Summary – The economic implications of national climate change mitigation strategies on the Auckland region

Prepared for

Tātaki Auckland Unlimited

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Prepared by Market Economics Ltd for Tātaki Auckland Unlimited.
Report author(s): Garry W. McDonald (Market Economics), Juan J. Monge (Market Economics), Caroline Orchiston (University of Otago)

Director approval: Nicola J. McDonald

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Introduction

To mitigate the effects of climate change, governments around the world have agreed, under the Paris Agreement in 2016, to limit the global average temperature increase to 1.5°C above pre-industrial levels. To comply with this agreement, the NZ Government enacted the Climate Change Response (Zero Carbon) Amendment Act 2019, providing a framework to "develop and implement clear and stable climate change policies" (Parliament of New Zealand, 2019). The Act established the following Greenhouse Gas (GHG) emissions reduction targets:

- reduce emissions from biogenic methane to 24-47% below 2017 levels by 2050, and
- reduce net emissions from all other GHGs to zero by 2050.

The Act also established the Climate Change Commission (CCC) to provide independent expert advice and monitoring to keep Aotearoa-NZ on track to meet these targets. "Ināia tonu nei: a low emissions future for Aotearoa" (CCC, 2021) presents transition pathways to a thriving, climate-resilient and low emissions Aotearoa-NZ.

"Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan" provides an overarching Tāmaki Makaurau response to climate action, focusing on greenhouse gas (GHG) emissions reduction targets, and preparation for the impacts of climate change.

In this study for Tātaki Auckland Unlimited, we assess the economic consequences of the proposed pathways considered under Ināia tonu nei and Te Tāruke-ā-Tāwhiri on the Auckland region and the rest of Aotearoa-NZ.

How are economic consequences assessed?

The economy is a bit of a black box. We might know what goes in, and what comes out, but understanding what happens in between seems incomprehensible. As we create action plans to achieve a zero-carbon economy, parts of the economy will change as we adopt new ways of doing things. These, in turn, invoke additional economic consequences. Our economies are characterised by dynamic feedbacks that make understanding future choices complex.

To understand the economic implications of potential pathways to a low carbon economy, the CCC used the Climate PoLicy ANalysis (C-PLAN) model (Wincester and White, 2022). In this study, we adapt C-PLAN to better reflect the makeup of the Aotearoa-NZ economy and separate out implications for Auckland and the rest of Aotearoa-NZ. We trace transition on an annual basis over a 30-year period.

The model's engine is based on economic theory and principles (Fig. 1). It captures both production (through labour, capital, energy, and commodities) and consumption (including transport and nontransport energy use) of goods and services. All parts of the economy are considered, including households, businesses by 36 sub-industries (e.g., dairy farming, beef and sheep farming, meat products, construction, accommodation and food services, other services, etc), government, and savings and investment. These are connected through pricing mechanisms (based on supply and demand), with prices for commodities, labour, and capital changing through time.

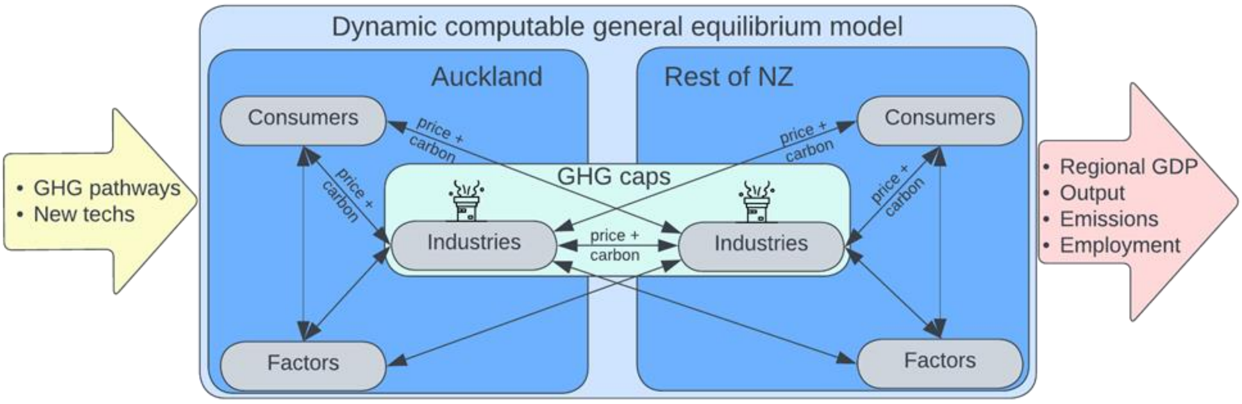

Fig. 1. The adapted C-PLAN model. Inputs (yellow), outputs (red), economic agents (grey), regions (blue), interactions (arrows), the GHG caps (green) imposed on polluting industries, and the resulting increase in commodity prices due to the addition of a carbon price.

