TE MANATŪ WAKA
MINISTRY OF TRANSPORT

Proactive Release

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Listed below are the most commonly used grounds from the OIA.

Section	Description of ground
6(a)	as release would be likely to prejudice the security or defence of New Zealand or the international relations of the New Zealand Government
6(b)	as release would be likely to prejudice the entrusting of information to the Government of New Zealand on a basis of confidence by (i) the Government of any other country or any agency of such a Government; or (ii) any international organisation
6(c)	prejudice the maintenance of the law, including the prevention, investigation, and detection of offences, and the right to a fair trial
9(2)(a)	to protect the privacy of natural persons
9(2)(b)(ii)	to protect information where the making available of the information would be likely unreasonably to prejudice the commercial position of the person who supplied or who is the subject of the information
9(2)(ba)(i)	to protect information which is subject to an obligation of confidence or which any person has been or could be compelled to provide under the authority of any enactment, where the making available of the information would be likely to prejudice the supply of similar information, or information from the same source, and it is in the public
9(2)(ba)(ii)	to protect information which is subject to an obligation of confidence or which any person has been or could be compelled to provide under the authority of any enactment, where the making available of the information would be likely otherwise to damage the public interest
9(2)(f)(ii)	to maintain the constitutional conventions for the time being which protect collective and individual ministerial responsibility
9(2)(f)(iv)	to maintain the constitutional conventions for the time being which protect the confidentiality of advice tendered by Ministers of the Crown and officials
9(2)(g)(i)	to maintain the effective conduct of public affairs through the free and frank expression of opinions by or between or to Ministers of the Crown or members of an organisation or officers and employees of any public service agency or organisation in the course of their duty
9(2)(h)	to maintain legal professional privilege
9(2)(i)	to enable a Minister of the Crown or any public service agency or organisation holding the information to carry out, without prejudice or disadvantage, commercial activities
9(2)(j)	to enable a Minister of the Crown or any public service agency or organisation holding the information to carry on, without prejudice or disadvantage, negotiations (including commercial and industrial negotiations)

Carbon Opportunities Report

Document number: ALRPC-ALRA-000PRO__-ZZZ-SU-CMW-RP-RPT-000002

Revision: P01

14 November 2023

Issue and revision record

Document control					
Report title		Carbon Opportunities Report			
Document number		ALRPC-ALRA-000PRO__-ZZZ-SU-CMW-RP-RPT-000002			
Rev	**Date**	**Revision details/status**	**Author**	**Reviewer**	**Approver**
P01	2023-11-14	Accepted for TOC1a	Varun Giridharan, Carlos Kershaw, Kirk Archibald	Kirk Archibald	Liz Root
Current revision		**P01**			

Approval			
Author signature	s 9(2)(a)	Approver	s 9(2)(a)
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Security Classification

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This deliverable has not been informed by mana whenua and Māori engagement at this time due to TOC1a being a close-out phase at ALRL's direction; further engagement will be required before this deliverable is endorsed by mana whenua. Please refer to the Document Review Record for relevant feedback relating to this deliverable.

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Figures

Tables

1. Introduction

This report outlines a series of opportunities to reduce Auckland Light Rail's (ALR) whole of life greenhouse gas emissions (WL GHG) that have been incorporated into the Carbon Appendix to ALRs economic case[1].

This report is not a comprehensive list of WL GHG emission reductions opportunities, rather it documents opportunities that can be assessed at this stage of ALR, where detailed design is limited. Opportunities considered include procuring lower carbon energy and materials and on opportunities for ALR to enable greater emission reductions and are listed as follows:

- **Low carbon enabling infrastructure** – through the use of low carbon materials, more efficient construction, greater recycling and re-use of materials and value engineering
- **Low carbon buildings** – through the greater use timber, use of low carbon cement and building energy efficiency standards greater than the building code
- **Reduced car-parking and low carbon transport** – through assuming a reduction in private vehicles per household and greater shift to active modes
- **Use of Low Carbon Materials** – This includes steel produced from 100% recycled steel and using renewable energy and the use of cements that contain low carbon supplementary cementitious materials

The report summarises the opportunity, the scale of impact, and trade-offs or considerations when implementing each opportunity currently being considered. It is recommended that the opportunities presented in this report are investigated further for implementation in future stages of the project.

Including in this report is a discussion of Power Purchase Agreements (PPA), which are a means to reduce operational GHG emissions related to electricity use. This opportunity was not included in the baseline assessment but has been incorporated into the carbon assessment for the Economic Case.

. It is expected that further opportunities are added to this report as design detail allows and through engagement with mana whenua . These include but are not limited to:

- Opportunities for design refinement (noting there is a large potential for reductions in carbon emissions from design refinement)
- Opportunities for resource recovery and re-use within The Project
- Opportunities for improved energy efficiency
- Use of structural timber
- Carbon removals including but not limited to nature-based solutions within the corridor, as a result of The Project.

