the potential of green hydrogen, and has been consulting with chemical engineers and aviation industry specialists. This includes a close affiliation with Hamburg Airport to progress airport hydrogen pilot studies and further enhance the German-New Zealand hydrogen partnership.

A sustainable aviation future

Decarbonised aviation is not only becoming a possibility, but also a policy objective. There are three key technologies for such a future - sustainable aviation fuels (SAF), electric planes, and hydrogen planes. Sustainable aviation fuels are of two types- biofuels and electrofuels (or e-fuels, also described as power-to-liquids PtL). The low-carbon former are based on biomass, from sources such as cooking oil, municipal waste, or forestry by-products, while the carbon-neutral latter, still in development and not yet economically viable, are produced from green hydrogen and gaseous carbon[61]. The European Union is introducing a 2% blending mandate for aviation biofuels from 2025[62], while Norway has adopted a target of 30% by 2030, to be produced without co-opting land that might otherwise be used for food and resources[63]. A similar biofuel mandate has also been proposed for New Zealand's Emissions Reduction Plan.

While biofuels merely represent a mitigation measure within the existing apparatus for aviation, new aircraft technologies represent a zero emissions prospect for a transformed infrastructure. Electric aircraft are already here and operating from Christchurch Airport. New Zealand's first electric plane, a two-seat pipistrel operated by Electric Air, offers trial flights from Rangiora and from Christchurch Airport, which has installed a charging point (see Figures 13 and 14)[64]. The Pipistrel Alpha Electro can be charged in less than an hour to provide more than an hour of flight time. For commercial passenger flight though, Sounds Air is planning to fly from Blenheim to Wellington with 19-seat electric aircraft from 2026[65].

Figure 13: Christchurch Airport's Electric Plane Charging Point

Figure 14: Electric Air's Pipistrel Alpha Electro

[59] For an introduction to green hydrogen and its applications, see: https://news.climate.columbia.edu/2021/01/07/need-green-hydrogen/

[60] See "The Future of Hydrogen: Seizing Today's Opportunities", available from: https://static1.squarespace.com/static/5c350d6bcc8fedc9b21ec4c5/t/5e968939e89b9e37585b8134/1586923883881/IEA+-+The_Future_of_Hydrogen.pdf

[61] in October 2021, Germany inaugurated the world's first more-than-laboratory scale plant for the production of CO2 neutral e-kerosene, see: https://assets.siemens-energy.com/siemens/assets/api/uuid:34bec577-f25a-48cd-8618-6dd848b38515/FactsheetWerlteEN.pdf

[62] See 'European Commission's ReFuelEU Aviation Proposal Details SAF Blending Obligation on Fuel Suppliers' https://www.greenairnews.com/?p=1374
- Furthermore, the EU's Aviation Safety Agency (EASA) is planning eco-labelling for airflights, so that consumers can assess the carbon impacts of their flight choices, see: https://www.engadget.com/europe-is-planning-to-label-flights-according-to-their-carbon-footprint-093055032.html
- This follows a proposal first made by Stefan Baumeister and Tiina Okila in 2017. See: Baumeister, S & T Okila. 2017. An eco-label for the airline industry? Journal of Cleaner Production 142 pp.1368-1376. http://dx.doi.org/10.1016/j.jclepro.2016.11.170 (A similar article appears in the European Journal of Tourism Research).

[63] See: 'Aviation in Norway. Sustainability and Social Benefit'. Available from: https://avinor.no/globalassets/_konsern/om-oss/rapporter/en/aviation-in-norway-sustainability-and-social-benefit-2020.pdf
And for Germany's roadmap for further developing and commercialising e-fuels to meet its carbon targets, see: https://www.greenairnews.com/?p=1116

[64] See: https://www.electricair.nz/
Christchurch City Council contributed to funding, and Electric Air is partnered with Meridian Energy, Airways (New Zealand's air navigation services provider), and of course Christchurch Airport. In November 2021 Electric Air made a historic flight across the Cook Strait. See: the https://www.odt.co.nz/news/national/first-electric-plane-flight-across-cook-strait