What emissions, trading schemes, and emission reduction technologies are considered?

GHG emissions are linked to two potential sources: 1) combustion-based GHG emissions e.g., CO_2 from coal, gas, and refined oil use, and 2) process-based GHG emissions including CO_2, CH_4, N_2O and F-gas emissions. Industries reduce GHG emissions by substituting between energy types (e.g., changing to renewables), becoming more energy efficient (i.e., using less energy per unit of production), and through other measures (e.g., more efficient feed utilisation in farming).

Emissions Trading Schemes (ETSs) are employed to mitigate the effects of climate change by incentivising reduction of GHG emissions through a price signal. Producers and consumers buy permits to emit GHGs that result from their actions. The permits available for purchase are determined by an ETS cap, which is based on specific GHG reduction goals. If more emissions are generated than are permitted by the caps, then permit prices are generated. The prices are the same for Auckland and the rest of Aotearoa-NZ. Some sectors receive free permits while they adapt to decreasing GHG caps.

Advanced and emergent technologies are also considered as low-emissions alternatives to conventional technologies that will be highly impacted by carbon prices e.g., electric vehicles, methane inhibitors for dairy, sheep and beef farming, geothermal electricity with carbon capture and storage, and electric and bioheat for industries heavily dependent upon industrial heating. As the cost of conventional technologies increases, due to increasing carbon prices, advanced technologies, with their lower GHG footprints, become more affordable.

What scenarios are used?

The model reports the *net* impacts of change for key economic indicators (e.g., industry output, household consumption, GDP and employment) under two scenarios.[1] Firstly, the *baseline scenario* considers current climate policies, uptake of electric vehicles, and projected industry growth trends. Secondly, a *policy scenario,* which builds on the *baseline scenario,* also considers emerging advanced technologies (e.g., methane inhibitors, renewable energy generation) and decreasing ETS GHG caps that align with the targets set out in the Zero Carbon Act 2019.

The *baseline scenario* uses growth projections based on assumptions from the Ministry for the Environment (2019) and other *ad hoc* sources covering GDP and labour growth, electric vehicle adoption, energy efficiency improvements, national afforestation projections, land productivity, national electricity generation, and output constraints by industry.

The *policy scenario* builds on the *baseline scenario* by adding reduction targets for GHG emissions. Specifically, two ETSs are included: 1) for biogenic methane from dairy, sheep, and beef farming with a 2050 target of 47% below 2017 levels, and 2) for all other GHGs with a net-zero target by 2050. Both ETSs start in 2022 and their caps decrease at a constant annual rate from 2022 through to 2049. Dairy, sheep, and beef farming receive free allocation of permits, but permits decrease at a constant annual rate from 96% in 2022 to 32% in 2050. The eco-efficiency of the methane reducing technologies increase annually. The iron and steel industry in Auckland receives a free permit that decreases from 97% in 2022 to 0% in 2050. As noted above, the adoption of advanced technologies is also accounted for.

Results

Key scenario results are presented for emissions, price of GHG permits, and impacts on industry, households, regional GDP, and employment.

1. Emissions

Under both scenarios, Auckland's total GHG emissions reduce over time, as is the case across the rest of Aotearoa-NZ (Fig. 2). The *policy scenario* is more ambitious and produces an 18-23% reduction in emissions compared to the *baseline scenario* for the Auckland region. Reductions in road transport (including for households) and electricity contribute the most to lowering emissions in Auckland. A major driver of this change is the increasing use of electric vehicles in Auckland. In the rest of Aotearoa-NZ the greatest reductions come from agriculture. Emissions decrease linearly over time and reach their 2050 Zero Carbon Act targets.