A document hierarchy including this Carbon Opportunities Report is shown in Figure 1.1.

s 9(2)(b)(ii)

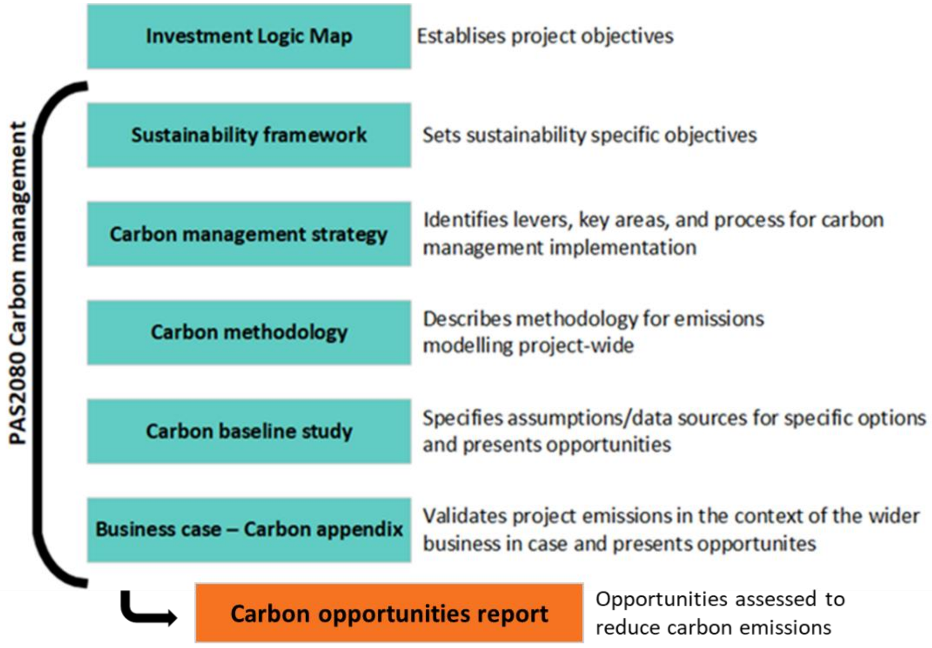

Figure 1.1 Document Hierarchy

2. Low carbon enabling infrastructure

Description:

The carbon emissions that result from the construction and operation of enabling infrastructure along the corridor is assumed to be built to a BAU standard. However, there are several initiatives that will result in a reduction in the carbon emissions from enabling infrastructure.

Key initiatives could include using low carbon materials for construction (such as using supplementary cementitious materials to lower the carbon impact of concrete), reducing the carbon impact of various construction activities (such as using efficient construction equipment and recycling/reusing existing housing), or reducing the volume of building materials required (such as through demand management measures or value engineering).

s 9(2)(b)(ii)

[redacted]

Opportunity Assessment:

The following figure shows the expected carbon emissions savings that will result from constructing low carbon enabling infrastructure across the corridor. Note that these savings are additional to savings identified as part of the Corridor Business Case carbon assessment for the EPO under the VHG scenario. Total additional carbon emission savings from 2032 to 2100 are 29,000 tCO_{2e}.

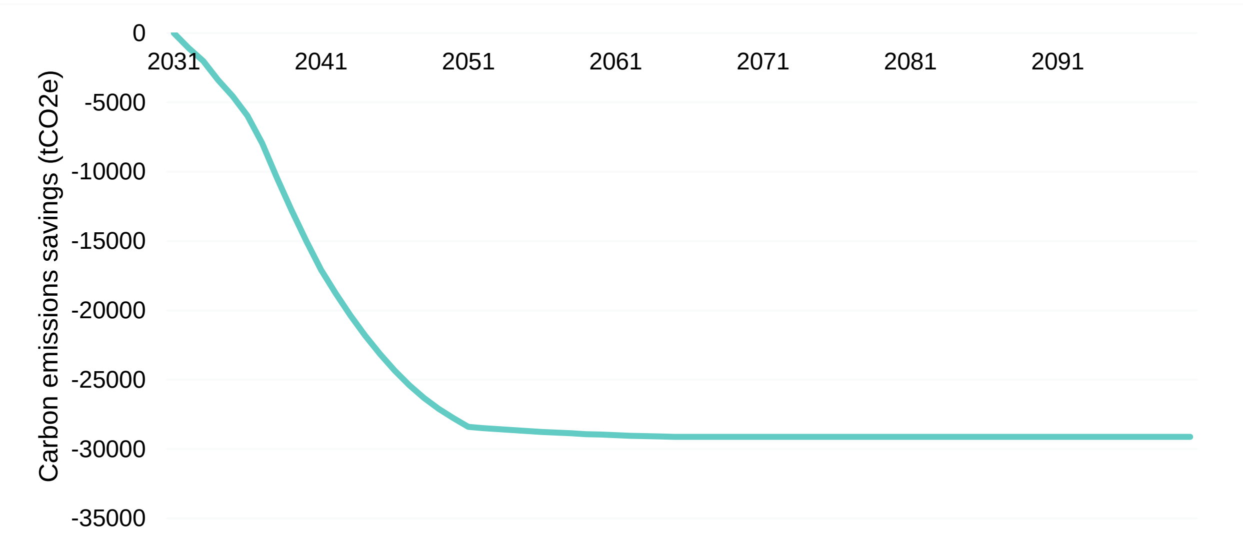

Figure 2.1 Enabling infrastructure carbon emissions savings

Key Risks and Feasibility:

Co-benefits:

The delivery of low carbon infrastructure is compatible with other strategies to create blue and green networks along the corridor. Low carbon infrastructure interventions are expected to reduce waste sent to landfill, pass on cost savings to residents/community, and improve the capacity of the sector to deliver innovative and low carbon infrastructure solutions. Initiatives implemented along the corridor could be rolled out across the region if successful.

Dependencies:

This initiative needs to be integrated into the corridor strategies and Provisional Catchment Development Frameworks (PCDFs). Sustainable and regenerative design is a core principle of the Urban Infrastructure Strategy. Note that the delivery of the initiatives will only be able to be confirmed over time.

Mechanisms:

Auckland Light Rail will need to engage with infrastructure service providers to confirm design standards and identify opportunities to deliver low carbon infrastructure. There will be opportunities to challenge standards to achieve carbon reductions, such as using recycled materials from site clearance activities for aggregate. Engaging early and identifying key relationships will help to understand how regulatory and consenting barriers can be smoothed out. Initiatives will need to be integrated into business cases and masterplans to ensure funding is in place to deliver the initiative.

Next steps:

Confirm that low carbon infrastructure initiative is well integrated in the Urban Infrastructure Strategy as well as the PCDFs.

3. Reduced carparking and low carbon transport

Description:

The PCDFs (including local movement networks) and the funding identified to support urban development in the CBC will likely encourage further carbon emissions benefits through more people using public transport and walking and cycling. This assessment quantifies the carbon emissions benefits of doing so. This is not part of the main carbon assessment that is included in the economic case given the lack of information at this point in time.

Approach:[2]

Key initiatives identified include:

- limiting residential carparking supply
- providing higher walking and cycling connections in and around station catchments
- upgrading public transport infrastructure

Research indicates that improved active mode infrastructure will result in a ~1% reduction in VKT, while assuming there will be 1 car per household along the corridor (likely overestimate), this will lead to a further ~7% reduction in VKT. Applying a risk factor of 75%, this results in the initiative reducing VKT by 6%. Carbon emissions benefits apply to both reduced emissions from lower VKT and reduced emissions from fewer cars needed to be manufactured.

Opportunity Assessment:

The following figure shows the expected carbon emissions savings that will result from initiatives to reduce VKT across the corridor. Note that these savings are additional to those identified as part of the Corridor Business Case. Total additional carbon emission savings are 530,000 tCO_{2e}.

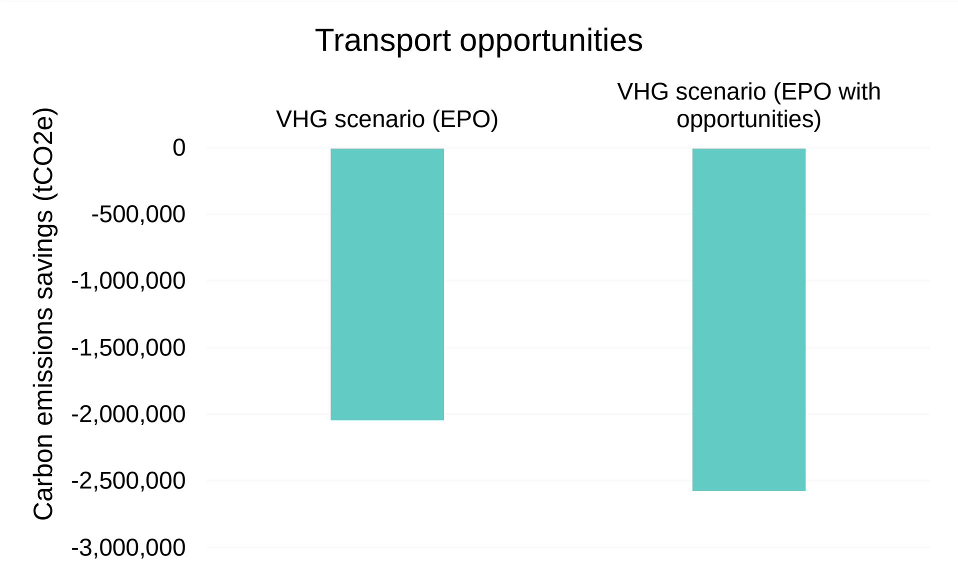

Figure 3.1 Transport carbon emissions savings

[2] https://www.caleemod.com/documents/handbook/full_handbook.pdf

Key Risks and Feasibility:

Risks could include lack of community support for some initiatives or funding not being able to be secured for the urban interventions/PCDFs.