[65] See: https://www.stuff.co.nz/travel/green-travel/300384673/couldnt-be-prouder-sounds-air-locks-in-electric-plane-deal
- For further information on the Heart Aerospace plane ordered by Sounds Air, including the climate policy incentives in Europe for developing electric aircraft, see: https://www.futureflight.aero/news-article/2020-09-23/heart-aerospace-advances-plans-es-19-electric-regional-airliner

In August 2021, Sounds Air publicly announced a plan to electrify its fleet, beginning with three planes produced by Heart Aerospace. Then, in September 2021, Air New Zealand announced its intention to introduce electric aircraft to its fleet from 2030[66]. A few days later, it went on to announce a partnership with Airbus to collaborate on hydrogen-powered planes[67]. This followed Airbus announcing in September 2020 its intention to introduce zero emission, hydrogen planes by 2035. This comprises three concept aircraft; a turbofan, a turboprop, and a 'blended-wing body'[68]. While electric planes are already in the sky, hydrogen-powered planes are in development. The prospect is being taken seriously though, with a German consortium announcing a project to design and test airside facilities for production and supply of liquid hydrogen for this next generation of aircraft[69].

Decarbonising aviation has been established as a policy objective in New Zealand's aviation sector, evident from submissions to the Climate Change Commission early in 2021[70]. In its submission, Christchurch Airport notes New Zealand's unique dependency on aviation, arguing that with a lack of international, low emission land transport routes, the decoupling of aviation from fossil fuels must be prioritised. It also notes New Zealand is well-placed to serve as an early adopter, citing the plan of Sounds Air, the possibilities of liquid hydrogen, and hence the need to install supporting infrastructure. Watching that project, the airport notes airports are well suited to serve as hubs for hydrogen production, serving multiple uses through the clustering of air travel and freight distribution. Crucially, it also argues for a public-private body to facilitate the transition to net zero aviation, enabling policy and investment, while also establishing regulatory frameworks. Looking to the UK's Jet Zero Council as an indicative exemplar[71], now in late 2021, a New Zealand equivalent is being formed, known as 'Sustainable Aviation Aotearoa'.

Committed to becoming a zero carbon airport, and with 93.4% of its Scope 3 emissions coming from flights, Christchurch Airport has compelling reason to provide the infrastructure for sustainable aviation technologies. Kōwhai Park is a crucial step toward this, especially when you appreciate the elevated electricity demand this technology transfer will require. Each charge of the Sounds Air 19-seat electric planes is projected to use 1.5MW of electricity, while Air New Zealand calculates converting its turbo-prop fleet to electric and hydrogen planes will raise New Zealand's electricity generation demand by 10%.

Climate risks and anticipatory planning

Christchurch Airport initiated its climate risk planning in 2020, not only in anticipation of new reporting standards required within the Climate-Related Disclosures Bill[72], but because it represented an obvious development in its approach to anticipatory planning and recognition of the significance of climate change. This began with physical risks, drawing on the IPCC's Representative Concentration Pathways (RCPs); projections of emissions trajectories and their effects depending on the extent to which effective climate stabilising actions are taken. The airport used two scenarios, RCP3.4 in which moderately effective mitigation efforts are made, and RCP8.5, a worst-case scenario in which emissions continue to rise as a result of ineffective mitigation efforts. Factors considered included wind, temperature, extreme weather events, and sea-level rise, using data from New Zealand's National Institute of Water and Atmospheric Research (NIWA) (*see Figure 15*).

Thinking through the physical risks of climate change includes consideration of multiple possibilities, for the region and the airport. For instance, reduced or erratic rainfall could impact on the water availability for hydroelectric power generation in the southern lakes, with consequences for the cost and supply of electricity. Reduced snow days could adversely affect the quality and duration of the ski season, affecting tourist travel. Convectic weather disruption in Australia could disrupt internationally scheduled flights to Christchurch. Temperature increases could increase the cost of airfield pavement maintenance. Such change could increase bird populations leading to elevated bird strike risk. And so on.