[1] Our *baseline* and *policy* scenarios are respectively aligned to the 'current policy reference' and 'target pathway 2' scenarios outlined in the CCC's draft advice to the government on climate action (Climate Change Commission, 2021b).

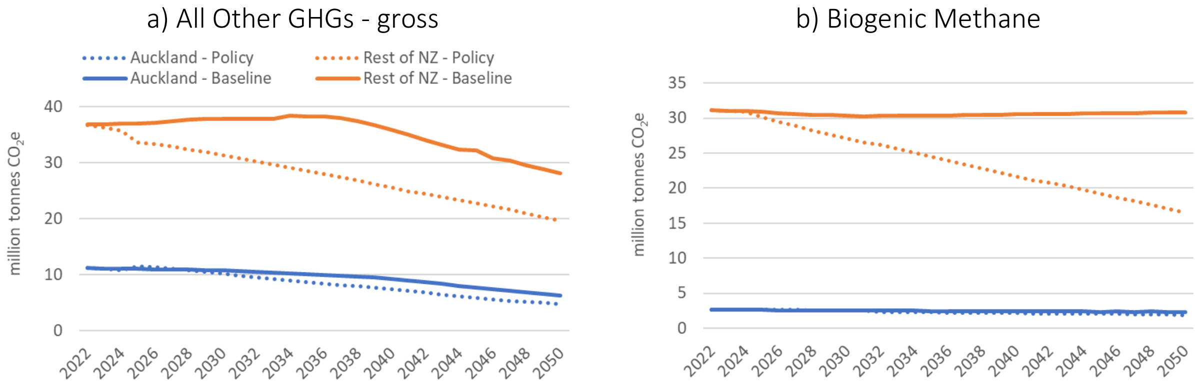

Fig. 2. Emissions for two different GHG baskets in the baseline and policy scenarios for Auckland and the rest of Aotearoa-NZ (million tonnes CO_2-e)

In 2014 Auckland's emissions mainly come from manufacturing and mining (31%), household consumption (17%), transport (14%), and services (15%), while for the rest of Aotearoa-NZ >50% come from agriculture. Over time, these emissions decrease across most industries (Fig. 3). The exception is household consumption and other commercial transport which grow due to an absence of any constraints. The reason for the decline in emissions is mainly due to the introduction of electric vehicles, plus energy efficiency gains and imposed caps on the most emitting sectors, such as heavy industrial manufacturing. In the rest of Aotearoa-NZ, the reduction in emissions under the *policy scenario* is driven by the ETS covering biogenic emissions (Fig. 3).