Co-benefits:

Initiatives will lead to high active travel and public transport benefits. Carbon benefits from most initiatives will likely be minor compared to other benefits. Reduced carparking supply will likely be attractive for developers given the high cost associated with carparks.

Dependencies:

This initiative needs to be integrated into the corridor strategies and Provisional Catchment Development Frameworks (PCDFs).

Mechanisms:

The CBC and PCDFs are the current mechanisms identified for delivering these initiatives.

Next steps:

Await confirmation of funding for initiatives.

4. Low carbon buildings

Description:

The carbon emissions that result from the construction and operation of new residential development along the corridor are assumed to be built to a BAU standard in the CBC for ALR. However, there are several initiatives that will result in a reduction in the carbon emissions from buildings that should be considered as a key opportunity for ALR.

Key initiatives could include constructing buildings using timber/CLT where possible, constructing units to high Homestar ratings to reduce operational energy use, and installing solar PV where possible on roofs.

Approach:

s 9(2)(b)(ii) [redacted] An update to the work done previously was undertaken to confirm results. To account for feasibility considerations given not all developers will choose to build using low carbon methods, risk factors were applied to each opportunity. The impact of this opportunity is detailed in Table 4.1.

Table 4.1 Impact of Low Carbon Building Opportunities

Initiative	BAU Carbon	**Low Carbon**	**Reduction Factor**	**Risk Factor**	**Final value**	**Commentary**
Substitution of CLT ($kgCO_2e/m^2$)	630	393.8	38%	25%	9%	Taking % difference between Precast concrete and CLT apartment from Nga Kainga Anamata
Substitution of low carbon concrete ($kgCO_2e/m^2$)	608	365	40%	40%	16%	50 MPA Allied ready mix concrete (608 kgCO2e/m3), 50 MPa Holcim ready mix concrete (with golden bay cement) 365 $kgCO_2e/m^3$
Low energy apartments (kWh/m^2)	70	31	56%	75%	42%	Current apartments are 70 kWh/m^2, Homestar 8 v5 are 31 kWh/m^2
Total embodied reduction					**25%**	
Total operational reduction					**40%**	

Opportunity Assessment:

The following figure shows the expected carbon emissions savings that will result from constructing low carbon buildings across the corridor. Note that these savings are additional to those identified as part of the Corridor Business Case. Total additional carbon emission savings are 200,000 tCO_2e.

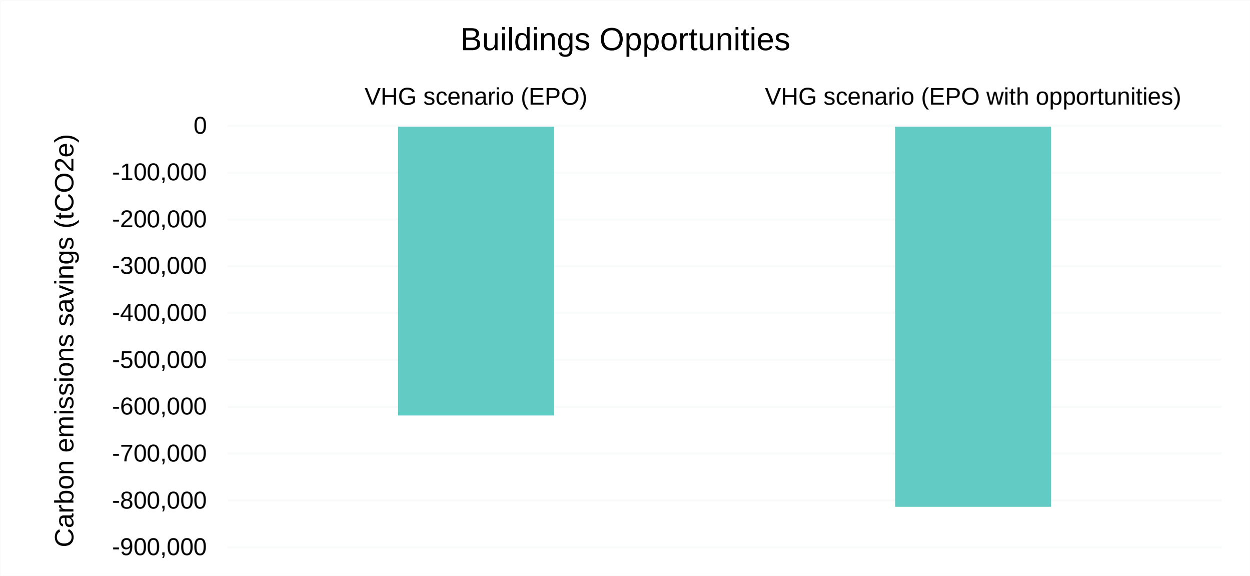

Figure 4.1 Buildings carbon emissions savings

Key Risks and Feasibility:

- Supply chain issues will greatly impact the level of emissions reduction that can be expected. For example, the volume of timber required likely exceeds current industry capacity and ability.
- There is generally a cost premium associated with low carbon materials and materials have been subject to high inflation in recent years.
- There are a number of regulatory barriers that will need to be overcome as well. Current suppliers are facing difficulty in scaling up production due to slow consenting timeframes for low carbon materials (including engineered timber and concrete).
- Given risks around consenting timeframes and cost increases are high, developers will be unlikely to build in low carbon approaches unless given an appropriate incentive.
- There is a risk that developers will choose not to build along the corridor if required to build in a low carbon manner, given potential difficulties.