By identifying the physical risks of environmental change, the airport has begun considering the kinds of operational risks a climate changed world may present. The next step is to consider the risks presented by transition efforts and their efficacy. This involves assessing the possibilities of both an orderly and a disorderly transition; the character by which New Zealand navigates the social and economic challenges of transition to a post-carbon future. The airport has therefore convened a working group within the New Zealand Airports Association to assist smaller airports in their climate risk planning. Transition to a low emissions economy entails fundamental socio-economic change, a challenge government and organisations in New Zealand are beginning to grapple with.

Climate risk planning is but one aspect of a more comprehensive approach to anticipatory governance established and developing at Christchurch Airport. Considering systemic risks over long time frames and developing tools to anticipate, assess, and avoid future harms is integral to high-level planning and decision-making. It involves recognising the interconnected dimensions of resilience, not just institutional and infrastructural, but also social, cultural, and economic. Indeed, in many respects the airport's approach is consistent with the ideal of anticipatory governance as outlined by Jonathan Boston, Professor of Public Policy at the University of Victoria, Wellington[73]. In his article, Boston makes multiple suggestions, many of which are evident in the airport's own planning. These include:

- Intergenerational thinking - being great kaitiaki means being great ancestors for future generations and the prospects for tomorrow[74]

[66] See: https://www.stuff.co.nz/business/industries/126364924/air-nz-plans-to-be-flying-electric-aircraft-by-2030-chief-pilot-says
- Most recently, Air New Zealand has announced a partnership with the Robinson Research Institute and Wellington UniVentures to develop superconducting motors for electric passenger aircraft. See: https://www.wellingtonuniventures.nz/news/new-technology-for-zero-emission-electric-passenger-aircrafts/

[67] See: https://www.stuff.co.nz/business/industries/126389976/air-new-zealand-and-airbus-launch-zeroemissions-aircraft-project
- For more extensive reporting on New Zealand embracing decarbonised aviation, including Christchurch Airport's commitment to infrastructure development, see: https://www.greenairnews.com/?p=1553

[68] See: https://www.airbus.com/newsroom/press-releases/en/2020/09/airbus-reveals-new-zeroemission-concept-aircraft.html
- And Airbus has been developing electric planes since 2010: https://www.airbus.com/innovation/zero-emission/electric-flight.html
- This includes an electric vertical take-off and landing (eVTOL) prototype, similar to the Boeing-supported Wisk electric air taxi currently in development in the USA and New Zealand, see: https://wisk.aero/

[69] See: https://www.wevolver.com/article/testing-maintenance-and-ground-processes-for-future-aircraft-generations

[70] For Air New Zealand's submission to the Climate Change Commission, see: https://p-airnz.com/cms/assets/PDFs/airnz-response-to-climate-change-commission-draft-advice-15-april-2021.pdf
- For New Zealand Airports Association's submission to the Climate Change Commission, see: https://www.nzairports.co.nz/assets/Files/public/NZ-Airports-Submission-to-the-Climate-Change-Commission-Draft-Advice-FINAL.pdf
- And for CIAL's submission to the Climate Change Submission, see: https://www.christchurchairport.co.nz/globalassets/about-us/sustainability/carbon/21.04.01-christchurch-international-airport-ltd-submission-on-climate-commission-pathway.pdf

[71] See: https://www.gov.uk/government/groups/jet-zero-council
- However, there are concerns about the Jet Zero consultation process and the aspirations for net-zero aviation by 2050, as critically discussed in this two-part article in The Ecologist:
Jet Zero and The Politics of The Techno-Fix: https://theecologist.org/2021/aug/27/jet-zero-and-politics-technofix
Jet Zero: A One Way Ticket to Climate Hell: https://theecologist.org/2021/aug/31/jet-zero-one-way-ticket-climate-hell

[72] For information on mandatory climate-related disclosures, see: https://www.mbie.govt.nz/business-and-employment/business/regulating-entities/mandatory-climate-related-disclosures/

[73] See: Boston, J. 2016. Anticipatory Governance: How well is New Zealand safeguarding the future? Policy Quarterly 12(3) pp.11-24. https://doi.org/10.26686/pq.v12i3.4614

[74] This is expressed on page 39 of the 2021 Annual Review:
Ko ngā pae tawhiti whāia kia tata
Ko ngā pae tata whakamaua kia tina
This translates as: The potential for tomorrow depends on what we do today
Available from: https://www.christchurchairport.co.nz/globalassets/about-us/who-we-are/financial-reports/2021-annual-review