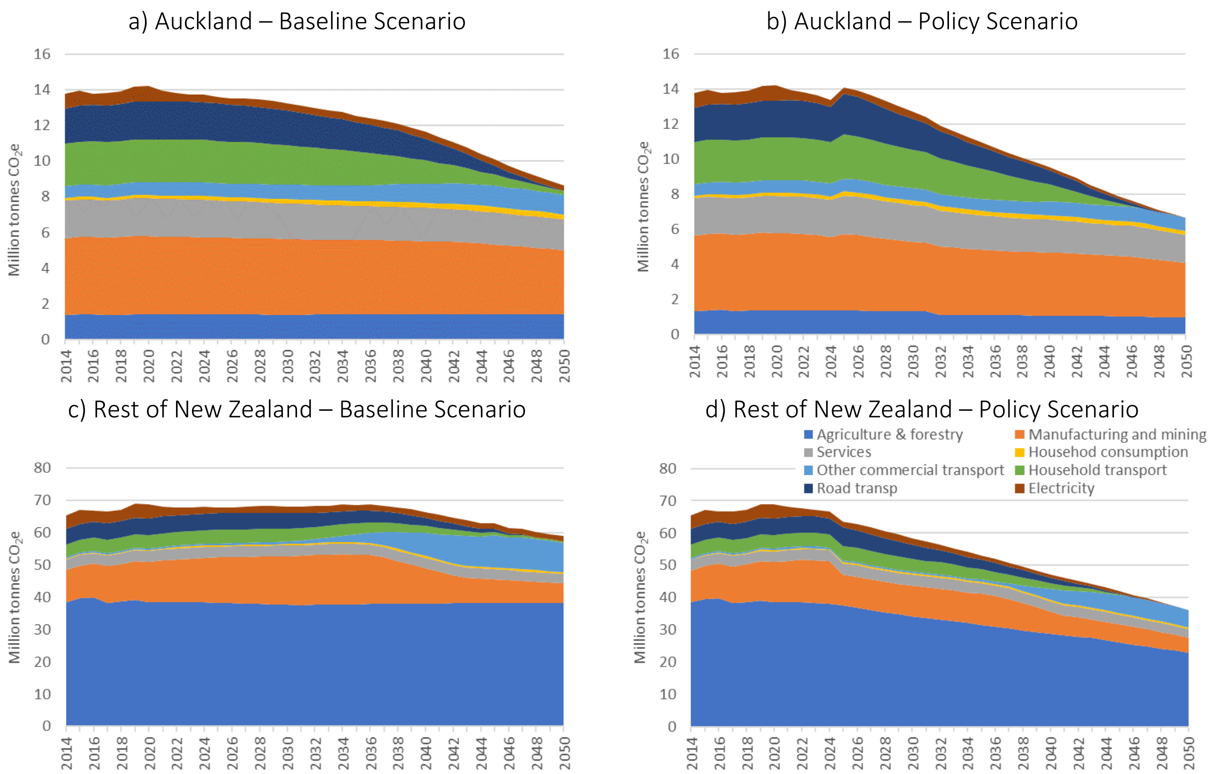

Fig. 3. Sectoral emissions for Auckland and the rest of Aotearoa-NZ under the baseline and policy scenarios (million tonnes CO_2-e without bunker fuels)

2. Price of GHG permits

The permit price for the ETS is the same for Auckland and the rest of Aotearoa-NZ. The price per unit increases as the availability of permits decreases. By 2050, the unit price for one tonne of CO_2-e could reach NZ$350. For biogenic methane, the permit price increases rapidly because of the decreasing ETS cap initially, but once methane reducing technologies are adopted in 2025, the price decreases again (Fig. 4). Technology solutions have limits, and once these are reached (around 80-90% for farming sector uptake), the price drastically increases. Future pricing may be influenced by setting further targets.

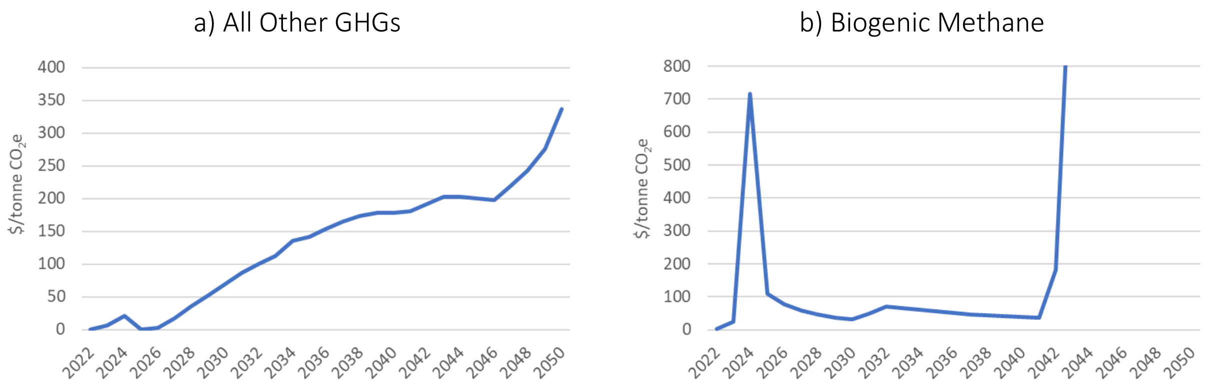

Fig. 4. Prices for the GHG permits under two different Emissions Trading Schemes in the policy scenario ($/tonne CO_2-e)

3. Industry impacts

Fig. 5a shows the change in output from various primary and manufacturing sectors in Auckland and the rest of Aotearoa-NZ under both scenarios. In terms of the primary sectors, the ETS caps under the *policy scenario* have the greatest influence in reducing agricultural emissions (dairy, sheep, and beef sectors) in the rest of Aotearoa-NZ. Auckland's primary industries only make a small contribution to regional emissions, so the effects felt are minimal. In terms of manufacturing, Fig. 5b shows how the ETS caps (*policy scenario*) affect mostly the refined oil, dairy and meat processing sectors across Aotearoa-NZ. Auckland's manufacturing sectors are also affected by the ETS caps, with refined oil outputs decreasing as more electric vehicles are introduced, lessening our reliance on the internal combustion engine.