Co-benefits:

Carbon emission reduction initiatives can be progressed along with initiatives to improve the quality of residential builds along the corridor. These will help improve the quality of life of residents.

Dependencies:

This initiative needs to be integrated into corridor strategies and Provisional Catchment Development Frameworks (PCDFs).

Mechanisms:

Next steps:

Confirm approach to encouraging low carbon apartments along the corridor.

5. Low carbon steel

Description:

There is a major opportunity within the construction of Auckland Light Rail to decrease the carbon emissions associated with the upfront embodied emissions of the project. A way that this can be achieved is by procuring steel from suppliers using 100% recycled steel and 100% renewable energy during manufacturing.

Approach:

E are assumed based on EPDs for steel procured from 100% recycled steel and using renewable electricity.

Opportunity Assessment:

Assuming all steel used is low carbon, the following shows the reduction in carbon emission for the EPO.

Table 5.1 Impact of Low Carbon Steel

Steel Type	Total Carbon Emissions (tCO_{2e})
NZ Steel 50% Electric Arc Furnace	s 9(2)(b)(ii) [redacted]
100% recycled steel with 100% renewable energy supply	[redacted]
Savings	[redacted]

While this opportunity would significantly reduce upfront GHG emissions there are likely to be challenges to procuring steel internationally at a higher cost than products produced locally. For this opportunity it has therefore been assumed that 30% of steel will be able to be procured internationally. This is shown in Table 5.2 below.

Table 5.2 Carbon impact if 30% of steel sourced is low carbon

Steel Type	Total Carbon Emissions (tCO_{2e})
100% recycled steel with 100% renewable energy supply	s 9(2)(b)(ii) [redacted]
30% of steel sourced from Acelormittal	[redacted]

Cost of GHG Emission reduction:

The cost associated with procuring 30% low carbon compared to all from NZ Steel is shown in table 6 below. The cost premium of sourcing low carbon steel is assumed to be s [redacted] based on a market study, however this may change in future. With, 30% of steel low carbon, this equates to s 9(2)(b)(ii) [redacted]. With a carbon reduction of s 9(2)(b)(ii) [redacted] this equates to a cost of emission reduction of s 9(2)(b)(ii) [redacted] As this is lower than the shadow price of carbon ($78 –

201 per tCO_2e[3]), procuring steel from overseas is likely to improve the benefit to cost ration (BCR) of ALR.

Table 5.3 Cost of sourcing low carbon steel

Steel Type	Total Cost ($)
NZ Steel 50% Electric Arc Furnace	s 9(2)(b)(ii) [redacted]
Acelormittal Steel	
Difference	

Key Risks and Feasibility:

The key risks associated with using imported, low carbon steel are the cost premium and appetite for additional spend to reduce emissions. In addition, there are likely to be political issues with procuring steel from overseas.

This said, the steel industry is decarbonising with a shift away from the use of coal as the primary energy supply and reducing agent, to electricity and hydrogen, both derived from renewable sources.

Co-benefits:

Potential to unlock low carbon markets and supply chains within New Zealand and put pressure on local suppliers to reduce emissions intensity of their projects.

Dependencies:

Developers and Steel Manufacturers

[3] Monetised benefits and costs manual v1.6 April 2023 (nzta.govt.nz)

6. Low carbon concrete

Description:

Concrete and in particular cement, is responsible for a large proportion ALRs upfront emissions. Low carbon cements are therefore a great opportunity reduce ALRs WL GHG emissions. The concrete mix used to baseline the projects carbon emissions uses EcoSure cement.

EcoSure is a Golden Bay general purpose (GP) cement mix which has lower emissions than a regular Portland cement concrete mix. However, there is an opportunity to use a cement that includes supplementary cementitious materials (SCM) like fly ash and ground granulated blast furnace slag (GGBFS). These SCMs are by-products of other processes and have lower embodied emissions than cements primary active ingredient, calcium oxide (quicklime). This opportunity assumes a cement mix containing 35% fly-ash.

Approach:

Cement mixes containing 35% fly ash are commonly used worldwide in all concrete applications. A cement mix containing 35% fly ash has been compared against the baseline product, EcoSure. Emissions factors for the baseline and SCM scenario are presented in Table 6.1.