- Embedding sustainability - generating a culture of sustainability, to integrate sustainability decision-making across its operations, and develop reliable processes for environmental accounting
- Infrastructure planning- the airport not only recognises the need for risk management to adapt to the impacts of climate change, but has committed to an energy transition requiring a responsible and realistic plan to upgrade and replace infrastructure
- Foresight processes - future-thinking is integral to airport management and anticipating social and economic change
- More-than-financial reporting - the airport has modified its business purpose, made commitments to decarbonisation, and incorporated sustainability measures into its reporting practices
- Resilience stress-testing – the airport has not only learned lessons from critical events such as the earthquakes, but has instituted regular exercises simulating management for low probability, high consequence events (LPHC)- sometimes described as Black Swan Events[75]. Of note - in 2018 the airport conducted a desktop exercise for responding to a global pandemic.

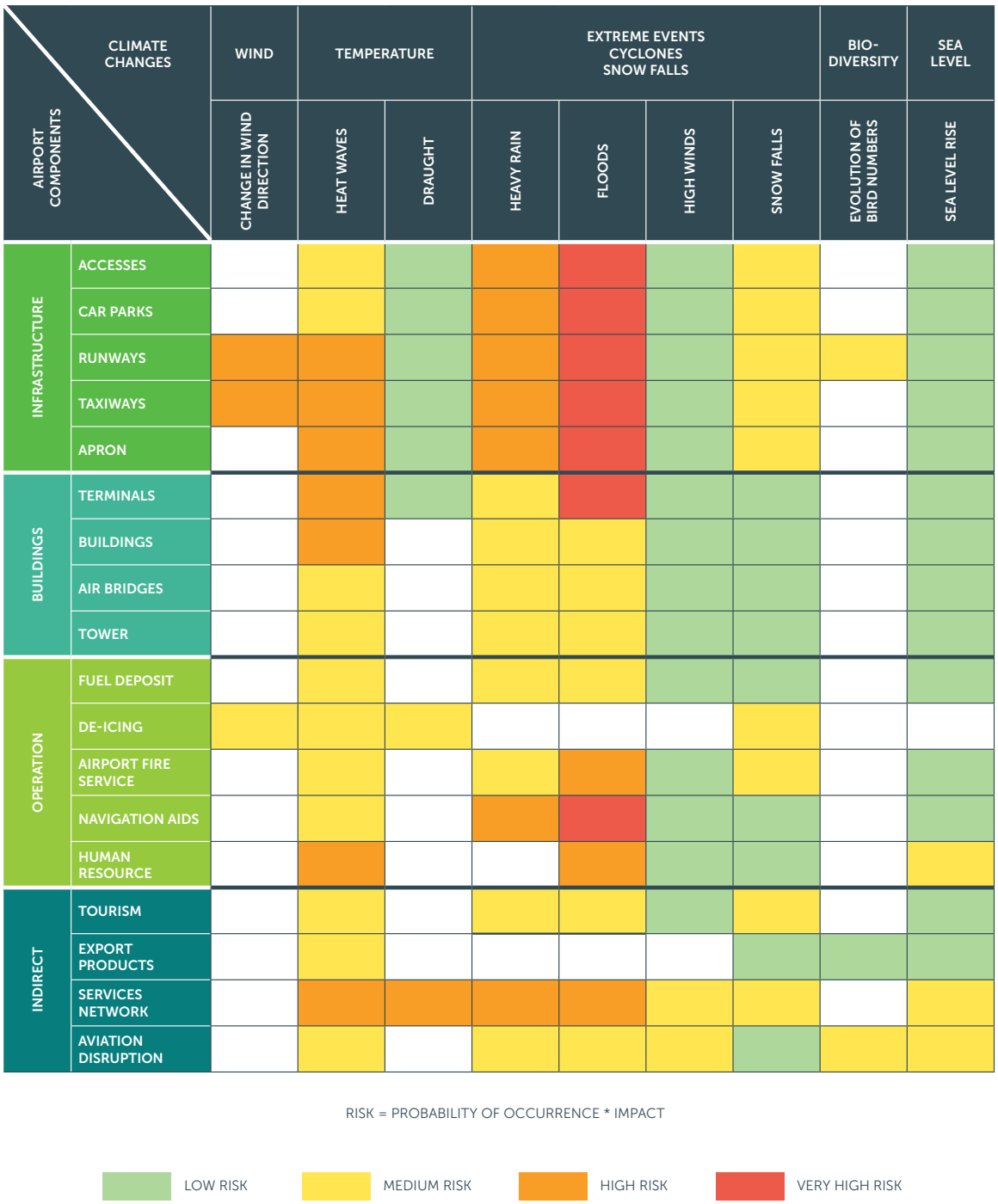

Figure 15: Summary table of CIAL's initial climate risk assessment (physical risks only)

[75] See: Taleb, N. 2007. The Black Swan: The Impact of The Highly Improbable. London: Allen Lane.

New ideas and transition thinking

The transformational efforts of the Christchurch Airport team represent a concerted attempt at building the future airport now. With New Zealand preparing to embark on the project of transition, this requires thinking beyond business as usual. Achieving a low emissions economy is an urgent project of deliberate social and economic transformation unlike anything attempted before[76]. This demands a willingness to challenge received wisdom, embrace new ideas, and consider behavioural change. For the airport, this means developing the tools for a comprehensive approach that treats transition as a social and economic as well as a technological challenge. As the airport's CE noted "Transitions need to be cultural, and need to be founded on systems that don't rely on one point of influence".