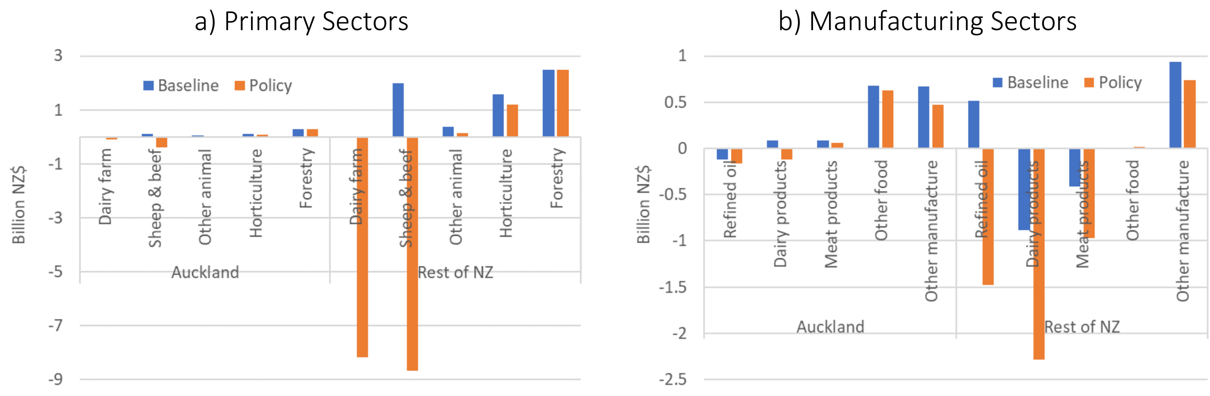

Fig. 5. Absolute change in output from various primary and manufacturing sectors in the 2014-2050 period under the baseline and policy scenarios for Auckland and the rest of Aotearoa-NZ (Billion NZ$)

Impacts are also felt in electricity generation and transport industries. For the electricity sector, Fig. 6a shows that both Auckland and the rest of Aotearoa-NZ experience a lift in output from green energy generation (geothermal, wind and solar), and conversely, a reduction in output from coal and gas sources over time under both scenarios. The decreasing output from conventional geothermal technology is picked up by new geothermal technology with carbon capture and storage under the *policy scenario*. Road and private transport emissions (Fig. 6b) reduce because of the electrification of vehicle fleets over time, while air transport emissions increase under both scenarios.

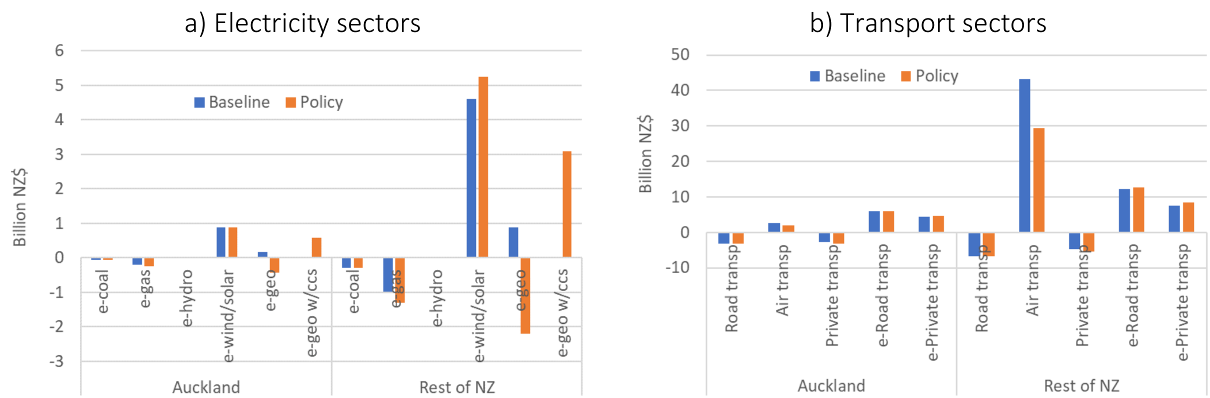

Fig. 6. Absolute change in output from various electricity and transport sectors in the 2014-2050 period under the baseline and policy scenarios for Auckland and the rest of Aotearoa-NZ (Billions NZ$)