Table 6.1 Concrete opportunity emission factors

Concrete Strength	EcoSure	35% FA Concrete Mix
50Mpa	s 9(2)(b)(ii) [redacted]	
40Mpa		
30Mpa		

Opportunity Assessment:

Table 6.1 compares the total embodied carbon emissions and costs associated with the project between EcoSure, and a 35% fly ash cement mix. The expected savings along with the associated cost that will result from using low carbon concrete are also documented.

Note that for this opportunity it is assumed that all concrete used during construction will be a 35% fly ash concrete mix. In addition, it is assumed that scarcity will increase the price of locally sourced SCMs to the point that there will be a premium associated with their use.

The total carbon emission savings are estimated to be s 9(2)(b)(ii) [redacted] and the cost associated with the change is s 9(2)(b)(ii) [redacted] This equates to s 9(2)(b)(ii) [redacted] Noting that costs are likely to change in future.

Table 6.2 Carbon impact and cost of 35% fly ash concrete mix

Concrete Type	Total Carbon Emissions (tCO_2e)	Total Cost ($)
EcoSure (baseline)	s 9(2)(b)(ii) [redacted]	s 9(2)(b)(ii) [redacted]
35% fly ash concrete mix		
Savings		

The shadow price of carbon during ALRs anticipated construction period, 2026 – 2032 ranges from \$78 – \$241 per tCO_2e [4]. With emission savings related to the use of 35% cement fly-ash cement estimated at s 9(2)(b)(ii) [redacted] it is possible that this opportunity could improve the benefit to cost ratio (BCR) of ALR if utilised towards the end of the project. That is, where the shadow cost of carbon exceeds the emission reduction cost.

Key Risks and Feasibility:

The key risks associated with using a 35% fly ash is the limited supply of fly ash within New Zealand. It is possible that new sources of fly-ash could be established in New Zealand (e.g., fly ash from process heat boilers) and that other locally sourced SCMs become available (e.g. bottom ash and GGBFS). In addition, scarcity of fly-ash is likely to be balanced by imports of fly ash and GGBFS (which are already imported for blending in New Zealand) and other SCMs like natural pozzolans and calcinated clay that are likely to become mainstream in the next 10 years.

Co-benefits:

Unlocking the supply of low-carbon cements in New Zealand and encouraging their local production.

Dependencies:

Cement suppliers.

[4] Monetised benefits and costs manual v1.6 April 2023 (nzta.govt.nz)

7. Low carbon non-structural concrete

Description:

Non-structural concrete (e.g., paving) is an important material for the construction of ALR. Public realm spaces and stations themselves will make extensive use of concrete paving or similar. Low carbon non-structural concrete mixes therefore have the potential to reduce ALRs emissions.

Approach:

The embodied emissions associated with non-structural concrete can be reduced by specifying a different concrete mix that is specific for non-structural purposes. LC3 Holcim mix was chosen for this opportunity as the low carbon non-structural concrete mix that is expected to be available in New Zealand by the time ALR is constructed.

This mix is made of clinker, calcinated clay, limestone, and gypsum. For this opportunity it is assumed to be used in conjunction with the 35% fly ash concrete mix, which is used for higher strength concrete.

Emissions factors for each scenario are presented in Table 7.1.

Table 7.1 Non-structural concrete opportunity emission factors

Concrete Strength	Emissions Factor (tCO_{2e} / tonne)		
	EcoSure	Holcim LC3	35% FA Concrete Mix
50Mpa	s 9(2)(b)(ii) [redacted]		
40Mpa			
30Mpa			

Opportunity Assessment:

Table 7.2 compares the total embodied carbon emissions and costs associated with the project between the baseline, EcoSure, and using LC3 Holcim mix for non-structural concrete along with the 35% fly ash concrete mix for structural concrete. The expected savings along with the associated cost that will result from using low carbon concrete are also documented.

Note that it is assumed for this calculation that all 30Mpa concrete used during construction will be the LC3 Holcim mix and all 50Mpa and 40Mpa concrete will be the 35% fly ash concrete mix. Therefore, the total carbon emission savings are tCO2e which equates to a s 9(2)(b)(ii) [redacted] increase in cost. Noting that this cost increase is likely to change in future. The cost of carbon is therefore s 9(2)(b)(ii) [redacted]

Table 7.2 Carbon Impact and cost of low carbon no-structural cement mix

Concrete Type	Total Carbon Emissions (tCO_{2e})	Total Cost ($)
EcoSure (baseline)	s 9(2)(b)(ii) [redacted]	
LC3 Holcim mix plus 35% fly ash concrete mix		
Savings		

When the savings and cost of carbon is compared between using the 35% fly ash concrete mix for both structural and non-structural concrete and using LC3 Holcim for the non-structural concrete. The cost of carbon increase from s 9(2)(b)(ii) [redacted] This illustrates that it is more beneficial to procure the same concrete mix for all purposes and applications.

However, if you compare both carbon costs to the shadow carbon price over the construction period of ALR, it can be seen that the shadow price could potentially be higher than the carbon costs associated with lower carbon concrete opportunities.