The foundations for this lie in the airport's revised business purpose of people, planet, and prosperity. Replacing profit with prosperity signals a set of values that opens the airport to economic thinking better aligned with our predicament of ecological overshoot[77]. In this regard the airport has engaged with Dr Kate Raworth's Doughnut Economics, seeking an approach to economy that is socially just and ecologically viable, where pursuit of profit does not come at the expense of people and planet. The doughnut is the 'sweet spot' between social needs and planetary boundaries, between what we need for a reasonable life and what the planet can afford us (*see Figures 16 and 17*). Dr Kate Raworth recognised their utility for an ecologically conscious approach to economy, and the airport has recognised the value of her people and planet thinking, as has the New Zealand government[78].

Tools like these are helping the airport embrace a broader, more holistic approach to its green transition. A working group has been established to think through integration of the environmental with the social and governmental, and dedicated effort is now being directed at Just Transition. A call to consider Just Transition was made at the Paris climate conference in 2015, and New Zealand's Zero Carbon Act of 2019 made it a legal responsibility to consider the differential impacts of transition. In New Zealand, it would be fair to say government work on Just Transition is only just beginning after initially focussing efforts on emissions reduction planning[79].

As the airport encourages decarbonisation in the aviation sector and across the multiple supply chains in which it is embedded, it will consider pathways for industries to transition, and to redeploy workers with new training for new technologies and infrastructures[80]. Just Transition thinking represents an important extension of the airport's approach to anticipatory governance.