4. Household impacts

Fig. 7 shows the change in household consumption for a variety of food products. The consumption of dairy and meat products decreases in Auckland under the *policy scenario*. This is a result of the ETS cap on biogenic emissions restricting output from dairy, sheep, and beef farming in the rest of Aotearoa-NZ and the ensuing interregional import price increase in Auckland. Consumer welfare, an overarching measure of impact for households[2], decreases in Auckland region (-5%) and increases in the rest of Aotearoa-NZ (1.1%) for the *policy scenario*.

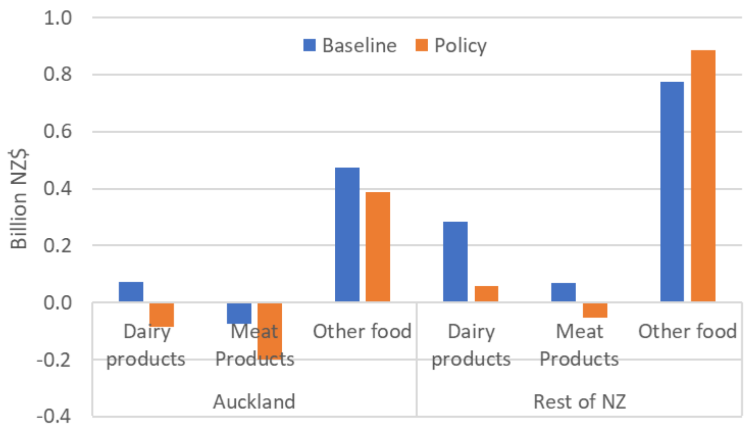

Fig. 7. Absolute change in the consumption of various food products by households in the 2014-2050 period under the baseline and policy scenarios for Auckland and the rest of Aotearoa-NZ (Billion NZ$)

5. Regional GDP impacts

Fig. 8 shows the absolute change in GDP under both scenarios. In relative terms, the GDP in both regions increases at a lower rate under the *policy scenario*. The Auckland economy is slightly more impacted, compared with the rest of Aotearoa-NZ.

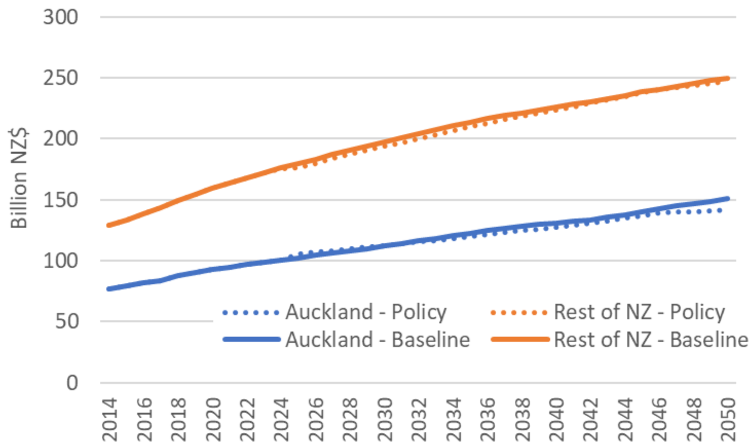

Fig. 8. Regional GDP for Auckland region and the rest of Aotearoa-NZ under both baseline and policy scenarios

6. Employment impacts

By 2050, job losses under the *policy scenario* for Auckland amount to around 1% (i.e., about 15,000 of 1.5 million employees). Net losses for Auckland are felt mostly in agriculture and geothermal energy (generation and supply). The worst affected occupations for job losses are in the farming and road transport sectors, e.g., farmers, transport professionals, truck and train drivers, and other

[2] Consumer welfare is measured according to the equivalent variation welfare metric.

manufacturing roles. The net result of the transition to a low carbon future does not greatly change the occupation profile of the Auckland economy. There is instead a gradual transition as more green jobs emerge and supersede carbon-intensive jobs.

For further information

For full technical details of the modelling work presented in this report please refer to Monge, McDonald and Cardwell (2022).

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