Key Risks and Feasibility:

The key risks associated with using LC3 Holcim mix concrete is that this mix uses a high proportion of calcinated clay which currently is not an approved concrete mix within New Zealand. However, it is expected to be readily available for non-structural use within the next 2 years.

Co-benefits:

A co-benefit of using low carbon concrete in large volumes would be that it could unlock a new supply chain and prove to the industry that more low carbon material opportunities are available.

Dependencies:

Concrete Suppliers

8. Power Purchase Agreement

Introduction to Power Purchase Agreements

Power Purchase Agreements (PPA) are a means to purchase electricity from specific generation assets. At the smallest scale, this could be rooftop solar, at the largest scale it could be from a portfolio of large-scale electricity generation assets.

PPAs are commonly used by consumers to reduce GHG emissions through enabling purchase of 100% renewable electricity. For companies investing in new electricity generation, PPAs provide a fixed income stream that can de-risk their project and increase the likelihood for getting project finance.

At a small scale a PPA could involve a 3rd party installing rooftop solar and a consumer purchasing this solar. At a large scale, where a consumer isn't directly connected to the electricity generation, they wish to purchase electricity from, they can enter into a virtual power purchase agreement (vPPA) with the generator. In this instance the consumer still purchases electricity from the wholesale market or a retailer. However, in parallel the consumers enter into a vPPA with a generator that links their supply and pricing to specific electricity generation assets.

Availability of PPAs in New Zealand

PPAs and vPPAs are commonplace globally and becoming more common in NZ. Rooftop solar PPAs are becoming common for residential and commercial consumers[5]. In these agreements solar systems (with or without batterie) are installed at a developed cost, with electricity generated and stored by this system purchased by the consumer. Large Scale vPPAs are becoming more common. Both between buying groups (like that established by the Major Electricity Users Group[6]) and between large consumers and generators[7].

Benefits of PPAs

The benefits of PPAs include:

- Allowing consumers to purchase 100% renewable energy and thereby reduce their GHG emissions
- Allowing consumers and generators to fix pricing for periods greater than 10 years
- Reducing the cost of electricity supply. New Zealand's wholesale electricity price is currently 70 - 90% higher than vPPA pricing and around 50% higher than rooftop PPA pricing
- Providing price certainty to generators which can de-risk new projects and reduce barriers to financing

Technical Feasibility of PPAs for ALR

Any electricity consumer can enter into a power purchase agreement. vPPAs linking larger consumers with large scale generation projects and PPAs for roof top solar are available in the NZ market.

Rooftop solar PPAs require space (typically roof space or land) to mount the solar panels with. PPA terms are typically for 15 – 20 years. As ALR will create new roof space through

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[5] https://www.stuff.co.nz/business/128726878/sylvia-park-to-build-largest-rooftop-solar-panel-array-in-the-country
[6] https://onestepoffthegrid.com.au/nz-biggest-corporate-ppa-seeks-up-to-2000gwh-a-year-of-new-renewables/
[7] https://www.datacenterdynamics.com/en/news/microsoft-signs-51mw-geothermal-ppa-in-new-zealand/

construction of ground stations, a depot, and other buildings there will likely be opportunity to use this roof space for solar generation.

However, given the scale of ALRs electricity consumption, only of a small fraction of ALRs electricity consumption will be able to be met through rooftop solar. The vast majority of electricity demand will need to be supplied through the grid. This can be backed by a vPPA which links this supply to large-scale generation projects.

vPPAs can be used to link all of a consumer's supply, or a portion, to specific a electricity generation source. The challenge with vPPAs is in matching a consumer's demand, which fluctuates, to the output of generation, which can also fluctuate. This is a particular issue if the vPPA is for intermittent generation only, like wind or solar. However, there are means to mitigate this risk, including contracting with a portfolio or projects and retailer products to sleeve PPAs with other renewable electricity generation[8] or with standard fixed price variable volume contracts as an example.

Economic Feasibility of PPAs for ALR

In the long-run, New Zealand's electricity market is expected to reflect the marginal cost of new generation. In the short-term however, pricing reflects supply and demand. Since around 2019, drought, gas field outages combined with their depletion, a lack of investment in new generation and increased demand have pushed wholesale electricity costs above long-term averages. High prices are expected for the foreseeable future with futures pricing above $150 / MW[9] (15c/kWh) for the next three years at least.

The pricing of PPAs is currently much lower than the wholesale market as the costs of PPAs reflects the cost to build and finance new generation. For commercial rooftop solar systems this equates to a PPA rate of around 11c/kWh and for vPPAs, pricing can be below 9c/kWh. As PPAs fix these prices for 10 – 20 years, they provide price certainty that isn't typically available from electricity retailers.

As well as fixed price options for pricing PPAs, other options exist like indexing to the wholesale price or to hedge a portion of demand using PPAs and purchase the residual at spot market prices or through another arrangement with a retailer.