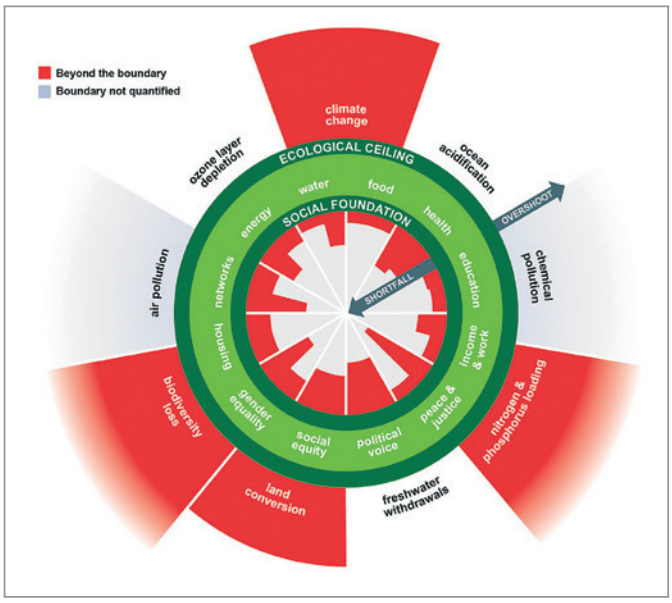

Figure 16: The 'Doughnut' space between social needs and planetary boundaries

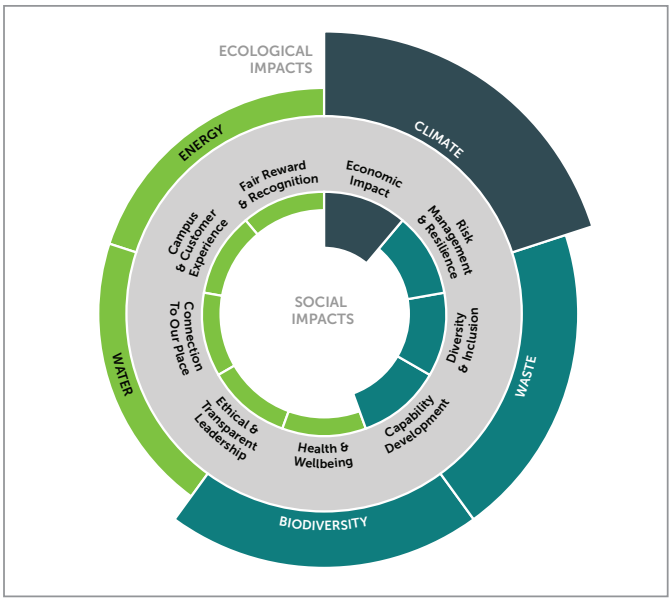

Figure 17: Christchurch Airport's 'Doughnut' for people, planet, and prosperity

[76] George Monbiot very helpfully reminds us of the kind of rapid changes instituted in the USA as it mobilised for the Second World War, suggesting that it provides object lessons for the challenge we face in averting climate catastrophe. See: https://www.theguardian.com/commentisfree/2021/oct/20/us-war-footing-1941-climate-emergency-earth-pearl-harbor

[77] In this regard, it is worth attending to critiques of green growth; the idea that we can adequately confront the ecological crisis with new technology while still pursuing continued economic growth. See: Hickel, J & G Kallis. 2020. Is Green Growth Possible? New Political Economy 25(4) pp. 469-486 https://doi.org/10.1080/13563467.2019.1598964 (for non-paywalled access, see: https://static1.squarespace.com/static/59bc0e610abd04bd1e067ccc/t/5cbdc638b208fc1c56f785a7/1555940922601/Hickel+and+Kallis+-+Is+Green+Growth+Possible.pdf).
And: Mastini, R, Kallis, G & J Hickel. 2021. A Green New Deal Without Growth? Ecological Economics 179 https://doi.org/10.1016/j.ecolecon.2020.106832
- These authors challenge the idea that economic growth can be sufficiently decoupled from material throughput from the perspectives of anthropology and ecological economics, while also raising concern about the viability of negative emissions technologies, widely used to support green growth models. By disciplinary contrast, the geometallurgist Simon Michaux comes to a similar conclusion, demonstrating that we do not have the time or resources to completely replace fossil-fueled power with renewable energy technologies unless we reduce demand. See: Michaux, S. 2021. Assessment of the extra capacity required of alternative energy power systems to completely replace fossil fuels. Geological Survey of Finland. Available from: https://tupa.gtk.fi/raportti/arkisto/42_2021.pdf
See also: Michaux, S. 2021. The mining of minerals and the limits to growth. Geological Survey of Finland. Available from: https://tupa.gtk.fi/raportti/arkisto/16_2021.pdf
- Reduced energy demand as a strategy for successfully mitigating climate change is by no means an outlier view, as this paper indicates: Grubler, A et al. 2018. A low energy demand scenario for meeting the 1.5 degree C target and sustainable development goals without negative emissions technologies. Nature Energy 3 pp.515-527. Available from: https://www.nature.com/articles/s41560-018-0172-6
- The idea that we cannot avert climate catastrophe without challenging the logic of growth through which our economies are managed is known as Degrowth. Doughnut Economics may be seen as a form of Degrowth, and until recently it has generally been assumed that Degrowth is anathema to modern business. That may be about to change, as Jennifer Wilkins argues in her recent Heliocene post "Will Degrowth Replace Green Growth?": https://heliocene.org/2021/10/16/will-degrowth-replace-green-growth/ Since then, with Bill Murphy of Purpose Capital, Wilkins has a released a white paper titled "Investing in Degrowth" which explores the problems with decoupling economic growth from resources, the importance of Doughnut-style social foundations and ecological ceilings, the transformation toward Degrowth, and the characteristics of Degrowth-compatible business: https://heliocene.org/reports/investing-in-degrowth/