In summary, while the wholesale market prices are expected to decline as new generation comes online and if large users like NZ Aluminium Smelters exit the market, rooftop PPAs and vPPAs provide a means to access this lower pricing now. As no investment is required to access these prices (other than transaction costs associated with setting up the PPA contracts), PPAs offer a low risk means to reducing electricity costs.

Credibility of Emission Reduction Claims

Grid supplied electricity in New Zealand has a relatively low and declining carbon footprint. This reflects the high and growing proportion of electricity generated from renewable energy. From 2024 – 2050, lifecycle grid electricity emissions are expected to decline from 156gCO_2 / kWh to 79gCO_2 / kWh[10]. The predominant options for renewable electricity generation in New Zealand, Wind, Solar and Geothermal have estimated lifecycle emissions of 13, 20 and 79gCO_2 / kWh respectively, with lifecycle emissions also expected to decline over time. Both as the global economy decarbonises and as carbon capture technology for geothermal energy matures. A PPA that displaces grid electricity with new renewable electricity generation will therefore reduce GHG emissions.

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[8] https://chapmantripp.com/trends-insights/energy-trends-insights/power-purchase-agreements-to-sleeve-or-not-to-sleeve/
[9] https://www.asxenergy.com.au/futures_nz
[10] https://www.branz.co.nz/environment-zero-carbon-research/framework/data/

Noting that simply purchasing renewable electricity from existing renewable energy generation via a vPPA or purchasing renewable electricity certificates does not reduce emissions directly. Neither of these approaches increase the supply of renewable electricity to the wholesale market or displace fossil fuel generation.

How can PPAs work for ALR?

For rooftop solar PPAs, ALR would have a grid connection, but in addition would agree to purchase any solar generated from a rooftop array installed by a third party on ALR property. This solar electricity would reduce electricity consumed by ALR so would simply reduce the amount of electricity ALR would have to purchase from retailer via a grid connection. It is unlikely a rooftop solar array would be large enough to produce solar exports, but if this was the case, these would simply net-off the bill for grid supplied electricity.

The vPPA itself is a contract for difference[11]. In practice, when the wholesale electricity price is below vPPA price, ALR would pay the renewable energy developer the difference and when the wholesale electricity price is above the vPPA, the renewable developer would pay ALR the difference.

For ALR, the likely approach to vPPAs would be to have a contract with a retailer to supply electricity at the wholesale price. In parallel to this, ALR would have a vPPA with a renewable energy developer to purchase electricity from large scale electricity generation. Ideally this would be to purchase electricity from a combination of solar, wind and geothermal projects rather than a single project.

The benefit of sourcing from a portfolio of projects, potentially through a renewable energy purchasing group[12], is that it smooths the output of intermittent generation (like wind and solar) and particularly if the portfolio includes geothermal, can enable 100% of electricity to be supplied virtually from renewable energy projects. Purchasing only from intermittent generation would require some electricity to be sourced from grid during times of low wind or solar output.

Given ALR's load profile, where electricity consumption is likely to be highest in the morning and evening commuting peaks and during the middle of the day, and lowest at night, a 1:1:1 mix of solar, wind and geothermal electricity has been assumed.

Opportunity Assessment:

Given that both rooftop PPAs and vPPAs are available to consumers and that the pricing is competitive with grid supply, it is expected that 100% of ALRs electricity consumption can be met through a combination of rooftop and virtual PPA's.

To enable 100% of electricity to be purchased via a PPA, it is assumed that it will be a 1:1:1 mix of solar, wind and geothermal. Recognising that purchasing 100% of electricity from wind and solar alone may be difficult or costly due to these sources' intermittent generation.

As with grid supplied electricity in New Zealand, lifecycle emissions related to new renewable energy generation are expected to decline over time. Table 8.1**Error! Reference source not found.** details estimated lifecycle emissions of renewable generation and the expected rate of decline over time.

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11 https://en.wikipedia.org/wiki/Contract_for_difference#Electricity_generation

12 https://onestepoffthegrid.com.au/nz-biggest-corporate-ppa-seeks-up-to-2000gwh-a-year-of-new-renewables/

Table 8.1 PPA Emission Factors[13]

Energy Source	Lifecycle Emission Factor (gCO_{2e} / kWh)			Average Annual Reduction
	2024	**2030**	**2050**	
Solar	19	16	9	3.6%
Geothermal	79	54	18	3.4%
Wind	13	12	7	1.9%
Combined vPPA emission factor	**37**	**27**	**11**	**3.1%**
Grid	156	123	74	5.3%

The impact of 100% renewable electricity supply via PPAs on WL GHG emissions for ALR is detailed in Table 8.2.

Table 8.2 Impact of 100% Renewable Electricity Supply[14]

Electricity Source	WL Emissions impact (tonnes CO_{2e})	
	2050	**Full Life**
Grid Electricity	169,000	386,000
100% renewable electricity via PPA	30,000	58,000

13 Electricity emission factors – PPA ALR

14 Digital Carbon Schedule 0.25 – "B6. Operational" tab