[78] Kate Raworth was invited to present on Doughnut Economics for the New Zealand government, and the Ministry for Business, Innovation, and Employment (MBIE) has posted slides from her presentation. See: https://www.mbie.govt.nz/dmsdocument/5722-doughnut-economics-kate-raworth

[80] For a recent article on developing Just Transition policy in New Zealand see: White, D & C Leining. 2021. Developing a policy framework with indicators for a 'Just Transition' in Aotearoa New Zealand. Policy Quarterly 17(3) pp.3-12. https://doi.org/10.26686/pq.v17i3.7125

[81] One small, preliminary example of Just Transition consideration is evident from the airport's initial plan to prioritise electric taxis. However, the airport realised that without sufficient support to transfer to EVs, this would unfairly impact on the livelihood of drivers of vehicles with combustion engines. Consequently, such prioritisation was put on hold.

A new airport for Central Otago?

As part of its long-term transition vision, the airport is also investigating the establishment of a new airport in Central Otago.

This may seem like a counter-intuitive proposition at a time when New Zealand is committing to reducing GHG emissions and creating a low-emissions economy.

What though, if the embodied emissions of constructing an airport could be achieved within emissions targets, as is expected to become a legal obligation for new infrastructure projects? What if a new airport could become a node in an infrastructure network facilitating sustainable aviation technologies? What if aviation from a new airport could save emissions otherwise incurred by road freight journeys to Christchurch? And, what if a new airport could stimulate the local economy, benefit the region, and fulfil the objectives of transition?

These are the kinds of questions the airport team are investigating - exploring infrastructure solutions that allow for future needs, that anticipate climate change effects, and that enable the deployment of low carbon aviation. A new airport for Central Otago could only be mandated if it were consistent with the sustainability values and targets that have become integral to the governance of Christchurch Airport.

7. Conclusion: pursuing and promoting transition

Legislative stimulus for transition to a low emissions economy is beginning to have an effect, with more and more organisations recognising the imperative to transform their operations. However, while the objectives may be relatively clear, the means to achieve them are not. Christchurch Airport has become an exemplar - a business that has explicitly endeavoured to become a prototype transition organisation, recognising its responsibility to share its expertise to assist others.

We have seen how a transition agenda emerged from a sustainability strategy, involving an organisation recognising the gravity of the ecological crisis, and transforming its operations in pursuit of a viable, decarbonised future. This involved rethinking business purpose to go beyond the bottom line, making sustainability considerations integral to prudent business decision-making. We have seen that this has involved creating a framework for driving change, and developing ways to educate, enthuse, and empower staff for innovative excellence. We have seen this has involved setting targets, upgrading infrastructure, utilising new technologies, and collaborating with partners. We have also seen this has involved advocating for transition, planning for climate risks, developing Just Transition thinking, and engaging with alternative economic models conducive to behavioural change in a low emissions economy.

What does the climate challenge mean for New Zealand? 60% of the country's energy comes from fossil fuels[81]. That places us sixth among OECD countries for our ratio of renewable energy and reminds us of the scale of change needed for the energy transition we must make.

This requires re-thinking the ways we do business, live our lives, and use energy. Businesses must go further, embracing more extensive plans for green transition as part of a broader collective mission. Greater cooperation and improved understanding will be necessary. The lessons learned, and being learned, by Christchurch Airport are numerous, and applicable for many other organisations. Its efforts to transition and to help others to transition, surely represents a crucial contribution to the challenge New Zealand is committing to.

[81] See: https://www.energymix.co.nz/our-consumption/new-zealands-consumption/
And also, MBIE's energy dashboard: http://energydashboard.mbie.govt.nz/

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